THE BOREAL FELT LICHEN
(*Erioderma pedicellatum* (Hue) P.M.Jørg.)
in
NEWFOUNDLAND

Geographical Distribution and Dynamics of its Habitats in Forested Landscapes

By

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INTRODUCTION

There is a great deal of conflicting evidence on the status of *Erioderma pedicellatum* and potential impacts of landscape ecosystem management strategies on the lichen.

The Government of Newfoundland, Department of Forest Resources and Agrifoods (DFRA), Forestry, Wildlife and Inland Fisheries Division staff have gone to great lengths to cooperate with biologists and environmental scientists, special interest groups and interested individuals and accommodate their concerns in management plans.

This report summarizes the results of field work on the distribution of *E. pedicellatum* carried out by DFRA staff over the past year. It also presents results of field work carried out in the early part of April, 1998 by the author and by conservation officers and ecosystem managers to examine the forest dynamics of *E. pedicellatum*. This knowledge is essential for understanding the ecological niche of the lichen's habitat and for developing mitigative measure to conserve the lichen. The author has conducted several decades of extensive scientific studies on the development of forests in cold climates and has applied results of this research relevant to the dynamics of forested landscapes in which *Erioderma* phorophytes (trees) grow. Also, details on the characteristics of location and human influences on *E. pedicellatum* habitats provides important information for assessing whether certain perceived threats to the *E. pedicellatum* in Newfoundland are apparent or real.

Since this is a consultants report intended for ecosystems managers and the policymakers, rigorous statistical analysis and scientific research and speculative theories are kept to a minimum. However, for those with a specialists interests in these matters, a few key references have been given which will lead them to refereed publications; while basic statistical parameters (namely, circular statistics) are given for those wishing to work out a more detailed statistical analysis. Suffice to state here, that the recommendations are developed from measurements and general observations of selected *E. pedicellatum* and on extensive scientific research on the dynamics of balsam fir forested landscapes in Newfoundland.

GEOGRAPHICAL DISTRIBUTION OF *Erioderma pedicellatum*

The best information on the biology and distribution of *Erioderma pedicellatum* is from the work of the Canadian lichenologist and biochemist Dr. Wolfgang Maass (1980, 1983). Although Dr. Teuvo Ahti had found the lichen in Newfoundland as far back as 1956, it is largely through Maass' work that lichenologists justifiably considered *Erioderma pedicellatum* to be a rare and endangered species: that is until large number of sites was discovered 1997-98, particularly by Departmentof Forest Resources and Agrifoods staff. During author's first day in the field accompanied with Bill Clarke, within 5 minutes of leaving the truck and being shown Erioderma at the Noseworthy's Gully, which was searched many times, he found 5 more thalli bearing trees (phorophytes); and two more the next day at Lockyer's Water. The author was present when four new sites were discovered: two on the coastal plain of the Northern Peninsula - one (site 50) near Eddies Cove west found by Jon Sharron; the other (site 51) on Zinc Mine Road near Daniel's Harbour found by Mark Lawlor; and two (sites 44b & 44d), beside the Burgeo Highway found by Bill Clarke and Ward Strickland, respectively. The Northern Peninsula sites are in the vicinity of sites found much earlier by Dr. Maass. But, like Dr. Maass' find, there was only one thalli at the Eddies Cove West and two at the Zinc Mine Road sites, respectively - which were on trees very close to the road; one (site 50) literately at the base of the bank of the highway, the other at the edge of treed fen barely 50 m from the Zinc Mine Road. Both were in poor shape, but apparently show signs of recovery.

As an indication of how extraordinary these new finds by conservation officers and others in 1997-98 can best be appreciated by a note on *Erioderma pedicellatum* on an internet site for a Preliminary Global Red List of Lichens[1], which contains the following notes well worth quoting:-

> **"*Erioderma pedicellatum* (Hue) P.M. Jorg. /Lecanorales, Pannariacea**
> ***Erioderma boreale* Ahlner, Red List Category. Critically Endangered (B1).**
> **Distribution: First reported in New Brunswick in Canada in 1898 and from Europe 1948 from eight localities in Sweden and Norway. One specimen each was found at two different sites in Norway (Nord-Trondelag) 1994. The last observance in Europe before that was made in 1956. It was refound in Newfoundland in eastern Canada 1971. About 10 localities are known in Canada, but in recent years surveys not refound in all of them.**
> **Habitat: The species is restricted to oldgrowth, very humid, rather open coniferous forests in boreal areas. In Europe it is found on twigs of *Picea abies* and in Canada on trunks of *Abies balsamea,* more rarely on twigs of *Picea mariana* and *P. glauca* as well as on trunks of *Acer.***
> **Notes: Forestry is an imminent threat to many localities. Change of very high and stable humidity. The species is rather small, but characteristic and hardly overlooked. Many lichenologists have searched for the species, both in Canada and in Norway.**
> **Source: E. Serusiaux (Belgium), the expert committee on lichens in Sweden.**
> **References: Ahlenr, 1948; Holien et al. 1995, Maass, 1980, 1983."**

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[1] *http://www.dha.slu.se/guest/global2.htm* (updated 10th., September, 1996)

Furthermore, *Erioderma pedicellatum* is also included in the Committee on the Status of Endangered Wildlife in Canada's(COSEWIC) provisional list of rare lichens of Canada[2]. The list notes that the species is:-

> **"......probably extirpated in NB. Intensive searching for this species in Atlantic Canada has uncovered 5 sites in NS (Maass 1983), and 34 sites (total of 677 thalli) in NF (Ringius, 1997). *Erioderma pedicellatum* is extirpated in Europe (P.P. Jorgensen, personal Communication)."**

However, as to the lichen's Canadian National Status, the authors close the endangered designation with a question mark: signifying that they are unsure of it's frequency. However, DRFA documentation shows that by the fall of 1997 more than 100 *Erioderma* sites containing almost 3,000 thalli had been found in Newfoundland. Currently, all but a dozen or so of the 151 sites recorded so far, have been found by DFRA conservation officers. At the time of writing, new sites are being reported almost weekly which have yet to be confirmed.

Figure 1. shows the phytogeographic regions of Newfoundland where *E. pedicellatum* has been found. The lichen has been found at eight sites in phytogeographic region 5 on the Northern Peninsula. On the 6 sites discovered by Dr. Maass (open circles) over 20 years ago, no thalli have been found since. At the two sites (filled circles) discovered recently by Jon Sharron and Mark Lawlor, respectively, only one very small thalli and two at another; both in very poor shape, but apparently showing signs of recovery. In fact, after two days of extensive searching as close to Long Range mountains as we could get, the general consensus of search groups was that the trees were sparsely covered with lichens and that the climate of coastal plain was considered too dry and windy a climate to be a prime area for *E. pedicellatum* (and for *Coccocarpia,* a companion of E. pedicellatum, for that matter). The majority of the sites occur within or close to phytogeographic region 2. In comparison to other regions of Newfoundland, region 2 is warmer in winter and cooler in summer and greater precipitation, particularly as rain (85%) than snow. The forests on the sites can be considered cloud forests, insofar as they located in areas where dense fog is frequent throughout the year. On one hand, these humid conditions, combine with strong, persistent winds and a high frequency of freezing rain in winter which places severe restrictions on the productivity of vegetation, hence the predominance of coastal blanket bogs, virtually treeless heath barrens and scrub forest. However, in sheltered valleys and fiords, there are quite large expanses of moderately to highly productive forests. Most of these forests clearly show signs of having been patch-cut or high-graded by many generations of families or equivalent natural disturbances by blowdown or insect infestation of single or patches of mature trees (≈65-80 years old for balsam fir). In dry summers, fire has been a major disturbance in some parts of the region. On the whole, these are conditions which promote an exceptionally high level of landscape biodiversity characterized by frequent and moderate disturbances.

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[2] Gower, Trevor, Irwin M. Brodo and Stephen R. Clayden (1998).*Rare Lichens of Canada: A Review and Provisional Listing*. COSEWIC Committee on the Staus of Endangered Wildlife in Canada.

Figure 1: Phytogeographic map showing the principle location of *E. pedicellatum* sites discovered in Newfoundland. Most occur in the more humid (southern) parts of the province. Note that vast and less accessible areas have not been searched

Table I gives the precise location of *Erioderma* sites.The sites discovered by DFRA conservation officers and ecosytems managers mainly within that last year, are distinguished from sites discovered by lichenologists and others over a 40 year period. Few of the old sites found by lichenologists no longer have thalli (e.g., the six sites on the Northern Peninsual and north section along the Burgeo Highway).

Nearly all the sites located so far are close to major highways and access roads and ATV trails and easily accessible hinterlands. Needless to say, given that vast and less accessible tracts of Newfoundland have still to be searched, the number of sites discovered so far must surely represent a small fraction of the potential number of sites on the island. There may also be other sites in Labrador, in the cool, fog belt of southern coastal Labrador.

Apart from being found on the branches (and at least occurrence on the stem) of black spruce, and reports of it on red maple and white spruce, balsam fir is the principle phorophyte for *Erioderma pedicellatum* in Newfoundland. In forest dynamical terms, it is confined mainly to the final stages of self-thinning (i.e., ≤ 5-7,000 stems ha^{-1}) at, or close to, the natural rotation age and virtual collapse of the forest canopy. This stage is characterized by a high percentage of standing dead and sporadic and frequent wind throw, particulary at the stand edge. In fact, the phorophytes are in the lower 2/3rds dbh class (i.e. ≤ 12 cm dbh), with the exception of sites on the Burgeo Barrens. Selective cutting (high-grading for sawlogs) and sporadic wind-throw and insect-killed trees of the larger diameter class creates ideal light regimes for *Erioderma pedicellatum* comparable to the final stages of natural self-thinning. In other words, *Erioderma pedicellatum* in Newfoundland is basically a disturbance species in the sense that the origin and decadence of stands are attributed to substantial natural disturbances (notably wind throw and human activities (low-impact logging). These and many other aspects of the very dynamical nature of *E. pedicellatum* habitats are reflected in the results of this survey.

Table 1: CONFIRMED ERIODERMA SITES
(1998/04/17)

Location	Known No. Of Sites	Known No. Of Thalli	Latitude & Longitude	Discoverer
1. Ninth Fox Pond (Fox Marsh)	3	100	47º 22' 20" N 53º 25' 44" W	T. Brinston M. Lawlor
2. McGee's Gully (Lockyer's Waters)	1	40	47º 20' 31" N 53º 16' 57" W	
3. Fourth Pond (Fox Marsh)**	1	30	47º 20' 30" N 53º 26' 30" W	T. Brinston
4. Noseworthy's Gully (Fox Marsh)	1	75	47º 21' 56" N 53º 24' 03" W	T. Brinston M. Lawlor
5. Lockyer's Waters	9	914	47º 20' 30" N 53º 16' 40" W	E. Conway & others
6. Tower Road	4	24	47º 19' 20" N 53º 19' 20" W	M. Pitcher
7. Between Fourth Pond & Ripple Pond (Fox Marsh)**	3	12	47º 20' 10" N 53º 27' 40" W	T. Brinston M. Lawlor
8. Colinet Road	1	15	47º 14' 34" N 53º 36' 42" W	J. Sharron
9. End of Fourth Pond Road**	1	15	47º 21' 50" N 53º 25' 30" W	S. Gullage
10. South of Frank's Pond (Avalon Wilderness)**	2	6	47º 05' 40" N 53º 13' 30" W	F. Coates B. Ryan
11. Salmonier Nature Park	1	4	47º 15' 40" N 53º 17' 45" W	
12. Hermitage Bay (Bay d'Espoir)**	1	4	47º 41' 18" N 55º 36' 27" W	H. Thomas
13. Long Pond (Burin Peninsula)**	1	3	47º 53' 20" N 54º 23' 50" W	S. Avery
14. Murphy's Waters**	2	2	47º 11' 30" N 53º 20' 15" W	J. Sharron B. Clarke
15. Southwest of Frank's Pond (Avalon Wilderness)**	1	2	47º 06' 25" N 53º 14' 50" W	T. Brinston M. Lawlor
16. North of Holyrood Pond (Avalon Wilderness)**	1	2	46º 58' 40" N 53º 23' 30" W	B. Ryan F. Coates
17. Peddle's Waters	2	2	47º 20' 20" N 53º 26' 00" W	E. Conway
18. Pool's Cove Access Road (Bay d'Espoir)**	1	1	47º 42' 43" N 55º 32' 20" W	L. Kendell
19. Little River (Bay d'Espoir)**	1	1	47º 54' 32" N 55º 34' 12" W	D. Parsons

20. Stoney Ridge (Avalon Wilderness)**	**1**	**1**	**47º 10' 40" N 53º 20' 05" W**	**B. Clarke**
21. Bloody Pond (Avalon Wilderness)**	**1**	**1**	**47º 11' 25" N 53º 11' 10" W**	**B. Ryan**
22. <u>South of Clam River</u>				
-nearest Clam River	**1**	**2**	**47º 20' 15" N 53º 24' 55" W**	**M. Lawlor**
-near brook; between other two sites	**1**	**7**	**47º 20' 05" N 53º 25' 05" W**	**B. Clarke J. Sharron**
-furthest from Clam River	**1**	**4**	**47º 19' 45" N 53º 25' 15" W**	**B. Clarke J. SharroN**
22 Ripple Ridge	**38**	**199**		**E. Conway**
23. Big Wolf Pond**	**1**	**7**	**47º 23' 50" N 53º 24' 50" W**	**M. Lawlor**
24. Merasheen Island**	**1**	**2**	**47º 32' 00" N 54º 14' 30 W**	**T. St. George**
25. Fitzgerald's Pond Park	**1**	**2**	**47º 20' 30" N 53º 44' 00" W**	
26. Near Noseworthy's Gully**	**1**	**17**	**47º 21' 50" N 53º 24' 20" W**	**T. Brinston M. Lawlor**
27. East of the End of Fourth Pond Road**	**1**	**4**	**47º 21' 50" N 53º 25' 35" W**	**J. Sharron**
28. Butler's Trail, Salmonier Nature Park	**1**	**3**	**47º 15' 10" N 53º 17' 40" W**	**M. Pitcher**
29. Third Junction Pond/ Peyton's Gullies	**1**	**1**	**47º 22' 00" N 53º 19' 35" W**	**M. Pitcher**
30. Little Wolf Pond**	**2**	**2**	**47º 23' 50" N 53º 24' 25" W**	**J. Sharron**
			47º 23' 45" N 53º 24' 25" W	**J. Sharron**
31. Fourth Pond - West Side**	**5**	**2**	**47º 21' 870" N 53º 25' 190" W**	**J. Sharron S. Gullage**
		2	**47º 21' 000" N 53º 26' 000" W**	**J. Sharron S. Gullage**
		1	**47º 21' 180" N 53º 23' 660" W**	**J. Sharron S. Gullage**
		7	**47º 21' 146" N 53º 26' 701" W**	**J. Sharron S. Gullage**
		1	**47º 20' 471" N 53º 26' 540" W**	**J. Sharron S. Gullage**

32. East Markland Road**	**5**	**25 5/site**	**47º 18' 15" N 53º 30' 20" W**	**M. Lawlor F. Coates**
33. Fourth Pond - South Side**	**2**	**1 1**	**47º 20' 270" N 53º 27' 242" W 47º 20' 350" N 53º 27' 242" W**	**J. Sharron J. Sharron**
34. Peddle's Waters South**	**1**	**1**	**47º 20' 10" N 53º 25' 45" W**	**C. Purchase**
35. Salt Pit-Twin Brooks Rd. (Bay d'Espoir)**	**8**	**258**		
A.	**3**	**40**	**47º 56' 10" N 55º 42' 45" W**	**D. Parsons**
B.	**1**	**29**	**47º 56' 30" N 55º 42' 20" W**	**J. Sharron T. Brinston**
C.	**3**	**198**	**47º 56' 45" N 55º 42' 30" W**	**J. Sharron T. Brinston**
D.	**1**	**1**	**47º 56' 45" N 55º 42' 30" W**	**B. Clarke D. Parsons**
36. Round Pond West**	**1**	**5**	**47º 22' 20" N 53º 25' 55" W**	**F. Coates B. Ryan**
37. Pegs Pond (Carbonear- Line Road) **	**1**	**4**	**47º 41' 40" N 53º 20' 35" W**	**F. Coates B. Ryan**
38. Foley's Gully, Goose Steadies, Eastern Waters	**3 ?**	**30**		**E. Conway**
39. Hr. Breton Rd.**	**2**	**7**	**42º 56' N 55º 35' W**	**J. Sharron T. Brinston E. Sullivan**
40. Little River, Bay d'Espoir (Jupujikuei Park)**	**2**	**275**		
A. (North & South of culvert)	**1**	**123**	**47º 55'.538 N 55º 34'.787 W**	**T. Brinston J. Dewling**
B.	**1**	**152**	**47º 55'.340 N 55º 34'.587 W**	**J. Sharron E. Sullivan**
41. Ripple Pond**	**2**	**59**	**47º 19' .236 N 53º 28' .475 W**	**J. Sharron T.Brinston**
42. Ripple Pond**	**3**	**95**	**47º 18' .968 N 53º 28' .743 W**	**K. Tremblett H. Clarke**
43. Little River, Bay d'Espoir (Jupujikuei Park)	**1**	**107**		**W. Maass E. Conway**

44. Burgeo Road A.**	**1**	**42**	**47º 52'' .775 N 57º 42' .350 W**	**T. St.George T. Brinston**
B.	**1**	**41**	**47º 52' .890 N 57º 42' .990 W**	**B. Clarke**
C.	**1**	**3**	**47º 56' .061 N 57º 39' .550 W**	**T. St.George**
D.	**1**	**2**	**47º 46' .540 N 57º 40' .354 W**	**W. Strickland**
45. Little River, Bay d'Espoir (Jupujikuei Park) (South of culvert)**	**1**	**175**	**47º 55' .253 N 55º 34' .488 W**	**J. Sharron E. Sullivan T. Brinston F. Coates**
46. Little River, Bay d'Espoir (Jupujikuei Park) (North of culvert)**	**3**	**50**		
A.	**1**	**8**	**47º 55' .904 N 55º 35' .480 W**	**J. Sharron E. Sullivan T. Brinston F. Coates**
B.	**1**	**41**	**47º 55' .770 N 55º 35' .000 W**	
C.	**1**	**1**	**47º 55' .660 N 55º 35' .001 W**	
47. Salt Pit-Twin Brooks Rd. (Bay d'Espoir)**	**3**	**199**		
A.	**2**	**127**	**47º 56' .553 N 55º 41' .788 W**	**J. Sharron E. Sullivan T. Brinston F. Coates**
B.	**1**	**72**	**47º 56' .250 N 55º 41' .880 W**	
48. Little River (Bay d'Espoir)	**1**	**11**	**47º 55' .395 N 55º 34' .350 W**	**J. Sharron E. Sullivan**
49. Little River (Bay d'Espoir)	**1**	**2**	**47º 55' .580 N 55º 34' .210 W**	**T. Brinston F. Coates**
50. Port Saunders (Northern Penn.)	**1**	**1**	**50º 42' .691 N 57º 12' .414 W**	**J. Sharron**
51. Zinc Mine Road (Northern Penn.)	**1**	**2**	**50º 16' .348 N 57º 30' .355 W**	**M. Lawlor**
Totals	**150**	**2953**		

**** sites have not been thoroughly checked.**

Note: a) Compiled by Jon Sharron
b) Shaded cells are sites discovered by Conservation Officers of the Department of Forest Resources and Agrifoods (Forestry, Wildlife and Inland Fisheries Division) .

FIELD SURVEY METHODS AND ANALYSIS

Visits to some of best known and readily accessible sites in Central Avalon were made in early April, 1998. The chief purpose was to gain an appreciation of the complexity of landscape ecology in which forest types with *E. pedicellatum* phorophytes occur. From these basic observations a sampling program was designed. The objective being to sample as many representative sites across Newfoundland as possible including searching for new sites in regions where few, or none have been found - namely in forest pockets on the barrens along the Burgeo Highway and the heavily forested areas on the coastal plain of the Northern Peninsula.

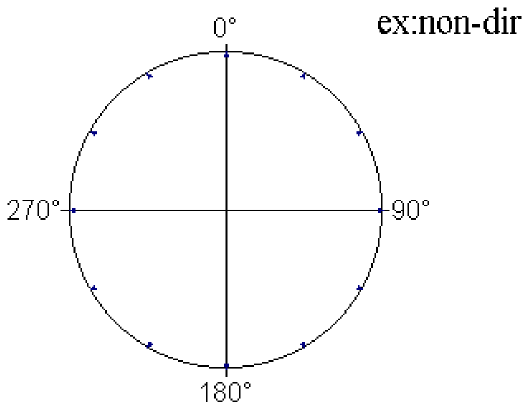
The number of sites, and plots within them, which could be measured was determined by time constraints, given that there was considerable urgency for this report. In a two-week period, 16 plots at 10 sites were measured: 1 site each on Fox Marsh and in Lockyer's Water in central Avalon, respectively; 3 sites at Salt Pit - Twin Brooks Road and 2 at Little River, near Head of Bay D' Espoir, and 3 on the coastal barrens along the Burgeo Highway.

Data collected included the standard measurements of height and diameter at breast height (dbh) and height to the base of the crown of the phorophytes. Core sample from several trees representing the range of DBH of the phorophytes were taken. General observations of site characteristics were recorded, such as forest type, degree and aspect of slope, ground cover as a soil moisture indicator, approximate stand density, percentage of crown closure and standing dead, extent of regeneration or wind throw within the stand and the general area, compass direction of each lichen on it's phorophyte (host tree), evidence of past and recent cutting and nearby human influences. The compass bearing of each thalli was measured, and the preferential orientation of plots with phorophytes was noted in relation to adjacent stands and landscape features. Ariel photos were used to assess general landscape patterning and extent of human and natural disturbance processes.

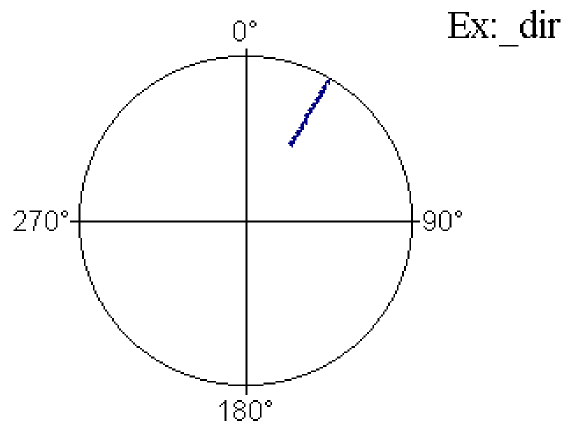
Basic analyses of phorophyte statistics included their average height, dbh, approximate stand density and age class. Specialized circular statistical analysis of the directional statistics of thalli included total number of thalli in plot, mean vector, length of mean vector (angular deviation, standard error of mean vector and the 95% confidence interval). For simplicity, two circular statistical graphs summarise the directional statistics. One shows the angular distribution (compass of the bearing) of each thalli plotted on a circle; the mean vector (average direction); and the length of mean vector (the fraction of the distance from the centre to circle which is a measure of the strength directionality (values lie within the range 0.00 at the centre (points evenly distributed on the circle) to 1.00 (all points at the same angle). The other diagram is a rose diagram showing the frequency of thalli within 10° widths (though somewhat redundant, the rose diagram gives a better graphical appreciation of the general compass bearing of thalli). Figure (2) gives examples on how to interpret the circular statistical graphs.

Figure 2. CIRCULAR STATISTICAL GRAPH

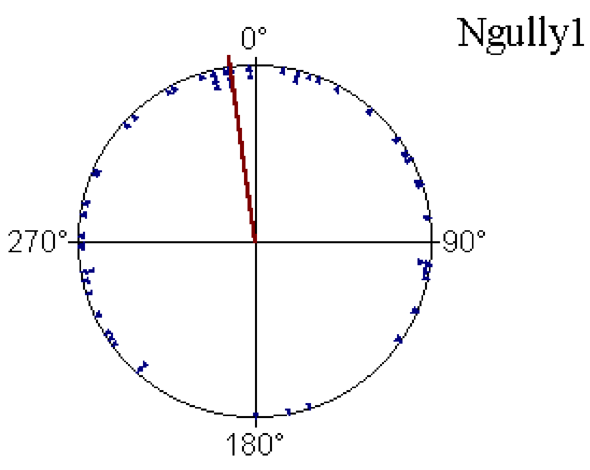
The series of graphs briefly demonstrate how to interpret a circular statistical graph. For simplicity, all statistical variables have been excluded from the graph except the line representing the mean vector. The mean vector, which helps to show if the thalli have a preferential direction, is statistically equivalent to the mean or average in standard statistics. The mean vector has a value ranging from 0.00 (i.e, in the centre of the circle (meaning that thalli have no preferential direction at all) to 1.00 (i.e., on the circle (meaning that thalli have only one angle of direction). In nature, depending on the number of thalli (points on a circle) the mean vector is usually in the range of 0.20 (not statistically significant) to 0.55 (a moderately strong directional bias).



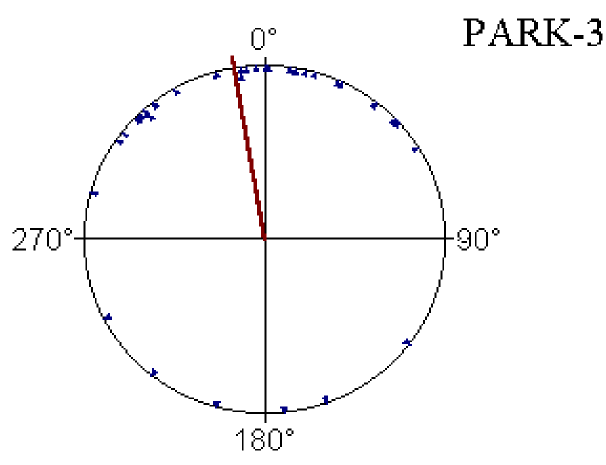
1. When mean vector = 0.00; the 12 points on the circle are equally spaced and have no directionality



2. When mean vector = 1.00; the 12 point on the circle are all at the same angle and, therefore, directional.



3. When mean vector = 0.25,; the points on the circle are not significantly directional; i.e., the thalli in site 4, plot at Noseworthy's Gully have no preferential direction on the phorophytes although the mean direction (352°) indicates a slight northerly bias.



4. When mean vector = 0.54; the points on the circle a significantly directional, i.e., the thalli in site 45, plot 1 at Little River have a definite preferential direction on the phorophytes and the mean direction (350°) indicates definite northerly bias.

SUMMARIES OF SURVEY RESULTS AND OBSERVATIONS OF SITES

Location maps, notes and statistical summaries of the 16 plots at 10 sites sampled across southern Newfoundland, where *E. pedicellatum* is most prevalent so far as we know, are given below. In some cases, the notes are accompanied by photographs with explanatory captions to give the reader a better sense of the sites.

All the sites generally have the following in common:

- stands with phorophytes have low productivity; except plot 1 in at site 47b which barely meets a definition of merchantability (i.e., 60 m^3 ha^{-1}).

- all sites occur as small patches in landscapes characterized by mosaics of forest ecosystems that have a long history of low impact logging, usually selective cutting larger diameters for sawlogs.

- phorophytes are generally in the mid- to smaller- dbh range, except the Burgeo Road sites where average dbh is in the range of 15 cm.

- most stands with phorophytes tend be non-commercial stands of small stature, apart from scattered sub-population of slightly larger (non-thalli bearing) trees that may be occasionally high-graded or the first to die off and be wind-thrown.

- the phorophyte stands are mostly in the 55-70 year age class that are characteristicly mature to decadent stands in the final stages of self-thinning with 20-30% standing dead (which are often colonized by *E. pedicellatum*), and usually a completely moss-covered forest floor.

- phorophytes are mostly bands of quasi-edge trees, benefitting from substantial diffuse light regimes of blow downs, edges of wave forests, bogs and cutovers.

- the angular distribution (compass bearing) of thalli has a northerly mean vector; however the strength of directionality is influenced by the phorophyte proximity to gaps and degree of crown cover; i.e., phorophytes are most often aligned as a band of inner edge trees around gaps, clearings (with advance fir regeneration) and, in one case, facing a bog and highway.

- most sites are readily accessible along trails, forest access roads and principle highways.

- several sites are near old cabins with wood and/or oil-burning stoves and old sawmills; the Little River sites are within Jipujijkuei Kuespem park boundaries having no effect on the epiphytic lichen population judging from the size, health, reproduction and extent of one of the largest colonies of *E. pedicellatum*.

Sites in the three principle areas sampled have somewhat unique characteristics. The following is a brief note on some differences.

Head of Bay D' Espoir

The productive forests of the Salt Pit-Twin Brooks Road has been long been a prime area for sawlogs. And contains the only plot (site 47b, plot 1) which meets the designation of a commercial stand. As the photo shows it is a short surviving strip (10 m long by 3 m wide) sandwiched between two wind thrown gaps about 15 m diameter. It is a moderately dry, typically Hylocomnium-balsam fir forest type. Most of the thalli are exposed to full sunlight for most of the morning and drying winds waft in from the patches. The fact, that the site has far from stable humidity is indirectly indicated by the large differences in the bark temperature on the shaded and sunny side of *E. pedicellatum* phorophytes (thalli-bearing trees) during a minute of observations when the ambient air temperature was -1°C (Table 2)

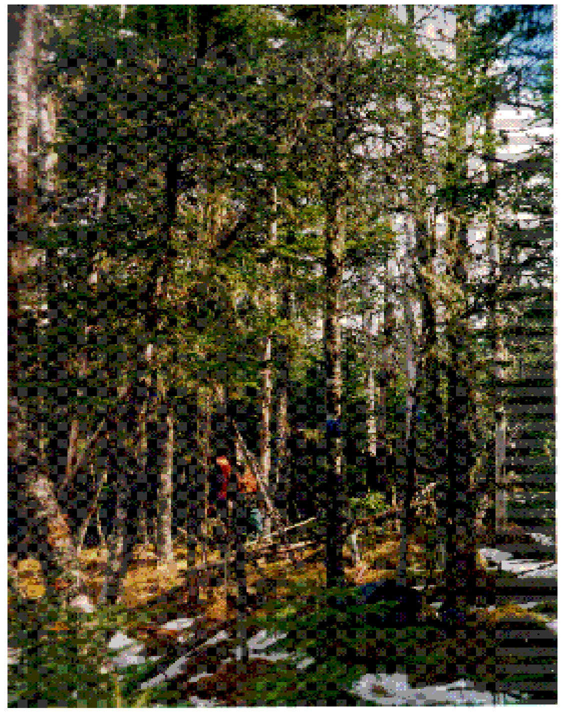


Figure 3. Site 47b, plot 1: a narrow plot sandwiched between wind throw gaps and having larger than usual phorophytes.

Table 2: Skin temperature of the bark on the shaded vs sunny side of an *E. pedicellatum* phorophyte measured with an Omegascope infrared temperature sensor when the abient temperature was -1°C

Shade (°C)	Sunny (°C)	Difference (°C)	Sky Conditions
1.6	9.7	8.1	Very thin veil of clouds
1.4	11.5	10.1	Clear
2.6	6.3	3.7	Thin veil of clouds
1.8	7.5	5.7	Thin veil of clouds
4.3	7.1	2.8	Thin veil of clouds
1.9	11.9	10	clear

The Salt Pit- Twin Brooks Road also has the only known commercially-thinned stand, on a terrace between the river and the road. No doubt the thalli are remnants of a colony prior to thinning. The thalli are very healthy and show signs of juvenility (i.e., if size is an indication of age). The thinned stands have a very low density and the crowns are far healthier and extend as low as 1.7 m above the ground.

Burgeo Barrens

The three sites within 100 m of the highway, are on seepage slopes below escarpments with a south aspect. Top Pond River and the highway separates sites 44a and 44b. Considering the highway up through a pass to a higher level of the barrens, and judging from the height of road bank, its construction was obviously involved major engineering that required several years work with heavy diesel-fulled tandem trucks. In addition, the present helicopter refuelling station and outfitter's hunting lodge within a 50 metres of the site was formerly a construction camp or depot. Despite the human influences these would engender, they have had very little effect on the forest on either side of the road and thalli, among the largest and healthiest ever found, are thriving.

Peters Woods (site 44d), 17 km south of 44a&b is very similar in that it has the same kind of forest on a seepage slope at the base of an escarpment and has a south aspect. But the phorophytes are virtually isolated decadent trees in a patch cut about 1978 with dense fir regeneration. The site was discovered on April 15, 1998 by Ward Strickland, the day before our survey team visited the site. So Mr. Strickland has not had time to search the vicinity thoroughly. On the most isolated tree, one thalli is huge by normal standards. It is about 20% larger than the one shown in the adjacent photograph. From the site which rises well above the coastal barrens there one gets an uninterrupted view with a span of 180° of the ocean beyond the barrens. The site is close to the cabin and highway and up-wind of them. This site says a lot about the durability and longevity of fully exposed *E. pedicellatum* in an area notable for its harsh and unforgiving climate and weather.

Figure 4. Conservation officer Tom Brinston shows off a magnificent specimen of ***E. pedicellatum*** (above index finger)) on an unusually large phorophyte beside Top Pond Brook, Burgeo barrens.

Central Avalon

The vegetation of central Avalon is one of the most dynamically complex and biodiverse in the circumpolar boreal biome. Even without human influences, the rate of structural and spatial changes in forested landscape ecology is fast compared to continental varieties of forest. The dominant forest type of even-aged mosaics of balsam fir give a hint of recurring major disturbances. On the Avalon balsam fir stands are relatively short-live: a decadent 'old-growth' stands on the verge of collapsing, with a lot of help from weather events

(strong winds, freezing rain, etc.), for example, has an age class in the range of a human life-span (i.e., 65-80 years old). Of course, in less windy climates, like Roddickton and along the Humber River, mature balsam fir stands are well over 100 years old on average. Of course, pristine as the central Avalon forest may seem to many, there are few, if any pockets of forests which haven't been affected by European settlers and perhaps, before them, aboriginals in one way or another . Figures 5 shows the extraordinary complex landscapes of parts of the areas most *E. pedicellatum* sites have been found so far.

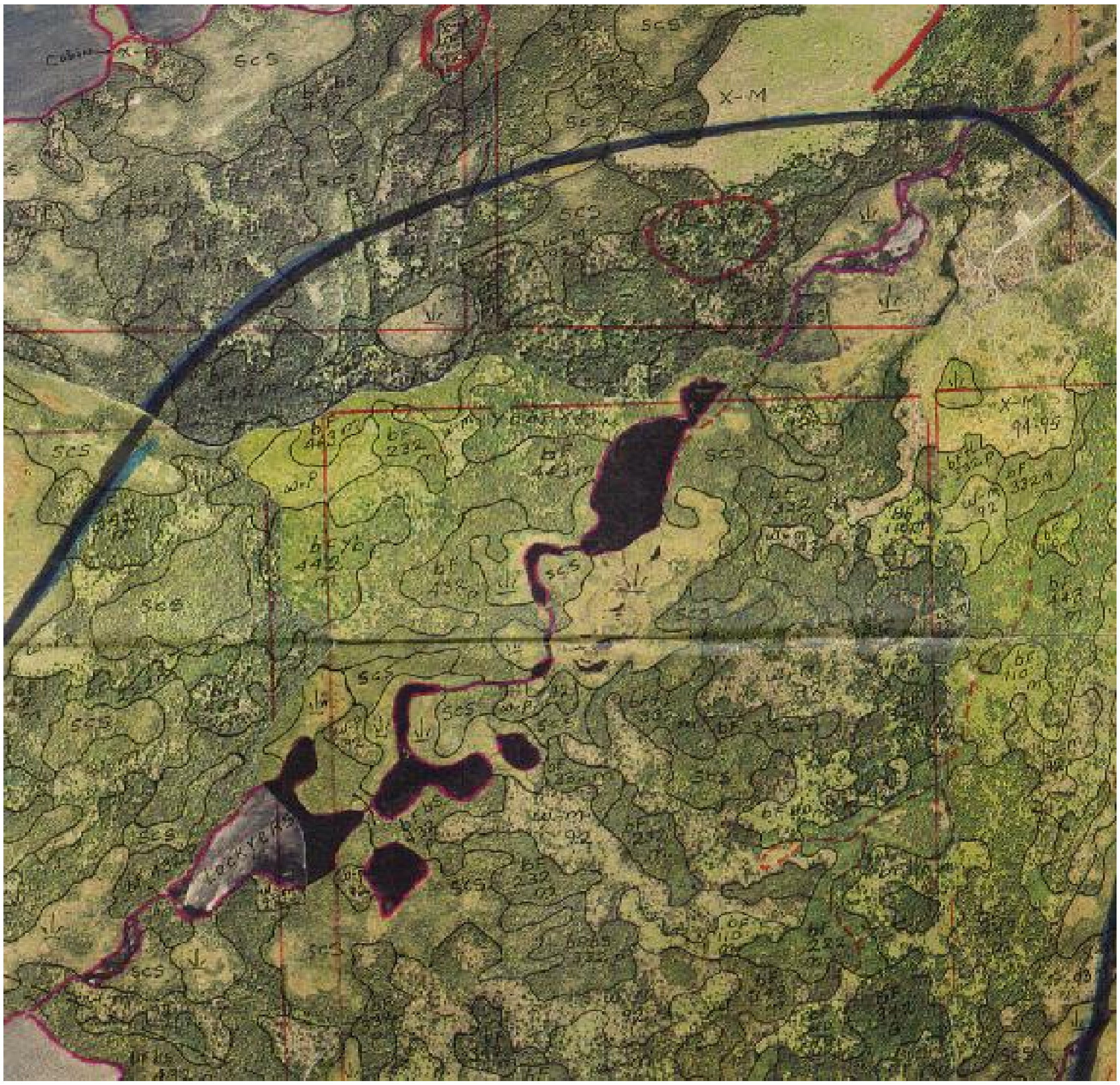


Figure 5. Air photo mosaic of Lockyer's Water in the vicinity of Muddy Gullies showing the very dynamic and complex landscape ecology in response to numerous natural disturbances (i.e., wind, freezing rain, insect infestations, animals (notably moose browsing and beaver dams) and human activities (patch and selective cutting, hunting, ATV and logging trails, cabins and small sawmills).

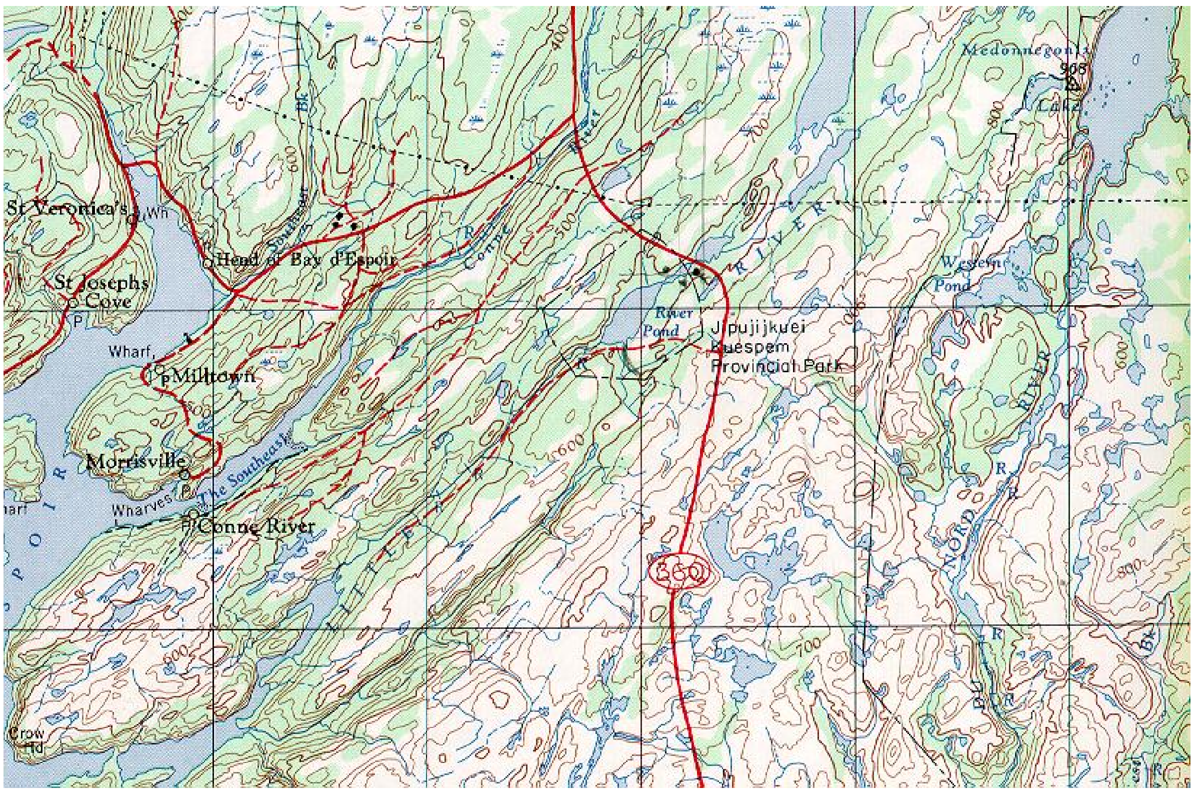
Some sites are beside traditional waterways used for transporting logs to sawmills near the coast and railway line (such as the large water-powered sawmill at Avondale which operated for most of this century until 1971). These replaced earlier sawmills on or near it which operated in the last century. Since the 1950's logging roads gradually replaced the waterways for transporting logs, and small diesel-powered sawmills have for many years operated about 200-300 m from some of the *E. pedicellatum* sites. In one of the large wind-throw areas there is an old hunting cabin with a wood-burning stove very close to some of the plots, which has apparently done no harm to the thalli since they are thriving. The timber lands on Fox Marsh (figure 6) have a similarly complex forest landscape with frequent and often intense natural and human disturbances and which has long been a source of timber for early mills at Colinet, Mahers, Ocean Pond and the modern sawmills on the Avalon.

Figure 6. Air photo mosaic of Fox Marsh, a traditional logging area for well over a century showing main traditional waterways for transporting logs which were replaced by logging trails in the latter part of this century. The very dynamic and complex landscape ecology is in response to much the same natural disturbance factors and human activities as in the Lockyer's Water area.

SUMMARY NOTES AND STATISTICS

FOR

HEAD OF BAY D' ESPOIR

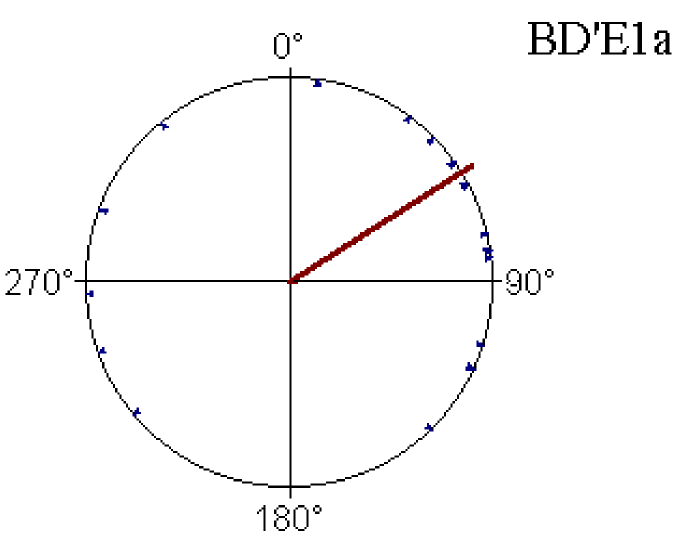


Site 47b:Plot 2:Head of Bay D'Espoir, Salt Pit - Twin Brooks Road.
Map Coordinates: 47°56'45"N; 55°42'30

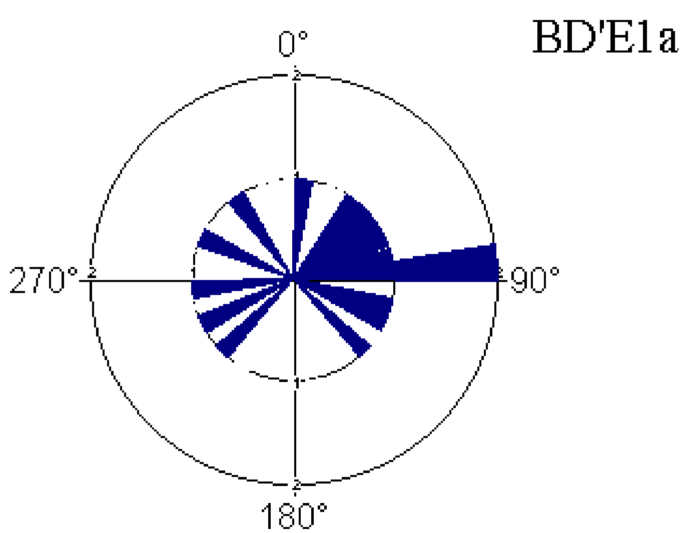
Located uplsope close to a black spruce fen and about 200-250 m west of the Bay D' Espoir Highway. Open stand of Hylocomnium-Balsam fir forest in late stages of self thinning (≈ 20% standing dead), partially wind thrown and thick moss-covered wind throw. The stand is short, narrow strip (5 x 20 m) sandwiched between two 15 m-diameter wind throw gaps. Large yellow birch are scattered throughout at a density of ≈ 100 stems ha^{-1}. Selective cutting is evident by old moss-covered sawn stumps.

Site 47b: Plot 1.

Phorophyte Statistics	
Number of phorophytes	**11**
Av. height (Standard deviation) of phorophytes	**9.8(±1.3)**
Av. DBH (standard deviation) of phorophytes	**11.34(±2.9)**
Approximate stand density	**5-6,000 stems/ha**
Age class of core samples	**65-70 years**
Directional Statistics of Thalli	
Total number of thalli	**16**
Mean vector	**58°**
Length of mean vector	**0.32**
Angular deviation	**86 °**
Standard error of mean vector (±)	**31°**
95% Confidence interval (-/+)	**358 °/117 °**



Angular distribution and mean vector of *E. pedicellatum*



Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

Figure 7. Site 47b, plot 1 with a small group of phorophytes in decadent stand sandwiched between wind-thrown gaps. Within less than a decade these trees will also be wind-thrown.

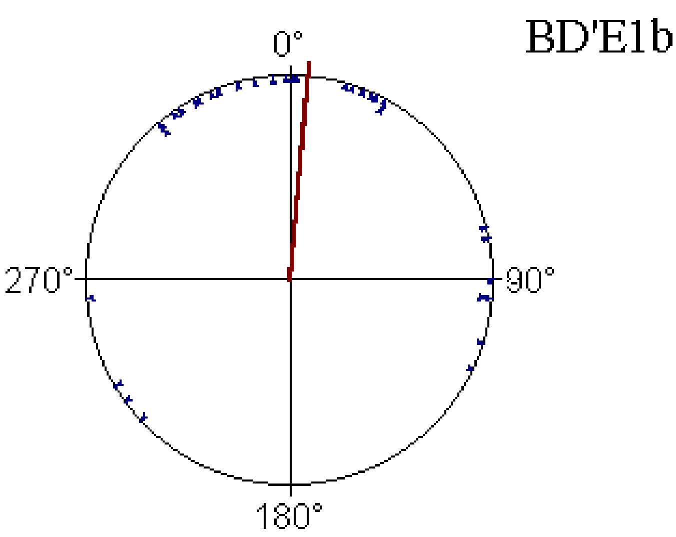
Figure 8. Site 47b, plot 1.A closer view of the site merging into a denser and less productive stand in which plot 2 is located. Note the high percentage of standing dead and both recent and old wind-thrown trees.

Site 47b:Plot 2:Head of Bay D'Espoir, Salt Pit - Twin Brooks Road.
Map Coordinates: 47°56'45"N; 55°42'30"W

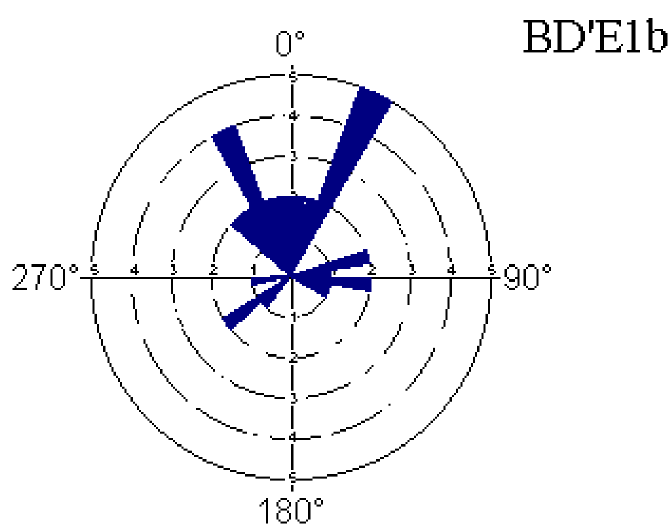
Adjacent to Site 1a. Similar in all respects but denser stand with smaller trees and greater crown closure and slightly earlier stage of self-thinnning. Thalli-bearing trees about 20 meters from plot 1, and confined mainly to a narrow strip of edge trees around the south side of a small gap (≈15m diameter) of standing dead and wind-blown fir and a few remnant yellow birch.

Site

Phyrophyte Statistics	
Number of phorophytes	**10**
Av. height (standard deviation) of phorophytes	**9.4(±3.8) m**
Av. DBH (standard deviation) of phorophytes	**9.5(±2.9) cm**
Approximate stand density	**8,000 stems/ha**
Age class of core samples	**60-65 years**
Directional Statistics of Thalli	
Total number of thalli	**32**
Mean vector	**5°**
Length of mean vector	**0.53**
Angular deviation	**65°**
Standard error of mean (±)	**12°**
95% Confidence interval (-/+)	**341°/30°**



Angular distribution and mean vector of *E. pedicellatum*



Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

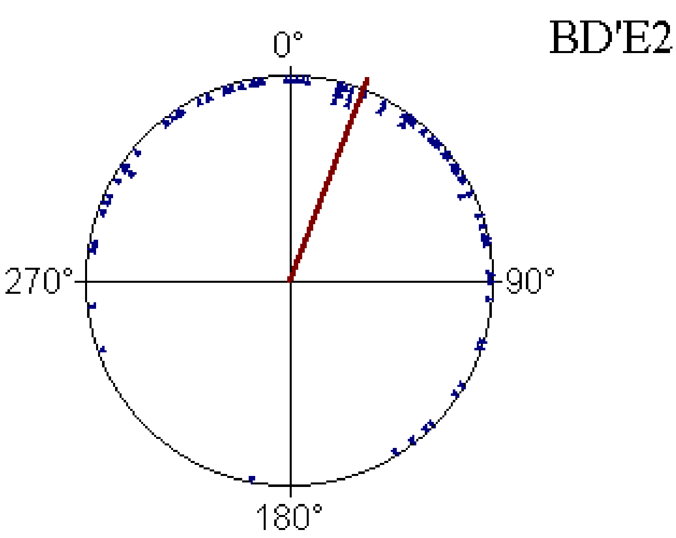
Figure 9. Site 47b, plot2. View from the strip of phorophyte edge trees around a wind throw gap with a large remnant yellow birch.

Site 35: Head of Bay D'Espoir, Salt Pit - Twin Brooks Road.
Map Coordinates: 47°56'45"N; 55°42'30"W

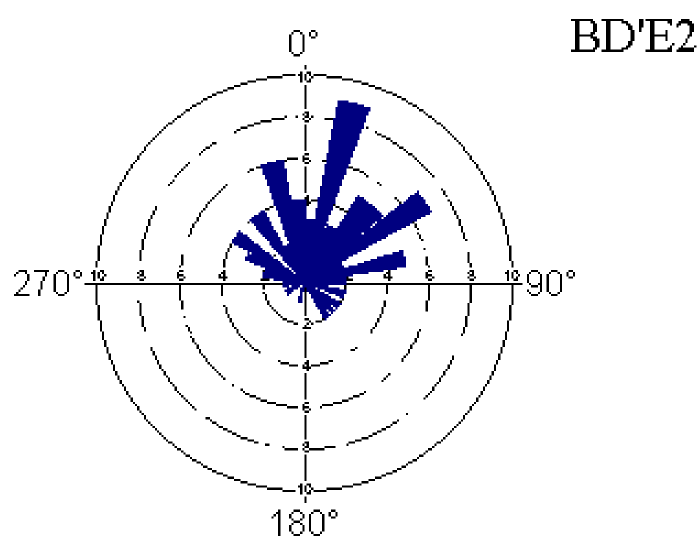
Thalli confined to a 10-15 m wide strip of edge trees along a slow moving wave forest on terrace 20 m above river. Mainly Hylocomium-Balsam fir forest type with virtually no regeneration in the understory. A few standing dead trees, well-rotted windthrow and sporadic cutting evident within the stand. Some thalli-bearing trees exposed to full sunlight in the afternoon.

Site 35

Phorophyte Statistics	
Number of phorophytes	38
Av. height (standard deviation) of phorophytes	9 m
Av. DBH (standard deviation) of phorophytes	6.7 cm(± 2.6)
Approximate stand density	4-5,000 stems/ha
Age class of core samples	65-70 years
Directional Statistics of Thalli	
Total number of thalli	79
Mean vector	21°
Length of mean vector	0.56
Angular deviation	62°
Standard error of mean vector (±)	7°
95% Confidence interval (-/+)	7 °/36°



Angular distribution and mean vector of *E. pedicellatum*



Rose diagram (10°widths) of the angular distribution of *E. pedicellatum*

Figure 10. Site 35. *E. pedicellatum* phorophytes on the edge of a wave forest located on a terrace above the river (about 40-50 due west (off to right in the photograph). The dieback front has a westerly aspectThe phorophyte are in a narrow, 10 m wide and 100 m long strip with a north-sout orientation located between two regenereating phase, the west side of which is aslowly advancing wave forest front (right half of photo). There is very little regeneration within the phorophyte stands.

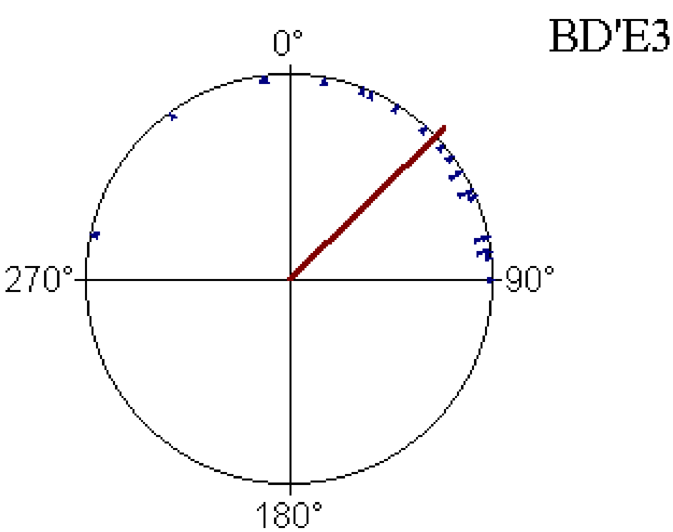
Figure 11.An example of a healthy, beautiful thalli on an outside edge tree along a wave forest front in site 35.

Site 35a: Head of Bay D'Espoir, Salt Pit - Twin Brooks Road.
Map Coordinates: 47°56'10"N; 55°42'45"W

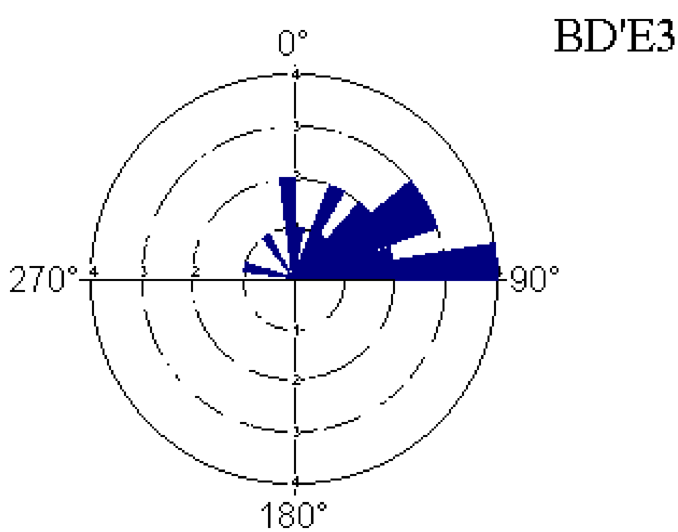
A recently thinned stand extending from forest access road to river. Mostly Hylocomium-Balsam fir forest type with remnants of 'old-growth' yellow birch and black spruce. Thalli are probably residual but, if size is an indicator of age, then the presence of very small thalli suggest that E.pedicellatum is on the increase. The density of thalli-bearing tree stands mimics the last stages of self-thinning, except that the crowns are fuller, healthier and crown base is lower than in unthinned stands of the same age class. Over-all the forest is quite patchy with stem density as low 500 stems/ha and fairly dense regeneration in small openings.

Site 35a

Phorophyte Statistics	
Number of phorophytes	**10**
Av. height (standard deviation) of phorophytes	**8 m**
Av. DBH (standard deviation) of phorophytes	**11.4(±3.3) cm**
Approximate stand density	**5,000 stems/ha**
Age class of core samples	**65-70 years**
Directional Statistics of Thalli	
Total number of thalli	**22**
Mean vector	**46°**
Length of mean vector	**0.77**
Angular deviation	**41°**
Standard error of mean vector (±)	**9°**
95% Confidence interval (-/+)	**29°/63°**



Angular distribution and mean vector of *E. pedicellatum*



Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

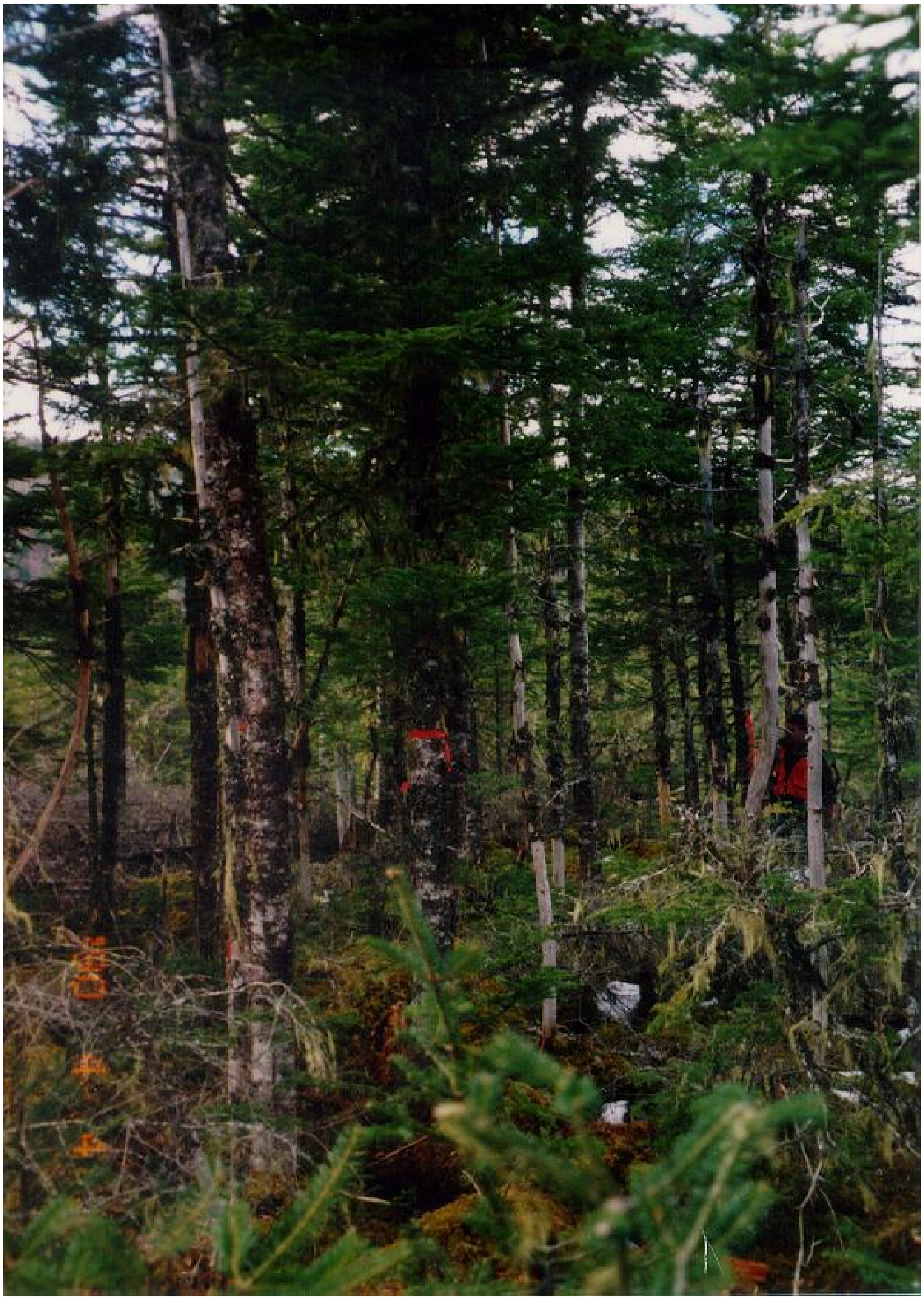


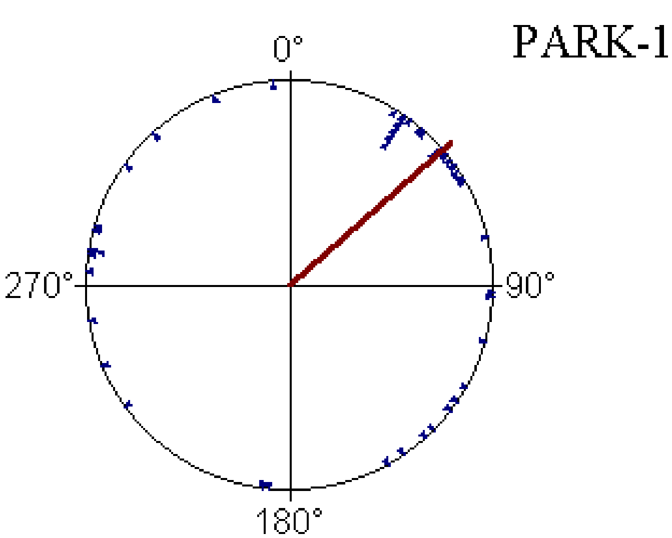
Figure 12. Site 35a. A pre-commercially thinned stand with several phorophytes. The trees are in the 65-70 age class. Judging from their size and condition, thalli are rejuvenating.

Site 40b, Plot 1. Little River, Jipujijkuei Kuespem Park
Map Coordinates: 47°55'34"N; 55°34'59"W

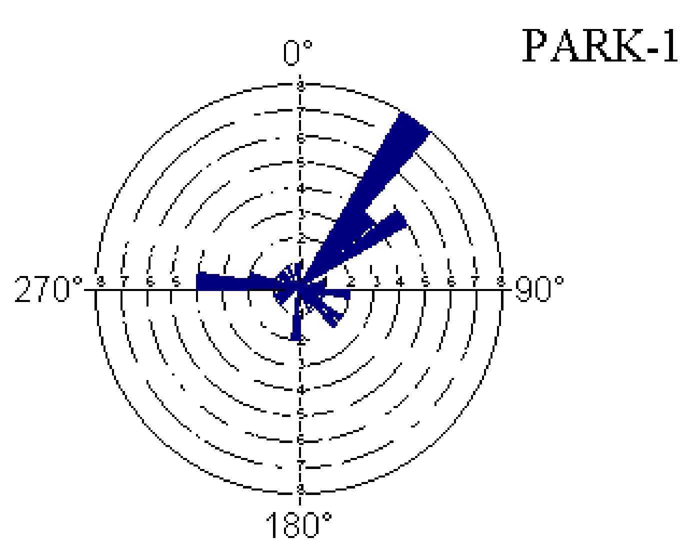
A small statured mainly Hylocomium-Balsam fir stand on flat terrain. Thalli restricted to a 10-15m strip of trees between the edge of a wave forest (with standing dead mature trees and dense 1-2 m tall fir regeneration) on the west side and 3 m tall fir regeneration on the east side. Some moss-covered windthrow on the floor, mostly well-rotted and evidence of sporadic selective cutting. The variable mosiac and short stature of the stand appears to result from high-grading.

Site 40b, Plot 1.

Phorophyte Statistics	
Number of phorophytes	**19**
Av. height (standard deviation) of phorophytes	**4.9(±1.9)**
Av. DBH (atandard deviation) of phorophytes	**6.7(±2.1)**
Approximate stand density	**6-7,000stems/ha**
Age class of core samples	**55-60years**
Directional Statistics of Thalli	
Total number of thalli	**43**
Mean vector	**49°**
Length of mean vector	**0.3**
Angular deviation	**89°**
Standard error of mean vector (±)	**20°**
95% Confidence interval (-/+)	**9°/89°**



Angular distribution and mean vector of *E. pedicellatum*



Rose diagram (10° widths) of angular distribution of *E. pedicellatum*

Figure 13. Site 40b, plot 1. Phorophytes (blue ribbons) in stand of edge trees along a wave forest front. Note that regeneration is not within the phorophyte stand.

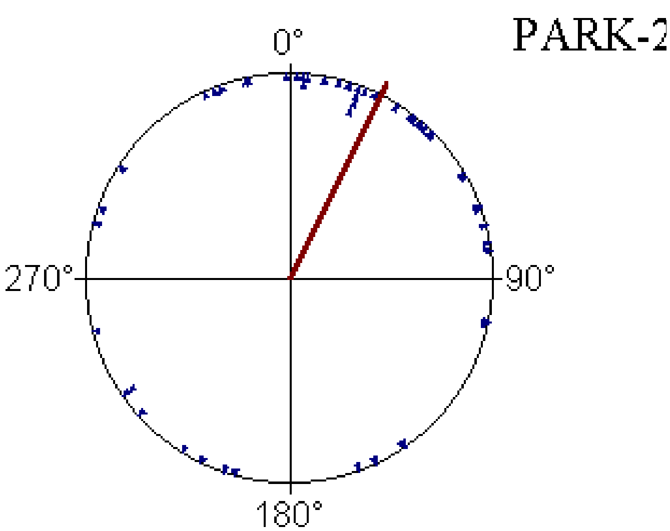
Figure 14. A broader view of the same plot, note the high pecentage of dead trees and wind throw penetrating into the stand but regeneration is restricted to the outside edge.

Site 40b, Plot 2. Little River, Jipujijkuei Kuespem Park
Map Coordinates: 47°55'34"N; 55°34'59

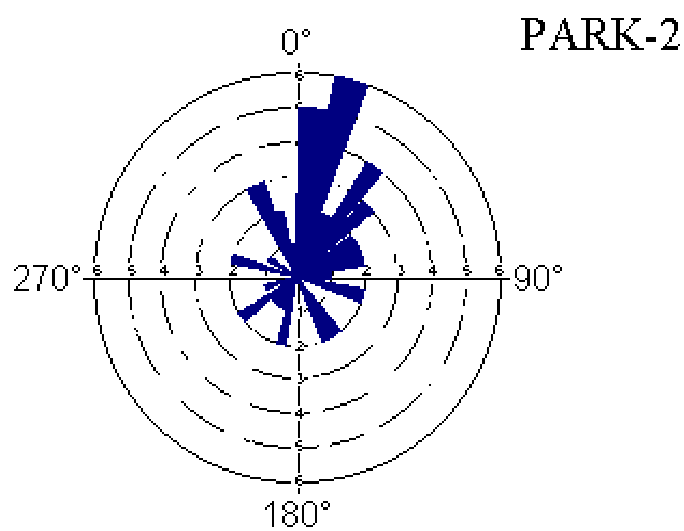
An unusual site where thalli-bearing trees are restricted to a northeast-facing outermost edge along a bog and about 15 meters from the highway. The stand gets full sunlight for most of the morning hours. The interior of the stand is not quite at the final phase of self thinning with about 25% standing dead. The stand edge is abrupt while the bog edge has short, scattered tamarack and black spruce. The elevation of the highway is more or less above the height of the stand signifying a great deal of heavy deisel machinery construction work.

Site 40b, Plot 2.

Phorophyte Statistics	
Number of phorophytes	**18**
Av. height (standard deviation) of phorophytes	**4(±1.2)**
Av. DBH (standard deviation) of phorophytes	**5.5(± 1.8)**
Approximate stand density	**8,500 stems/ha**
Age class of core samples	**55-60 years**
Directional Statistics of Thalli	
Total number of thalli	**50**
Mean vector	**27°**
Length of mean vector	**0.39**
Angular deviation	**79°**
Standard deviation of mean (-/+)	**14°**
95% Confidence interval (-/+)	**359°/54°**



Angular distribution and mean vector of *E. pedicellatum*



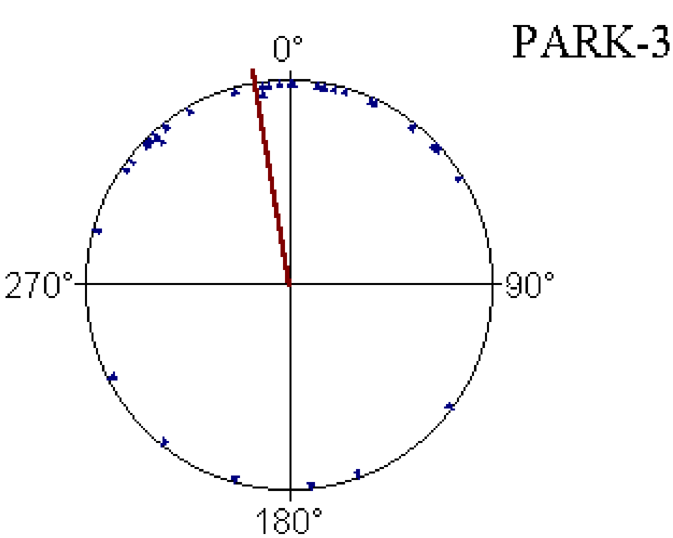
Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

Figure 15. Site 40b, plot 2 at Little River. Phorophytes are located on the outermost edge trees facing eastward across a sparsely treed bog bounded by the Hermitage - Harbour Breton Highway about 15 m from the stand.

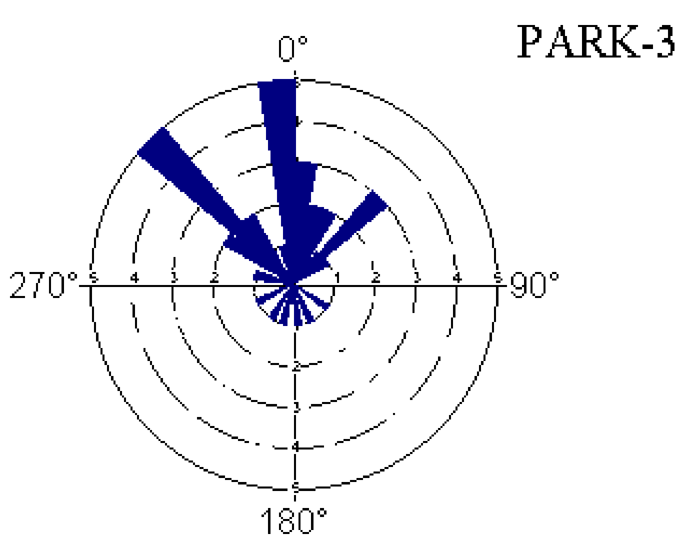
Site 45, Plot 1. Little River, Jipujijkuei Kuespem Park
Map Coordinates: 47°55'25"N; 55°34'49"W.

This site is the southern part of a narrow strip (≤5 m wide) of somewhat disjunct thalli-bearing plots 1,2&3 that make up site 45. The strip is oriented roughly southeast from starting about 25 m from middle of the east side of the pond extending south of the highway. It is more or less an even-aged stand of small stature with a sub-population of taller (8-10 m) slightly older age class of balsam fir and black-spruce trees and standing dead throughout. The site is almost flat dominated by balsam fir stands that are not quite in the final stages of self-thinning, i.e.with a nearly closed canopy and about 25% standing dead. Some wind throw on the ground and selective cutting of larger trees. The thalli-bearing trees are generally in a narrow band of edge trees with higher light levels adjacent to a Carex-Sphagnum site with scattered standing dead and live trees (≈8-10 m tall) and dense, 1-2 m tall regeneration (mainly balsam fir and some black spruce).

Phorophyte Statistics	
Number of phorophytes	**16**
Av. height (standard deviation) of phorophytes	**5(±2.5)**
Av. DBH (standard deviation) of phorophytes	**6.4(±3)**
Approximate stand density	**8-9,000 stems/ha**
Average age of core samples	**55-60 years**
Directional Statistics of Thalli	
Total number of thalli	**34**
Mean vector	**350°**
Length of mean vector	**0.54**
Angular deviation	**64°**
Standard deviation of mean (-/+)	**12°**
95% Confidence interval (-/+)	**327°/13°**



Angular distribution and mean vector of *E. pedicellatum*



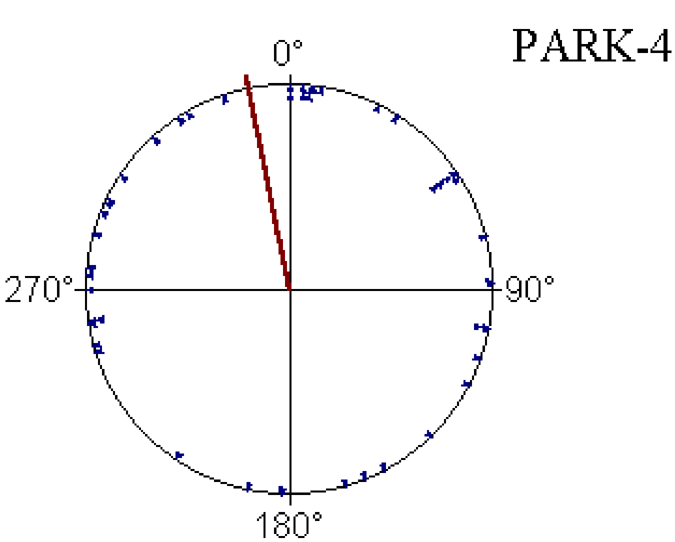
Rose diagram (10° widths of the angular distribution of *E. pedicellatum*

Site 45, Plot 2. Little River, Jipujijkuei Kuespem Park
Map Coordinates: 47°55'25"N; 55°34"49"W.

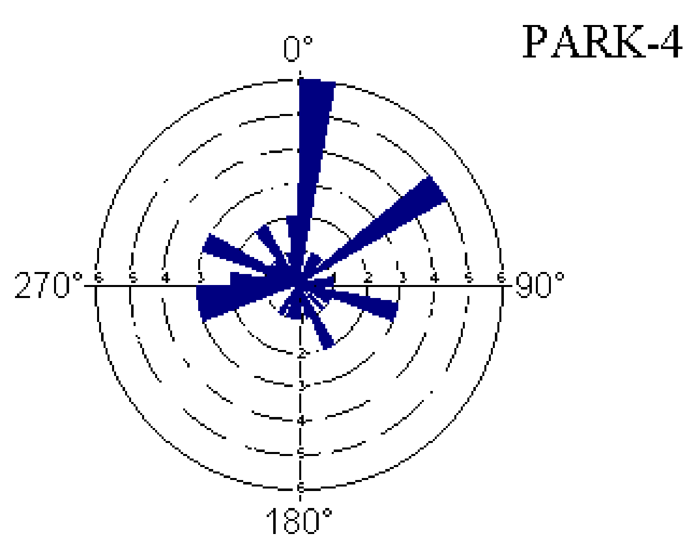
Similar in many respects to plot 1 insofar as the stand is contiguous and adjacent to 1-2 m fir regeneration and scattered standing dead trees and live 10 m tall black spruce and frequent selective cutting. However, the stand is more circular
and not as dense as plot 1. In a denser part of the plot, a small, virtually dead tree (2 m tall and 4.0 cm DBH) has at least 5 thalli on its trunk and 11 on its branches.

Site 45, Plot 2

Phorophyte Statistics	
Number of phorophytes	**20**
Av. height (standard deviation) of phorophytes	**3.6(±2)**
Av. DBH (standard deviation) of phorophytes	**5(±2.3)**
Approximate stand density	**7,000 stems/ha**
Age class of core samples	**55-60 years**
Directional Statistics of Thalli	
Total number of thalli	**45**
Mean vector	**349°**
Length of mean vector	**0.22**
Angular deviation	**99°**
Standard deviation of mean (-/+)	**26°**
95% Confidence interval (-/+)	**297°/41°**



Angular distribution and mean vector of *E. pedicellatum*



Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

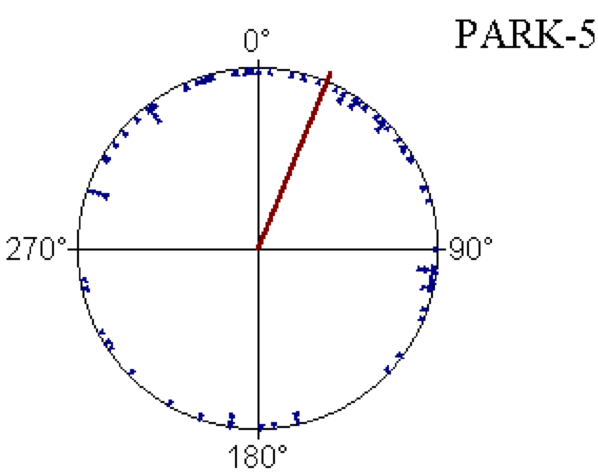
Figure 16 Site 45, plot 2. A small phorophyte with at least 5 thalli on its bole, and 11 on its branches (orange tags mark the approximate location of thalli on the tree. Note that phorophyte is an edge tree roughly 2 m from a gap with dense balsam fir regeneration.

Site 45, Plot 3. Little River, Jipujijkuei Kuespem Park
Map Coordinates: 47°55'25"N; 55°34'49"W.

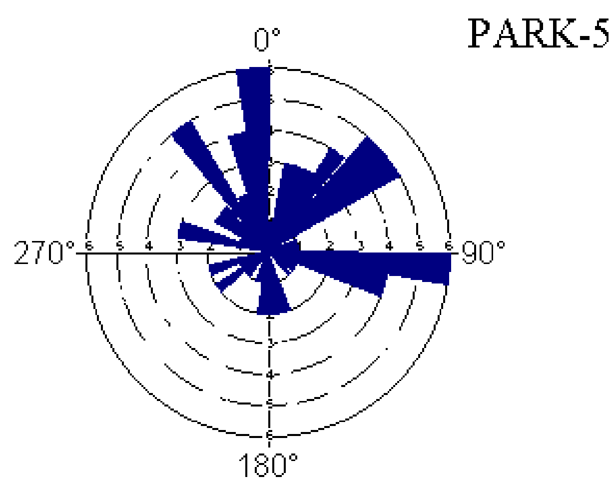
The third and final section of Site 45. The 40° difference in the mean vector is indicative of the slight eastward curvature of the stand edge following the pattern of regeneration and, hence, light regimes conducive to thalli. On the whole, the thalli-bearing sections of the stand appear to be a little less dense (i.e., a slighly more advanced stage of self-thinning).

Site 45, Plot 3.

Phorophyte Statistics	
Number of phorophytes	**47**
Av. height (standard deviation) of phorophytes	**5(±2)**
Av. DBH (standard deviation) of phorophytes	**5.3(±2.6)**
Approximate stand density	**7,000stems/ha**
Age class of core samples	**55-60 years**
Directional Statistics of Thalli	
Total number of thalli	**76**
Mean vector	**23°**
Length of mean vector	**0.32**
Angular deviation	**86°**
Standard deviation of mean (-/+)	**14°**
95% Confidence interval (-/+)	**355°/50°**



Angular distribution and mean vector of *E. pedicellatum*

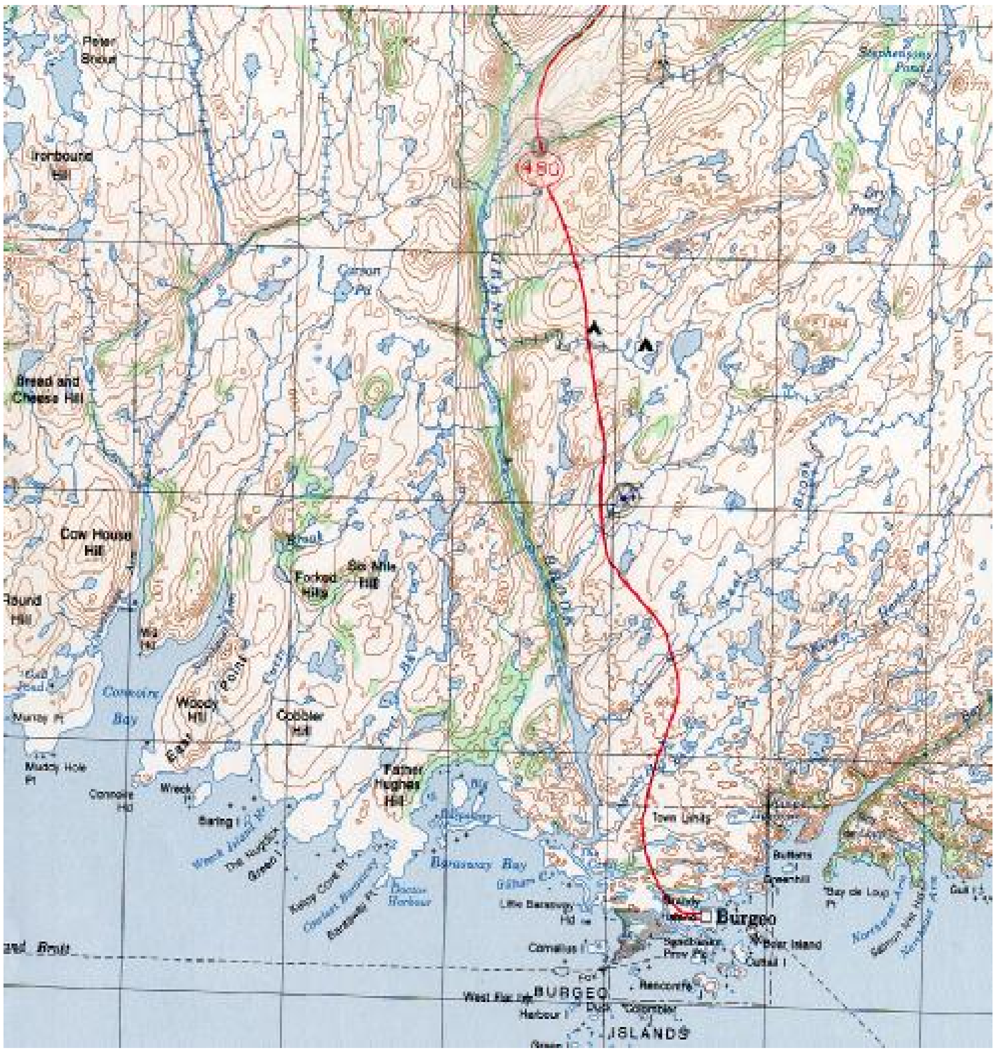


Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

SUMMARY NOTES AND STATISTICS

FOR

BURGEO BARRENS



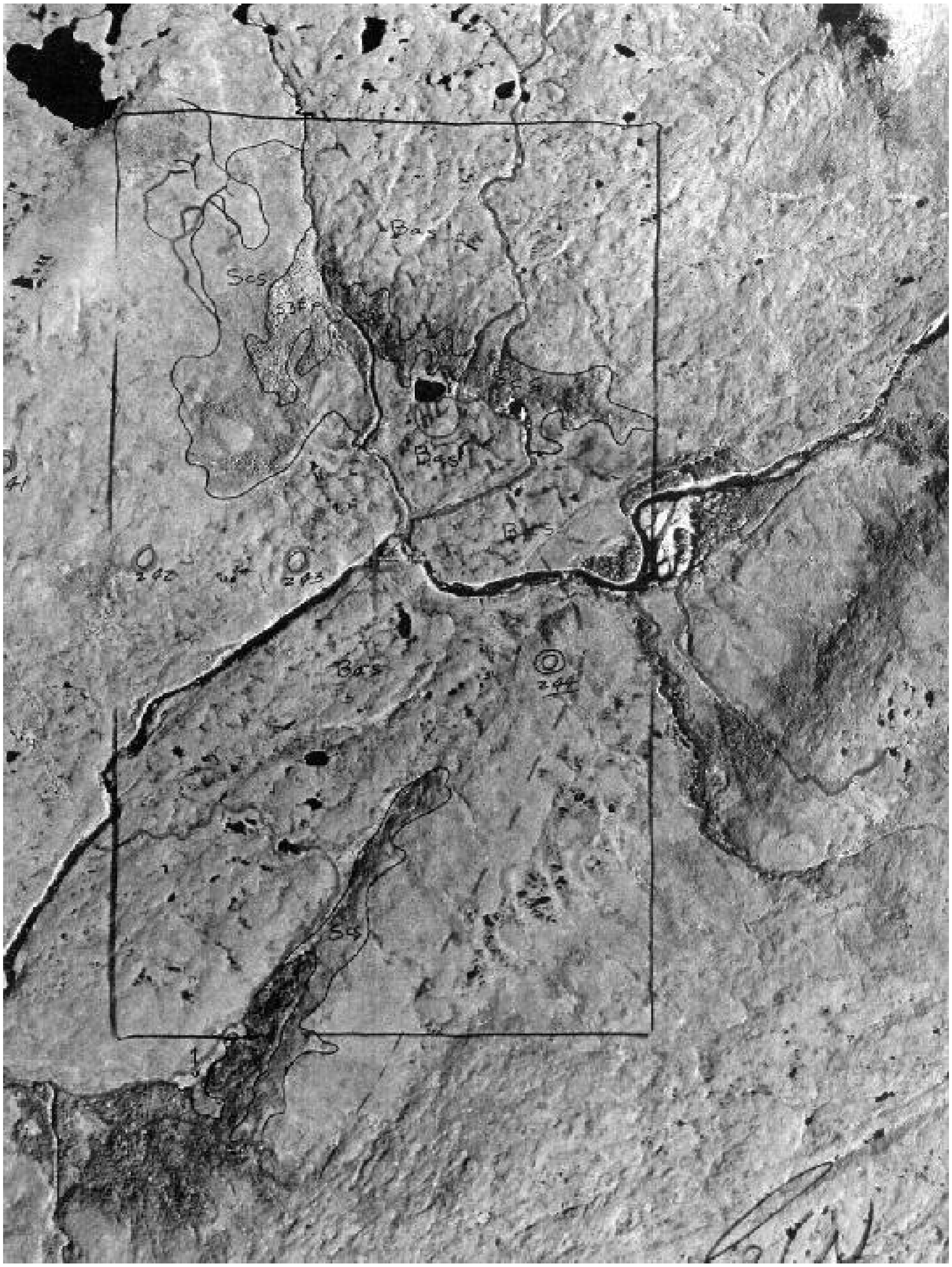


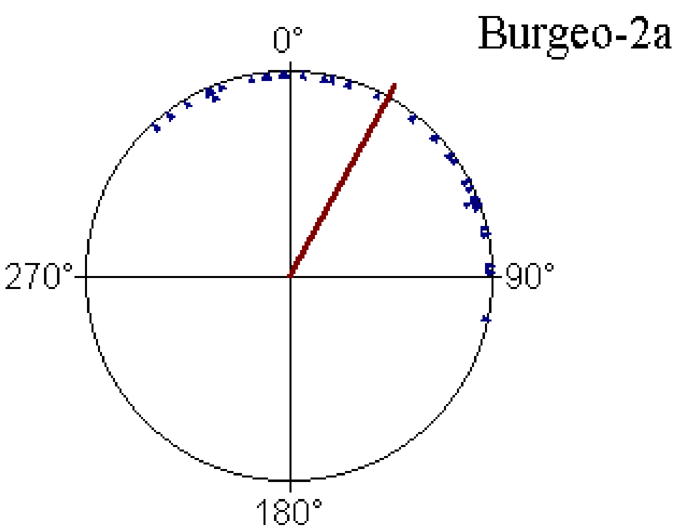
Figure 17. Air photo of the Burgeo barrens taken before the highway was built. The dashed pencil line marks the route of the highway. Sites 44a and 44b are located on either side of the highway, respectively, where it passes over the escarpment beside the small pond due north of the sharp bend in the river on the left.

Site 44a: Top Pond Brook, Burgeo Highway.
Map Coordinates: 47°53'99"N; 47°42'40"W. Altitude: 35.4 m

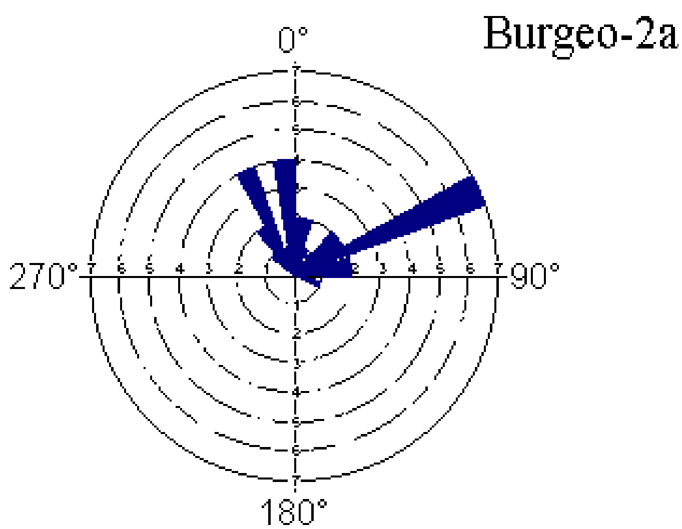
The site is east of the highway about 75 m from helicopter fueling depot and hunting cabin (actually a log house rather than a cabin). This site probably formed a contiguous strand of thalli-bearing trees with site 44b, before the highway was constructed through the pass. Since the built up level of the road level is above the stands, the thalli (which are upwind) survived heavy pollution from several years of large diesel-fuelled construction machinery and currently from the helicopter fuelling depot, general traffic and cabin smoke. This site is roughly where the coastal fog belt begins; i.e., this is a cloud forest of sorts. The site is a typical seepage slope and although the forest is typically in the last stages of self-thinning with ≈ 20% standing dead trees and fairly open, low density stands, the ≤ 0.5 m regeneration is quite dense. Thalli-bearing trees occur on the edges of small clearings resulting from wind throw and selective cutting. Despite exposure to relatively high light levels and constant wind these are among the largest and healthiest of thalli ever found.

Site 44a

Phorophyte Statistics	
Number of phorophytes	8
Av. height (standard deviation) of phorophytes	8.9(±1.9)
Av. DBH (standard deviation) of phorophytes	14.5(±3.2)
Approximate stand density	2,000 stems/ha
Average age of core samples	85-90 years
Directional Statistics of Thall	
Total number of thalli	34
Mean vector	29°
Length of mean vector	0.75
Angular deviation	43°
Standard error of mean (-/+)	7°
95% Confidence interval (-/+)	15°/43°



Angular distribution and mean vector of *E. pedicellatum*



Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

Figure 18a. A southward view of site 44a with the barrens visible in the background. Note the gaps, low-density, decadent stands and balsam fir regeneration understory

Figure 18b Site 44a. Southward view with barrens visible in the background. Note the gaps, low stand density, decadent trees and regenerating understory.

Figure 19. Tom Brinston and Jon Sharron pose at the edge of gap with large-than-usual diameter phorophytes with exceptionally large *E. pedicellatum* thalli

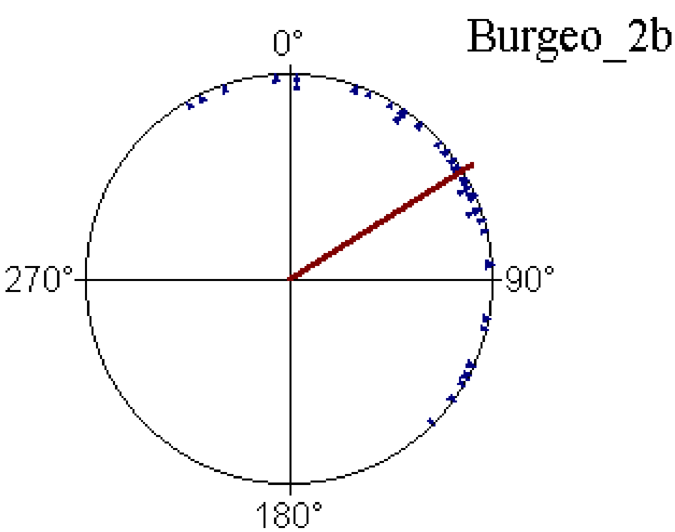
Figure 20. Site 44a. Another patch of trees heavily with colonized with lichens is indicative of a humid fog forest. Note the unusually dense regeneration in the understory and high percentage of standing dead trees.

Site 44b: Top Pond Brook, Burgeo Highway.
Map Coordinates: 47°53'99"N; 47°42'40"W. Altitude 35.4 m

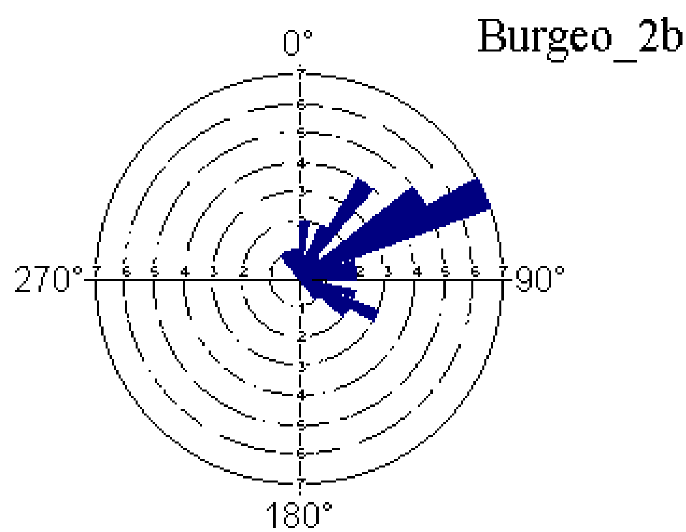
This site may have been the west end of contiguous strand of thalli-bearing trees extending to Site 44a before the highway was constructed through the pass. The site is about 20 m west of the highway and about 50 meters north of the helicopter fueling depot and hunting cabin (actually a log house rather than a cabin). The thalli-bearing trees are in stands with a very low stand density surrounded by stands of ≤500 stems/ha. Like its eastern cohort, despite exposure to relatively high light levels and persistent wind, the thalli are among the largest and healthiest ever found.

Site 44b

Phorophyte Statistics	
Number of phorophytes	11
Av. height (standard deviation) of phorophytes	8.4(±0.9)
Av. DBH (standard deviation) of phorophytes	13.4(±3.6)
Approximate stand density	1,500 stems/ha
Age class of core samples	85-90 years
Directional Statistics of Thalli	
Total number of thalli	38
Mean vector	58°
Length of mean vector	0.76
Angular deviation	43°
Standard deviation of mean (-/+)	7°
95% Confidence interval (-/+)	45°/72°



Angular distribution and mean vector of *E. pedecellatum*



Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

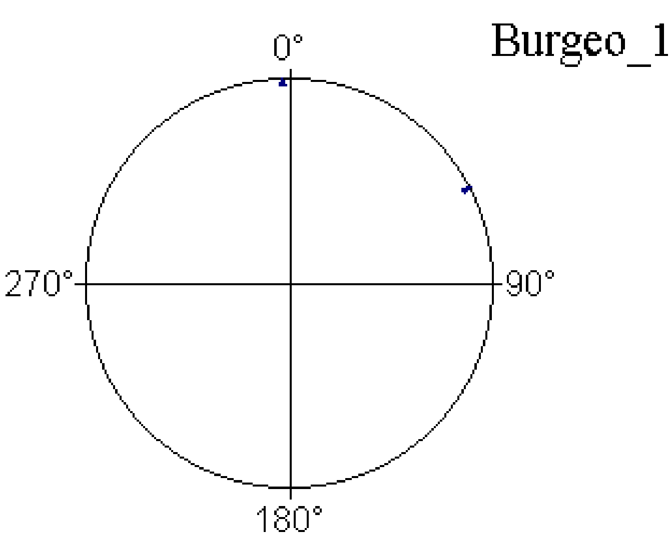
Figure 21. Site 44b with open decadent stands similar to
site 44a. Note the high percentage of standing, broken dead trees, especially the phorophyte with most of its lower bark rotted off.

Figure 22. View from the parking lot of the helicopter fuelling station and outfitters lodge. The site is on the
mid-slope of the escarpment in top right of the photo.

Site 44d: Peter’s Woods, Burgeo Highway.
Map Coordinates:47°46'00"N; 57°39'19"W. Altitude 25 m

This is a unique site extending from the bottom of a 50 meter bare cliff with both phorophytes being comparatively large dead and virtually dead trees, respectively. Phorophytes are isolated remnants of a decadent section in a balsam fir forest which was salvage in winter (hence the tall cut stumps) about 20 -25 years ago. The vegetation is typical of a seepage slope with dense fir regeneration (≈ 1-1.5 m tall) and wetter parts dominated by ***Sphagnum, Carex*** and occassional clumps of ***Juncus effusus.*** This is best described as cloud forest characterized by a high frequency of onshore fog. A cabin beside the highway is about 25-30 m downwind from the thalli-bearing trees, and the site is open to the seaward across the the treeless barrens. Nevertheless, thalli are among the large and healthiest encountered. Further surveys will undoubtedly find ***E. pedicellatum*** in the remaining forest stands.

Phorophyte Statistics	
Number of phorophytes	2
Av. height (standard deviation) of phorophytes	10
Av. DBH (standard deviation) of phorophytes	20.5
Approximate stand density	Solitary trees
Age class of core samples	85-90 years
Directional Statistics of Thalli	
Total number of thalli	2
Mean vector	N/a
Length of mean vector	N/a
Angular deviation	N/a
Standard error of mean (-/+)	N/a
95% Confidence interval (-/+)	N/a



Angular distribution of *E. pedicellatum*

Figure 23a. Site 44d. Peter's Woods showing high stumps indicating winter cutting above an exceptionally deep snow cover. The site was cut around 1978.

Figure 23b. Site 44d. Old weather-beaten stands with many standing dead 'snags' or 'starrigans' reflect a harsh climate. Fog in summer and severe loading of glaze by freezing rain is frequent in late fall and late winter are common weather events.

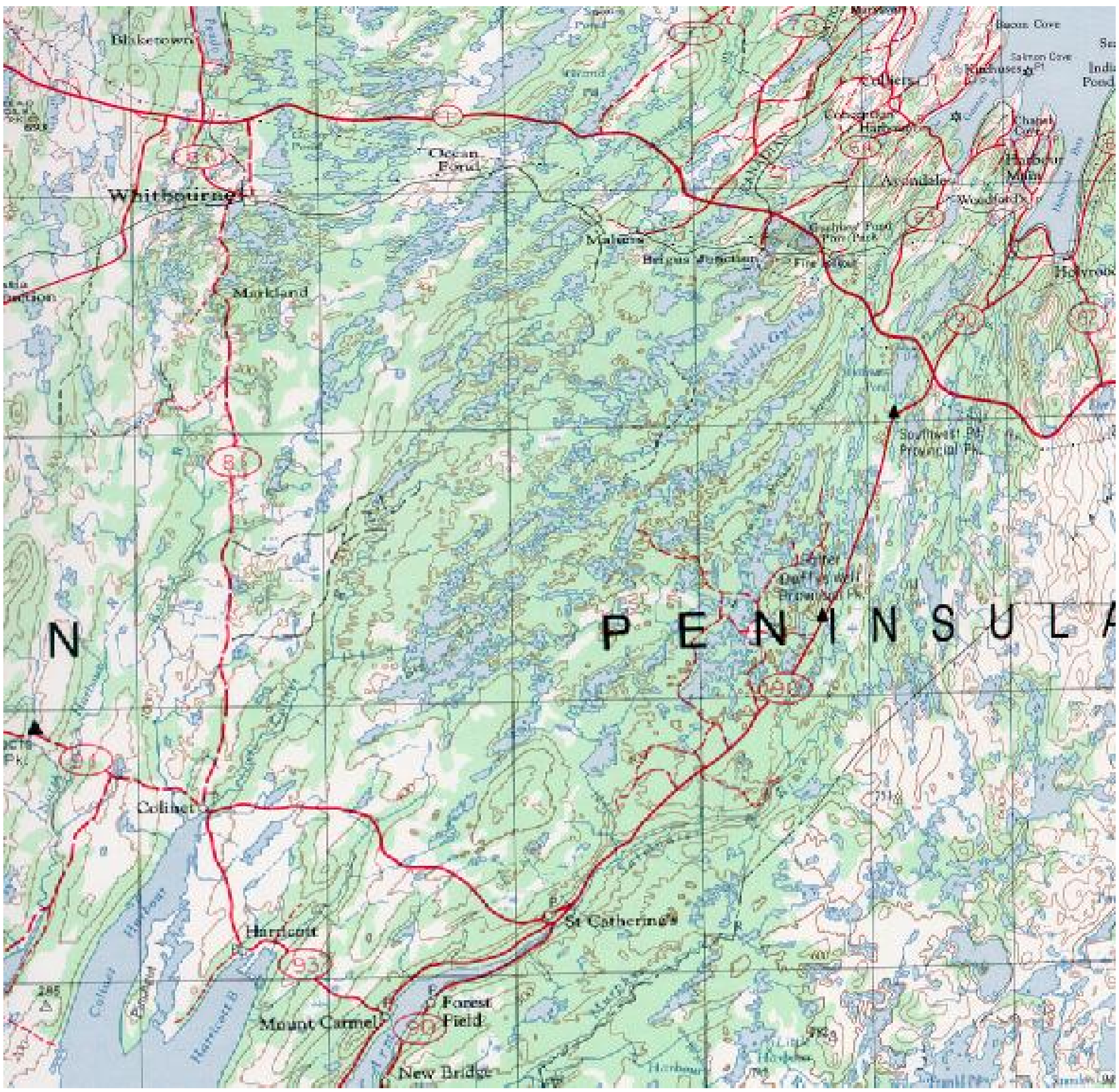
Figure 24a. Site 44d. View from the highway. The two phorophytes discovered so far are isolated, decadent trees located in the clearing in the mid slope (centre).

Figure 24b. Site 44d. View looking westward showing how exposed the site is to strong, dry westerlies. In summer, on-shore winds from the south and southwest frequently shroud the barrens in fog. The tallest dead tree in the centre is one of the *E. pedicellatum* phorophytes

SUMMARY NOTES AND STATISTICS

FOR

CENTRAL AVALON

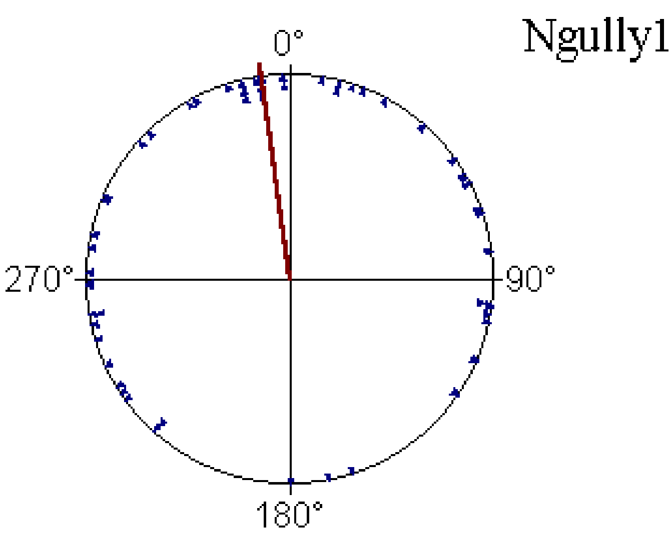


Site 4: Plot 1: Noseworthy's Gully, Fox Marsh
Map Coordinates: 47° 21' 56 "N; 53 ° 24' 03" W

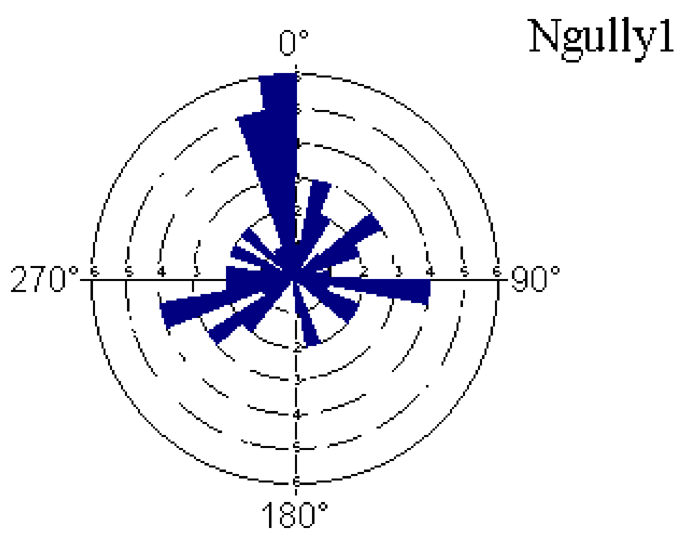
The site is a remnant stand in the final stage of self-thinning with 20% standing dead trees, 50-60% crown closure, recent blow-downs (i.e., not moss-covered) throughout. The forest floor is 100% covered by moss dominated by Hylocomnium and Pleurozium and about 10% Sphagnum moss. The stand is adjacent to pockets of wind throw, fen, and dense fir-regeneration on a salvaged clear cut of hemlock looper-damaged stands on the west side of Noseworthy's Pond (i.e., exposed to prevailing southwesterly winds). The slope is 1% with a 270° aspect.

Site 4: Plot 1

Phorophyte Statistics	
Number of phorophytes	47
Av. height (Standard deviation) of phorophytes	7.1(2) m
Av. DBH (standard deviation) of phorophytes	7.2(2.4) cm
Approximate stand density	6-7.000 stems/ha
Age class of core samples	65-70 years
Directional Statistics of Thalli	
Total number of thalli	58
Mean vector	352°
Length of mean vector	0.25
Angular deviation	95°
Standard error of mean vector (±)	21°
95% Confidence interval (-/+)	311°/33°



Angular distribution and mean vector of *E. pedicellatum*



Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

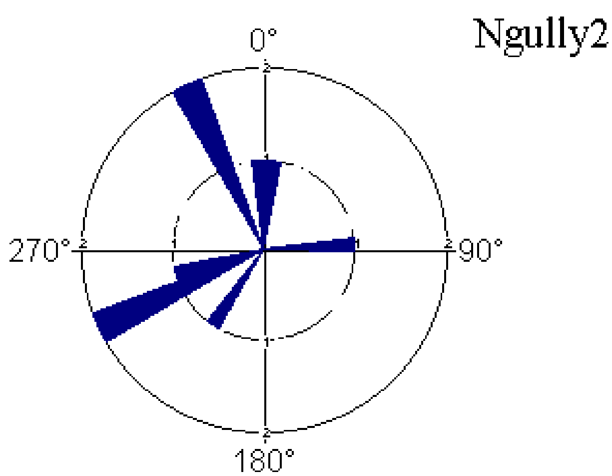
Figure 25. Air photo of Fox Marsh Site 4 is located on the east side the Noseworthy's Pond (between the two spur roads) opposite the bend on the pond and between the fen and small circular pockets of wind-throw (light colours). Note the complex landscape ecology influenced by extremely dynamic natural and human forest disturbances typical of central Avalon.

Site 4: Plot 2: Noseworthy's Gully, Fox Marsh
Map Coordinates: 47° 21' 56 "N; 53 ° 24' 03" W

Located downslope from Site 4: Plot 1; on a flat and very wet site with depressions of standing water throughout (hence 100% moss cover (60% *Sphagnum* moss, 20% *Hylocomnium* and 15% *Pleurozium,* 5% other). The stand is short, low productivity with 20% crown cover and quite open compared to Plot 1. It is adjacent to fen with open-growing black spruce a few of which have *E. pedicellatum* on their lower branches. On the far side of the fen, starting about 10-20 m from the stand, the area was clear-cut in the 1970's mainly to salvage severe hemlock looper infested stands and is regenerating vigourously by dense stands of 2-3 m high balsam fir. This plot is exposed to prevailing southwesterly wind blowing off Noseworthy's Pond into the site.

Site 4: Plot 2.

Phorophyte Statistics	
Number of phorophytes	8
Av. height (Standard deviation) of phorophytes	4.5(1.8)m
Av. DBH (standard deviation) of phorophytes	5.7(3.4)cm
Approximate stand density	6-7,000 stems/ha
Age class of core samples	75-80 years
Directional Statistics of Thalli	
Total number of thalli	9
Mean vector	301°
Length of mean vector	0.4
Angular deviation	78°
Standard error of mean vector (±)	39°
95% Confidence interval (-/+)	224°/18°



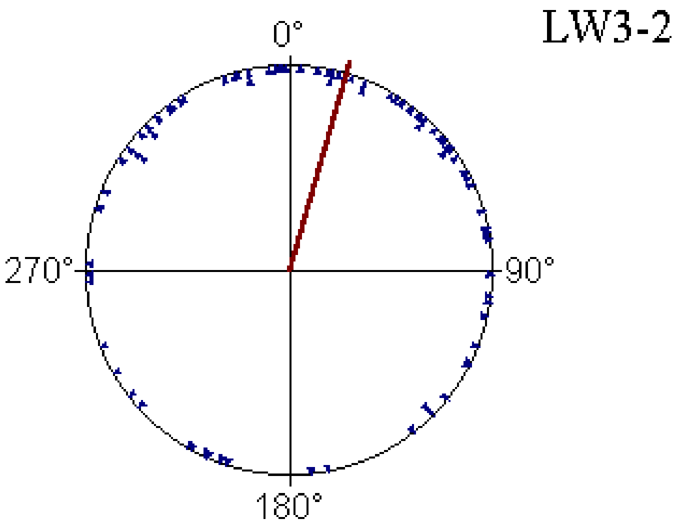
Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

Site 5: Plot 3-2: Muddy Gullies, Lockyer's Water
Map Coordinates: 47 20'30" N; 53° 16' 40" W

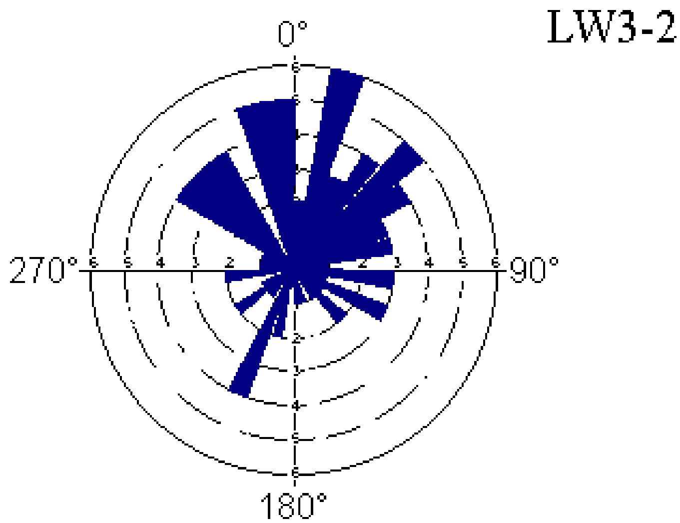
This is a non-commercial, even-aged, typical moist to wet Hylocomnium -balsam fir type stand of short stature with 40-50% crown closure and 30% standing dead trees and the forest floor completely moss- covered (50% *Hylocomnium*, 25% *Sphagnum*, 15% *Pleurozium* and 10% others) - on a 1-2% slope with 284° aspect. Pockets of recent and old (moss-covered) wind throw occur throughout and selective saw-log cutting on the fringes of the site. Because of time constraints, not all of the phorophytes were sampled.

Site 5: Plot 3-2

Phorophyte Statistics	
Number of phorophytes	66
Av. height (Standard deviation) of phorophytes	6.6(2) m
Av. DBH (standard deviation) of phorophytes	5.8(2.5) cm
Approximate stand density	5-6,000 stems/ha
Age class of core samples	65-70 years
Directional Statistics of Thalli	
Total number of thalli	81
Mean vector	16°
Length of mean vector	0.34
Angular deviation	84°
Standard error of mean vector (±)	13°
95% Confidence interval (-/+)	351°/41°



Angular distribution and mean vector of *E. pedicellatum*
Angular distribution of *E. pedicellatum*



Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*

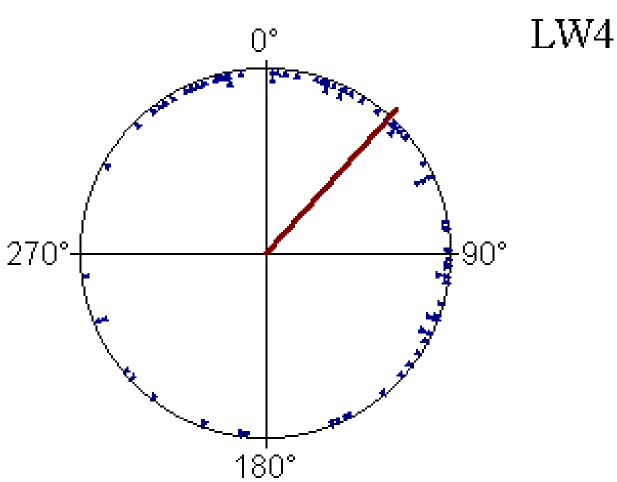
Figure 26. Air photo of Lockyer's Water. Site 5, including plots 3-2 and 4 is located to the right of the string of small ponds and near the edges of large patches of wind throw.

Site 5: Plot 4, Muddy Gullies, Lockyer's Water
Map Coordinates: 47° 20'30" N; 53° 16' 40" W

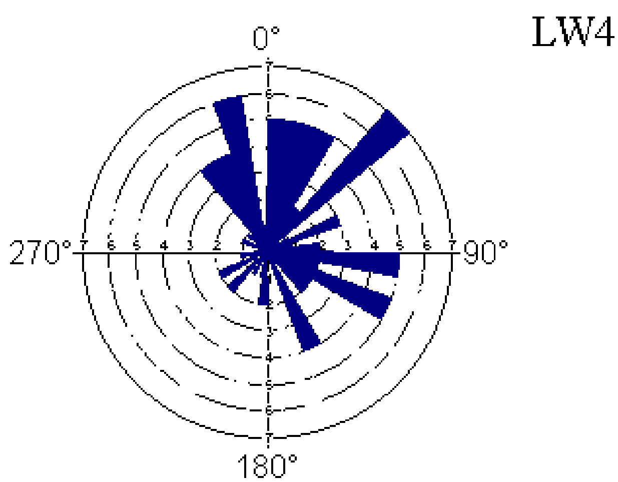
Similar to Site 5: plot 3-2, but slightly more open stand with slightly taller trees and 30% standing dead trees. Forest floor moss covered with 30% sphagnum, but still only a moderately dry site. Pockets of blowdown (not moss-covered) throughout and 20 meters from the edge of major blowdown. Stumps of larger trees cut for sawlog scattered throughout. Slope negligible (1%) and 330° aspect.

Site 5: Plot 4.

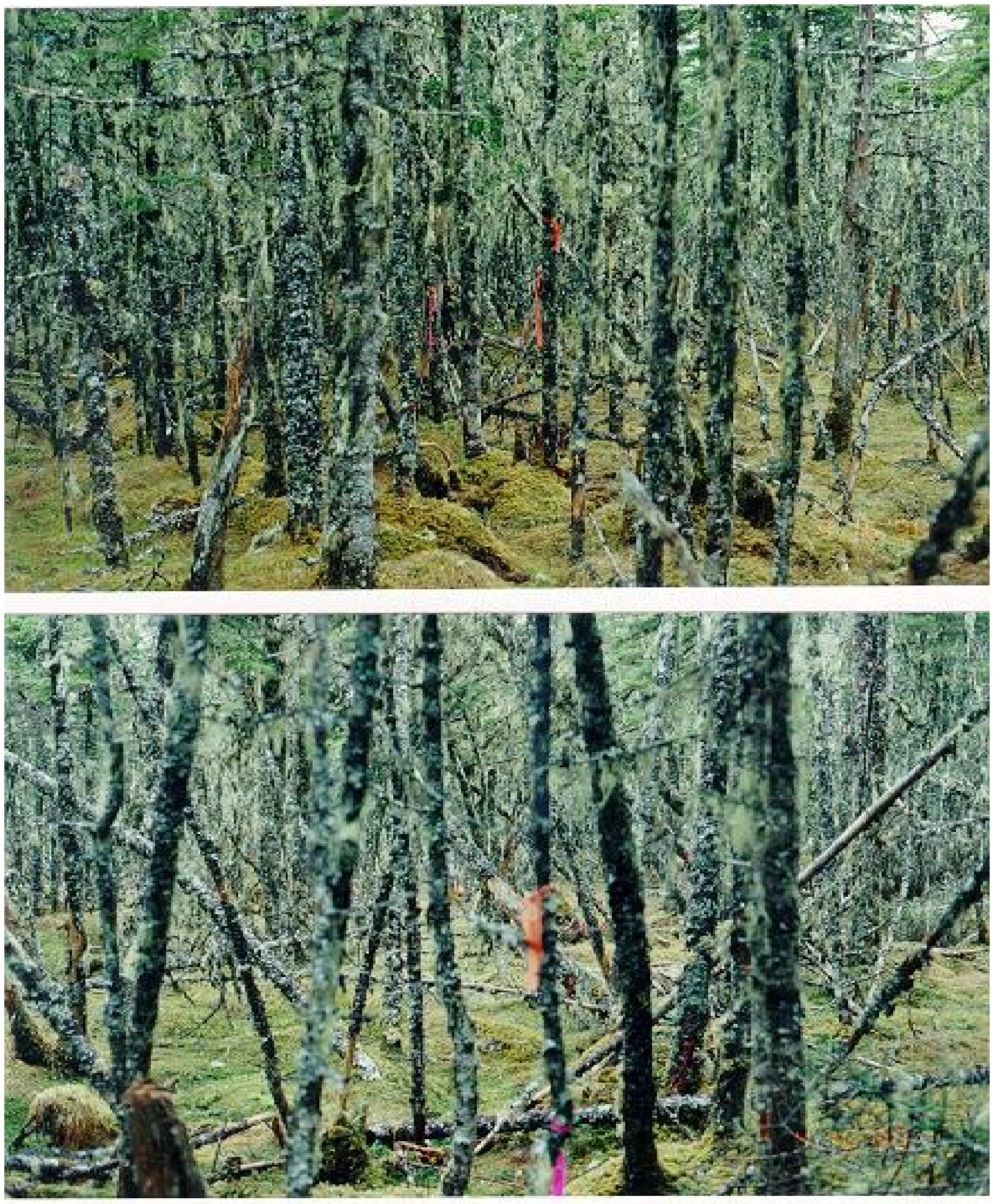
Phorophyte Statistics	
Number of phorophytes	58
Av. height (Standard deviation) of phorophytes	7.4(1.5)m
Av. DBH (standard deviation) of phorophytes	606(2)cm
Approximate stand density	4-5,000stems/ha
Age class of core samples	75-80 years
Directional Statistics of Thalli	
Total number of thalli	77
Mean vector	42°
Length of mean vector	0.39
Angular deviation	78°
Standard error of mean vector (±)	11°
95% Confidence interval (-/+)	20°/64°



Angular distribution and mean vector of *E. pedicellatum*



Rose diagram (10° widths) of the angular distribution of *E. pedicellatum*



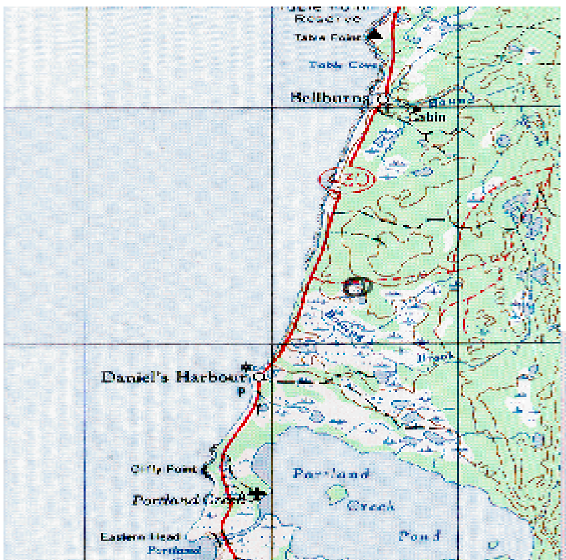
Site 5, 3-2: Classical Hylocomium-Balsam fir type stand with phorophyte. Note the low productivity stands with considerable standing dead and wind-thrown trees.

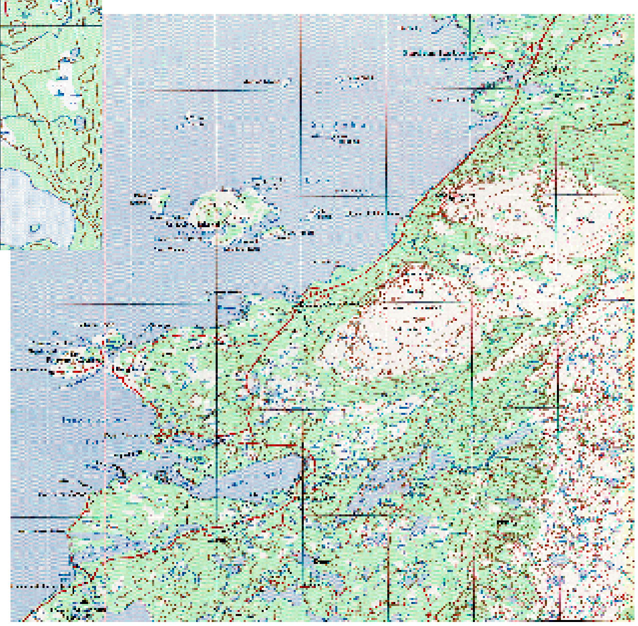
Figure 27. Site 5, 3-2: Classical Hylocomium-Balsam fir type stand with phorophyte. Note the low productivity stands with considerable standing dead and wind-thrown trees and developing gaps indicative of decreasing crown closure in the latter stages of self-thinning and some old stumps (e.g., bottom left) from selective cutting (high-grading) for sawlogs.

SUMMARY NOTES AND STATISTICS

FOR

Coastal Plain
of
Northern Peninsula





Site 50:Eddies Cove West
Map Coordinates: 50°42' 35"N; 57° 12' 41" W.

The lone thalli found at this site is literally beside the Viking Trail Highway 430 (constructed in the late 1970's) at base of a ≈15 m high road bank. The phorophyte is an outside edge tree and the thalli is facing the roadbank. The stand is a typical *E. pedicellatum* habitat, i.e., even-aged (55-60 age-class), low productive Hylocomnium-Balsam fir stand, getting close to the final stages of self-thinning. Despite a thorough search by a team of 8 on both sides of the highway for several kilometres, in what at first appeared to be promising sites, it became evident that this was not a particularly good area for the lichen. The stands are extensive closed canopies but the trees are fairly clean of lichens and virtually no sitings of the boreal felt lichen's constant companion *Coccocarpia*. The site is in the vicinity where Hoisington and Maass found *E. pedicellatum* in 1983. They found one thalli surviving on a dead wind thrown tree within an experimental clearcut 100 x 100 m. It is not surprising that thalli was not rediscovered, since it close to the end of the normal span of the residence time for thalli. The sawn stumps on the skid trail leading down to the pond suggest the small gap was created by a small winter logging operation in the late 1970's. Hoisington and Maass also describe it as "...largely pristine hilly and forest wetlands...." However, the forests around this site, like the region in general, have a long history of logging and most of the stands are balsam fir even-aged which regenerated from old logged patches.

Site 51: Zinc Mine Road
Map Coordinates: 50° 16' 35" N; 57° 30' 36" W.

The site is about 30 m from the Zinc Mine Road in the vicinity of the site where Hoisington and Maass found the lichen in 1983 - who did not find it again in 1991. Only two thalli were found on a short, surprisingly old balsam fir tree with crowns beginning close to the ground. Its a wet site on the edge of a bog with a transitional mixture of balsam fir and black spruce. As with site 50, there were certainly many stands of similar stature, density and age class which look like very promising habitats - except that the potential phorophytes are relatively 'clean' of lichens. One clue that the climate is not moist enough for *E. pedicellatum* (and its constant companion *Coccocarpia*), is the slow decay rates of trees that were wind-thrown 20-30 years ago. Although wind-thrown trees have a thick cover of moss, they still as solid as the day they fell. In fact, some which had been sawn-through a couple of years ago have no traces of stem rot.

Hoisington and Maass stated that drying out of stands,i.e., advection of-the local (boundary layer) air mass from neighbouring clear cuts, caused the demise of *E. pedicellatum* at this site. That certainly is true of some of the earlier sites in the area discovered by Hoisington and Maass in 1983. But on some sites where the forest is near total collapse, perhaps, the boreal felt lichen's (and *Coccocarpia's*) demise could be simply that it had run its course in terms of residence time (usually about 20-25 years). But in the vicinity of this site, where there are many stands which seem to be potential habitats, the fog-free weather due to prevailing brisk, dry westerly winds seems too dry to promote a good population of common tree lichens, let alone a species that is at northern extremities of its range. The forests in this area is the winter range of tens of thousands of caribou - evidence of them in the woods literally every few metres. The possibility that their browsing may be partially responsible for the low abundance of tree lichens was contemplated. However, the complete lack of browsing line on the trees dispels this notion.

FOREST DYNAMICS and *Erioderma pedicellatum*

The dynamics of the type of balsam fir forest in Newfoundland, in which *E. pedicellatum* habitats occur most frequently, have been studied intensively.[3] The habitats are generally restricted to the final stages of self-thinning of even-aged, monospecific balsam fir stands with age classes normally in range of 55-70 years old. Neighbouring fir stands quite often have scattered black spruce and birch (yellow birch and *B.x cordifolia* in the south and *B. x cordifolia* on the Northern Peninsula).

Based on the authors' earlier scientific research, even-aged balsam fir forests of the type frequented by *E. pedicellatum* have five distinctive stages:

- 0-15 years: mass regeneration often up to (140,000 seedlings ha^{-1}) and closed, contiguous canopy.

- 15-20 years: influx of new seedlings ceases, stands strongly self-thinning but still with a complete crown closure.

- 25-40 years: trees mature, stands lightly self-thinning with 70-80% crown closure

- 40-50 years: senescence begins, self-thinning virtually ceases, with 15-20% standing dead, crowns become deformed with little change in percentage of crown closure

- 50-60 years: trees are decadent forming open stands with 40-60% canopy closure, the main canopy has as much as 30% standing dead, often with bark rotting off, and sporadic wind throw and breakage by loading with freezing rain are common, frequent storm winds and heavy loads of freezing rain create pockets of wind throw trees and broken standing dead trees (stripped of branches and bark) which expand to become progressively larger die-back fronts with dense fir regeneration (i.e., the wave forest phenomenon).

It is in the final stage which becomes visibly colonized by *E. pedicellatum.* Presumably because the high diffuse light regime favors the growth of the phytobiont (*cf*. the blue-green, filamentose algae *Scytonema*).

In the early stages of complete regeneration (i.e., no new cohorts are introduced into the regenerating phase) and canopy closure complete at about age 15-20 years, the forest floor receives very little light and is covered by little more than decaying necromass and fungi. At this point the so called -3/2 self-thinning takes effect. About midway through the self-thinning process

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[3] For example see Robertson, Alexander (1993). *Wind and Wave Forests: A Case Study and Implications for Silviculture*. In *Forest Development in cold climates*, Plenum Press.

(~ 25-30 years) mosses and lichens become prominent and seedlings emerge which, being shade tolerant, will remain virtually dormant in a so-called ‘pre-physiological state’[4] until the final self-thinning stage where decadence meets youthfulness at the edge of the stand characterized by bleached and bark-less skeletons of standing dead trees towering above a surface strewn with windthrow and colonized by vigorous fir regeneration. Based on the results of the current study, ***E. pedicellatum*** phorophytes fit within a narrow, final temporal stage in the -3/2 self-thinning process. The self-thinning process and changes in stand structure is illustrated by the following figures: figure (a) illustrates the -3/2 self-thinning rule of the non-regeneration phases based on data from measurements of the development of even-age, pure balsam fir stands in Newfoundland; figure (b) shows the frequency of basal stem diameters at intervals of age classes and stand density of such stands; and figure (c) the proportion of dead and living trees for age class 45 years old (too young to have phorophytes) and 55 years old (the shaded section showing the range of dbh for phorophyte trees which excludes a sub-population of larger diameter (but not necessarily taller) trees.

Some ecologists refer to the final stages of self-thinning and beyond as old-growth forest which is generally long-lived - that is, the so-called climax ecosystem determined by the local climatic and biophysical environment (that is the process is linear). The problem is that, when climax theorists discuss the role of disturbance in gap formation, they tend to focus primarily on biological factors and rarely ask how gaps are formed and expanded by abiotic (say climate and weather).

In reality, complex landscapes, like those obvious in the air photo mosaics of Lockyer’s Water and Fox Marsh, are best described as a mixture of short-term predictability and long term unpredictability - regardless of whether human factors are part of the process or not. Experimental mathematicians who study chaotic dynamics of natural environments, like the author[5], refer to this as self-organizing complexity. It is beyond the scope of this report to explain the practical implications of how this relates to the topic at hand. What it means simply is that parts of habitats which appear to be cyclical (like trends towards old-growth forests) are knocked out-of-phase by disturbances. In reality what we really see in typical landscape are ‘patterned instabilities’.

The magnitude and rate of change in the pattern (e.g., a forest type) in response to disturbances are reflected most obviously in the changes of structure and ecology. There is a general recognition that a high degree of biodiversity is a positive environmental process because it provides a greater number of niches for a greater range of species. Frequent gap formation,

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[4] In counting tree rings the ‘pre-physiological’ stage, recognized by the darkened area round the pith, is usually ignored since it doesn’t represent a stage of open-growing regeneration.

[5] For example Robertson, Alexander (1994). ***Directionality, Fractals and Chaos in Wind-Shaped Forests***. Agricultural and Forest Meteorology 72:133-166.

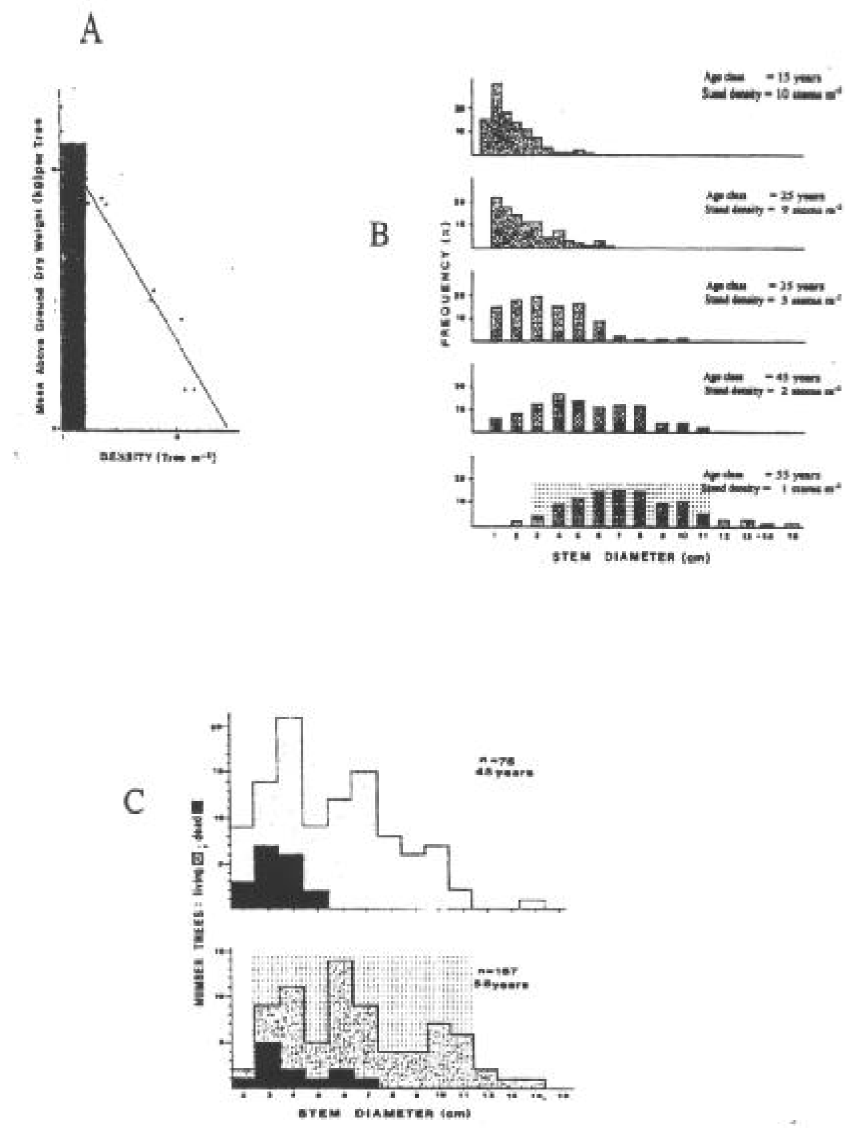

Figure 28. Three basic features of an even-aged balsam fir stand development: **a)** the self-thinning rule (slope = -3/2) of tree mass vs stand density; **b)** frequency of dbh for successive age classes; c) proportion of living vs standing dead trees at 45 years and 55 years old respectively. The shaded area in all three graphs is the domain where *E. pedicellatum* occurs (at least visibly).

such fragmentation of ecotypes in forested landscapes (both natural and anthropogenic), is the reason for their extraordinary biodiversity.

The results of this survey clearly shows that ***E. pedicellatum*** is very much a product of fragmentation processes since it occupies within the threshold of the transitional forest states from decadence to juvenility. In other words, unlike fir trees, the boreal felt lichen cannot recycle in the same location, at least not until the stand has reached 50 years or more. In otherwords, ***E. pedicellatum*** merely occupies a short-term phase of about 23 years according to Maass which is more or less substantiated by these results. There are, of course, reports of ***E. Pedicellatum*** colonizing stands as young as 25-40 years old. However, our core samples of several diameter sizes of both live and standing dead trees on sites on which these low ages were reported yielded trees in 65-70 age class (not including the so-called "pre-physiological" age when balsam fir seedlings remain virtually dormant for decades under a stand until higher light regimes releases them for vigorous growth).

In all probability the boreal felt lichen may never be found again at the same location for a couple of centuries, or whenever the habitat, phorophyte and biogeophysical properties are repeated. Consequently, the more complex the forest landscape disturbance regimes which promote small patches of even-aged, low-productive balsam fir sites, like those of current sites where the lichen is most prevalent, the better the chances of it's success in the region.

Table (3) illustrates the complex dynamics of forest response to various types of disturbances in Newfoundland. Based on the results of this survey the shaded section is typically the habitats where *E. pedicellatum* phorophytes fit into the scheme of disturbance/response scenarios.Table (3) is only a generalized perspective on the changes in patterning in landscapes typical of the areas where *E. pedicellatum* is found in Newfoundland. The table is based on the fairly new science of fractal analysis, sometimes called the "geometry of heterogeneity" or more precisely a measure of roughness. In this case, it is a measure of the roughness of edges and gives a fair indication of how rapidly a particular patch and it neighbours are changing. For simplicity, I have dispensed with the fractal dimension since it has very little meaning to those not familiar with fractal geometry and is not essential for this discussion. However, the rest of the table should be self-explanatory to experienced observers of forested landscapes dynamics.

TABLE 3: Changes in Forest Landscape Patterns in Response to Disturbances

PARAMETER			RESPONSE					
Forest Type	**Disturbance** --------------------- **Intensity**	**Frequency**	**% of Forest Type Affected**	**Undisturbed** **Number of clusters**	**Size of cluster s**	**Disturbed** **Number of clusters**	**Size of clusters**	**Some causes of Disturbance**
Rare	Low	Low	<5%	Minor change	Minor change	Minor Change	Minor Change	Hiking trails
Rare	Low	High	55-75%	Decreases	Largest decreases	Increases	Largest increases	Small group ecotourism, mining exploration
Rare	High	Low	<5%	Minor change	Minor change	Minor change	Minor change	ATV's (forest habitats)
Rare	High	High	75-95%	Declines sharply (phase change)	Largest Declines sharply	Increases sharply	Largest increases sharply	Large group ecotourism (botanical collecting),
Common	Low	Low	<5%	Small changes	Small changes	Small changes	Small changes	Sports fishing, rabbit hunting, trail construction
Common	Low	High	>50%		Largest patch fragmented into high number of clusters			Low-level insect and diseases infestation. Windthrow and/or patch cutting (≤5 ha) followed by natural regeneration.
Common	Medium	Low	<50%	Increases	Edges increase	Increases	Edges increase	Selective cutting (sawlogs), individual trees wind thrown, self-thinning mortality (natural dieback)
Common	Medium	High	>80%				Approaches initial structure of undisturbed habitat	Storm winds, freezing rain damage.
Common	High	Low	>95%		Initial structure becomes like disturbed habitat			Forest fires, major disease and insect infestations, light urban encroachment
Common	High	High	>95%		Initial structure becomes like disturbed habitat			Clear cutting (≥50 ha) , agricultural expansion, monoculture plantations, metropolis

Note: Stands with *Erioderma pedicellatum* phorophytes normally occur in disturbance responses in the highlighted section of the table

COMMENTARY ON THREATS TO *E.pedicellatum*

Lichenologists have given a long list of threats to lichens in general. Their list of concerns for rare lichens in particular, such as *E. pedicellatum*, focus heavily on anything and everything that would destroy their habitats - including transplanting threats which are symptomatic of environments in and close to industrial heartlands of Europe and the eastern seaboard of Canada and the United Staes of America.

There are reports which list natural disturbance (wind, insects, fire, etc.,) as serious threats to *E. pedicellatum*. Given the dynamical nature of landscape ecology; lumping natural disturbances as threats is inappropriate.

Any mention of human influences on lichens tends to invoke a negative response. However, there are there many examples of species, including many rare ones, which benefit from human disturbances. For example, of the 96 species of the genus Carex in Newfoundland[6], 50% are widespread because of direct and indirect human disturbances in the natural environment. None of the carex, incidentally, have become noxious weeds. An extreme example, is *Carex cumulata* whach has an entire population of only two or three tufts in Newfoundland (i.e., in a gravel pit near Gambo quarried out of a stand of red pine (*Pinus resinosa*).

The majority and most populous colonies of *E. pedicellatum* have so far been found in stands which regenerated from patches that were either wind thrown or cut about 55-70 years ago in areas that have a long history of cutting, hunting and fishing. Virtually all sites surveyed for this report have been high-graded (selectively cut) for sawlogs slightly before or during the final stages of self-thinning (45-50 year age class) before the thalli would have colonized the stand. Two points to bear in mind are that: a) the lichen avoids the sub-population of larger, saw-log diameter trees which, by themselves, have a stand density of < 500 stems ha^{-1}; and, b) that their removal opens the stand to provide sufficient light for *E. pedicellatum* to colonize and procreate. In other words, high-grading of immature stands isn't very different from the natural thinning caused sporadic wind throw and mild insect and disease infestation.

Similarly, phorophytes occupy a niche as inside edge trees along the margins of small gaps and extensive blowdown areas and also around patches of selective cutting of mature trees and in natural gap formation in the final self-thinning stage of stand decadence. The prime *E. pedicellatum* areas in the central Avalon, Bay D' Espoir and on the Burgeo barrens are very good examples of very dynamic and complex landscape mosaics that evolved from the combination of human and natural disturbances as agents of gap formation necessary for the the lichens to colonize and procreate.

This must not be misconstrued that the author is condoning large-scale clear-cutting: here,

[6] Robertson, Alexander (1984) *Carex in Newfoundland*. Government of Canada, Ottawa (2nd edition, 1995)

I merely to point out that there is a positive aspect of some human influences which have largely been responsible for such large and healthy colonies of *E. pedicellatum.*

Many biota are rare by default and society is often at loss what to about them. Unwittingly, or otherwise, where favouring one species disadvantages another.The replacement of part of a red pine stand by a gravel pit, which provided the only known niche for *Carex cumulata* in Newfoundland, is a case in point. Conservationists give red pine a high profile. But no one has spoken up for the only two tufts of this unpretensious little brown sedge? Nor, apart from a couple of specialists, has anyone taken notice of the new species *Carex saxilittoralis*.A small colony of this tiny sedge was discovered on the Great Northern Peninsula by the author[7] It is, unquestionably, one of the rarest plants in the world. Incidentally, *Carex saxilittoralis* thrives only on constantly disturbed sites (erosion by wind and water and under-foot of the beachcombers). Hence, like the boreal felt lichen, this tiny sedge is a product of disturbance regimes: albeit at the opposite ends on the disturbance spectrum: viz., the former in vegetating a little patch of gravelly seashore; the *latter* at decadent end of a rotting and collapsing forests.

While this may seem irrelevant, it does show that the author is also an expert and concerned about rare plants. Besides, it reinforces the principle meassage that humans occasionally exert positive influences on the natural environment. Indeed, some environmental philosophers contend that humans are part of the earth's natural biotic force, much like ants and elephants, only much more pervasive and potent. Of course, the philosphical problems on what constitutes wildness and pristine is an endless treadmill of debate because the subjectiveness of individuals is such that we all have preferences as to which biota are precious, beautiful, harmless- rare or otherwise - and worthy of special attention at the expense of other biota. It is an unenviable job and quite an impossible task for policymakers and ecosystems managers to cater every individual and special interests group's preferences.

Lichenologists highlight the demise of *E. pedicellatum* in Europe. It is widely believed by experienced lichenologist that it was pollution that killed off the last *E. pedicellatum* in Norway. Some have suggested that smoke from the pipe of a forest company industry official done in the European population. Others say that it was taken by a plant collector or that it's demise is a consequence of the drying effects of advection from surrounding logged sites around. No one seems to have the answer.

ATMOSPHERIC POLLUTION

With regards to atmospheric pollution, a note on an internet site regarding the threat of atmospheric pollution[8] states

> "Like other cyanophilic lichens, *E. pedicellatum* is probably highly susceptible to atmospheric pollution. However, as Grong is situated within the part of Norway with the lowest sulphur concentration in the precipitation (Statens forurensingstysyn 1992), this is unlikely to be a threat for this species in Norway."

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[7] *Carex saxilittoralis* **Robertson**, Rhodora 82:369-374. 1980

[8] *Http://www.toyen.uio.no/botanisk/bot-mus/lav/factshts/eriopedi.htm*

Those familiar with Grong, Nord Trøndelag, in central Norway know that it much more populated, has a much denser network of roads and railways, and factories than any part of Newfoundland other than the St. John's Metropolitan area as it used to be called. Nevertheless, continental air masses are said to transport pollution into the province. In dry years smoke from massive forest fires gets trapped in the inversion layers in the canopy of our forests. There are of course, substantial local sources of sulphurous pollution; such as, Come-by-Chance oil refinery, Holyrood Generating station and, not so long ago, the Long Harbour Smelter. Some also maintain that traffic on the Trans Canada Highway is a major source of emmissions harmful to the boreal felt lichen. Some claim that emmissions from chainsaws, summer cabins, logging trucks and skidders, recreational trucks and all-terrain vehicles, smoke from wood-burning stoves of hunting lodges and summer cabins are major sources of harmful emissions.

On the contrary, as the summary notes for each plot shows, nearly all the healthiest sites have thrived down-wind of many of these emmission sources, which has existed continuously long before the lichens could have possibley colonized the surveyed sites. In fact, probably the largest concentration of thalli in the smallest area is within the boundaries of the popular Jipujijkuei Kuespem Park. Quite apart from atmospheric pollution, the boreal felt lichen quite content to share it's domain the camping and hunting fraternity, campfires and vehicles and all. Furthermore, at the time of writing, there are unconfirmed reports of *E. pedicellatum* in the urban heartland of Torbay (upwind of St. John's).

Judging from the distribution, size and health of *E. pedicellatum* thalli, particularly coastal sites on the Avalon (upwind of Argentia and close Long Harbour) and in parks and dense 'cabin country' of central Avalon, continental and regional scales of advection of atmospheric pollution obviously has had little or no effect on populations of *E. pedicellatum*.

Considering we have such clean air, cleansed by persistent winds, and protected by ever stricter emmission control standards, pollution is not likely to be a major threat to *E. pedicellatum* in Newfoundland.

WIND

It is surprising that anyone would consider wind as a threat to lichens. This report frequently comments on the wind as an essential vector in landscape patterning and processes. Persistent and stronger wind (often laden with freezing rain, ice-crystals, dryness and humidity) from all points of the compass is necessary to hasten stand decadence, create gaps and slow attrition of single trees in forest stands to produce phorophytes for *E. pedicellatum*. In short, wind may seem an evil to many, but it is a natural and very necessary one for creating suitable habitats for the lichen.

In any case, as the summary notes show, many of the sites are exposed to persistent wind for most of the year. In fact, *E. pedicellatum* thrives on isolated trees in one of the harshest and windiest terrestrial environments in the world - that is, on the Burgeo barrens. Most of the sites on the Bay D'Espoir are on the edge of wave forests, created by strong westerlies.

LOGGING

Logging on a massive scale is of course a threat to ***E. pedicellatum***. However, it must be conceded that infrequent, low impact patch (<5 ha) and selective cutting (scattered large diameter trees not favoured by the lichen) over a century or more has created many niches in the landscape mosaic for ***E. pedicellatum*** to thrive. The survey results in this report show that is exactly what has happened. For example, high-grading of the small percentage of dominant population of trees (>12 cm dbh) in an even-aged balsam fir stand is a form of thinning akin to natural thinning processes such as mild infestations of insects[9], isolated tree mortality and pockets of wind throw which provide just the right light regimes for ***E. pedicellatum*** to thrive. In fact, site 35a in the Bay D'Espoir area, was thinned to boost timber yield, and has a healthy colony of ***E. pedicellatum*** (albeit a residual colony prior to thinning). Of course, it hardly needs stating that selective cutting needs to be strictly controlled as matter of good silvicultural practice.

This study shows that phorophytes in all sites are adjacent to gaps both large and small. Phorophytes are most often edge trees beside a gap where there is a higher level of diffuse light (and even direct sunlight in the morning and sometimes in the evening) than the density of the stand provides. In such cases the thalli are highly directional, i.e., they prefer the north and east sides of the tree. But if the stand is fairly open (caused by high-grading or natural attrition) and has a crown cover $\leq$60%, the phorophytes penetrate deeper and in greater numbers into the stand and the angular distribution of thalli is spread more-or-less around all points of the compass.

[9] Ringius, Gordon S. 1997. Evaluation of Potential Impacts of Development on ***E. pedicellatum*** in Eastern Newfoundland. Canadian Forest Service, Ottawa.

RECOMMENDATIONS FOR THE CONSERVATION of *E. pedicellatum*

Ecosystem management is an extraordinarily complex task determined mainly by constant changes of policy, economic and social issues. Indeed, the complexities are far too nebulous for many people to comprehend and appreciate. It would be no less presumptuous for the author of this report to provide recommendations on such special interest topic as the conservation of *E. pedicellatum*or any rare biota or ecosystem for that matter. Firstly, most phytosociologists will recognize the distinct possibility that one or all of the following recommendations, while they create conditions conducive to *E. pedicellatum,* in some situations it may be at expense of sacrificing or inhibiting habitats of other biota. Secondly, no matter what tact this author takes, the recommendations, at best, are likely to endear one faction and irritate another. Regardless of the ecopolitics of this affair, I have endeavoured as much as possible to avoid speculation and let the facts of the survey speak for themselves. Some will avail of the facts widely, others will twist them. Regardless, however one wishes to colour the results of this report there is one recommendation with which all but a few would agree, that is:-

> " To recognize that staff of the Department of Forest Resources and Agrifoods have the jurisdiction for ecosystems management in this province and have the knowledge and the talent to understand the complexities, ramifications and practicality of recommendations presented in this report."

This newly structured department combines the talents of wildlife, forestry, and fisheries of well-trained and experienced experts well-known for having a keen interest in conservation. In them rests full responsiblity for enforcing laws and implementing policies and guidelines. Policies and guidelines, it must be said, developed in consultation with the public and experts from many professional disciplines.

The recommendations are couched in terms of how best to mimic the way in which natural and human (if there really is such a distinction) disturbance regimes have been responsible for the extraordinary numbers of *E. pedicellatum* in Newfoundland.

Since *E. pedicellatum* rarely occurs in merchantable stands (i.e., the accepted value of 60 $m^3\ ha^{-1}$) :-

"the current policy of limiting patch cutting to $\leq$ 5 ha on the Avalon Peninsula, which may be applicable to other areas of the Province with *E. pedicellatum,* should be maintained."

Suggestions that emissions from chainsaw and extraction equipment are harmful is not supported by the fact that logging activities have been carried out for decades within in and adjacent to surveyed sites with abundant thalli, therefore:-

"Salvage logging in large wind throw areas (generally more than five hectares) in the

> vicinity of *E. pedicellatum*, especially on areas where the prevailing wind blows away from the phorophytes, should be carried out no closer than 10 metres from the edge of thalli-bearing stands in order to regenerate the type of stands which *may* become potential habitats for *E. pedicellatum* 50-60 years hence."

Since most of the best *E. pedicellatum* sites are located close to trails, and new highways, and access roads, indicates that the lichen is quite tolerant of construction providing it is carried out in a judicious and environmentally friendly manner. However, since *E. pedicellatum* habitats are usually on low productivity, often wet sites, then:-

> "Routes for new extraction routes and roads should naturally avoid *E. pedicellatum* sites as is currently the usual practice."

The survey shows that *E. pedicellatum* phorophytes are often edge-trees where thalli benefit from a high level of diffuse visible light radiated from small gaps into the phorophytes at the edge of bogs, wave forests, pockets of wind throw and insect infestations, sporadic cutting; alos, since phorophytes are generally restricted to smaller diameter trees (≤12 cm dbh) non- or marginally-merchantable stands, it may be advantageous to increasing populations of *E. pedicellatum to:-*

> "Leave a buffer zone of at least 20 metres around *E. pedicellatum* sites and which, if not already high graded naturally or by humans, could be according to the historical practice of restricting high-grading to trees greater than 12 cm dbh, which may increase the number of potential phorophytes in much the same way that mild insect infestations and pockets of wind throw do and selective cutting practices have done. Conservation Officers of the Department of Forest Resources and Agrifoods will mark trees for high-grading and strictly enforce guidelines for careful cutting and extraction as they deem necessary."

E. pedicellatum sites have yet to be searched for in vast tracts of "fog" forest zones in southern Newfoundland and coastal Labrador and elsewhere. Therefore , it is in the best interest for conservation of the boreal felt lichen to understanding the nature of its habitats and how they pertain to the role disturbance regimes in the general dynamics of landscape ecology and to refine appropriate conservation measures". Therefore:-

> "Staff of the Department of Forest Resources and Agrifoods should routinely continue their search for *E. pedicellatum* sites and conduct further surveys of new sites and establish permanent sample plots in and around its habitats"

Undoubtedly, there are countless more recommendations that should be made. However, there are already a great many regulations and recommendations on the books which apply to environmental stewardship which can, and probably are, applied in context of ecosystem management of prime *E. pedicellatum* areas.