Recovery Plan
for
Porsild's Bryum
(*Bryum porsildii* (I. Hagen) Cox & Hedderson)

(John Maunder photo)

Initial Draft Prepared By:

René J. Belland

(this report has been reviewed, revised and edited prior to publication by the Limestone Barrens Species at Risk Recovery Team)

December 2006

Lead Jurisdiction/Other Jurisdictions/Key contacts:

Lead: Government of Newfoundland and Labrador, Department of Environment and Conservation, Wildlife Division, Endangered Species and Biodiversity Section

Recovery Team Members, Working Group Members, and Associated Specialists:

Recovery Team Members:

Luise Hermanutz, Memorial University of Newfoundland (Co-Chair)
Nathalie Djan-Chékar, The Rooms, Provincial Museum
Douglas Ballam, Nature Conservancy Canada
Joe Brazil, Newfoundland and Labrador Department of Environment and Conservation
Henry Mann, Memorial University of Newfoundland
John Maunder
Wilf Nicholls, Memorial University of Newfoundland Botanical Garden
Leah Soper, Newfoundland and Labrador Department of Natural Resources
Gerry Yetman, Newfoundland and Labrador Department of Environment and Conservation
Michael Burzynski, Parks Canada
Claudia Hanel, Newfoundland and Labrador Department of Environment and Conservation (Co-Chair)
Dulcie House, Limestone Barren Habitat Stewardship Program
Anne Marceau, Parks Canada
Jeri Graham, Newfoundland and Labrador Department of Environment and Conservation

Working Groups and Associated Specialists:

René Belland, Devonian Botanic Garden, University of Alberta

Acknowledgments

The author thanks Jennifer Doubt for reviewing the draft and providing many helpful comments.

Disclaimer:

This Provincial Recovery Strategy for Porsild's bryum has been prepared in cooperation with the members of the Limestone Barrens Species at Risk Recovery Team. It defines the recovery goals, approaches and objectives that are deemed necessary to protect and recover the species. It does not necessarily represent the views of all individual members of the recovery team, or the official positions of the organizations with which the individual team members are associated. The goals, objectives and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new findings and revised objectives. Implementation of the plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations. Further details will be provided in one or more associated action plans.

Recommended Citation:

Belland, R.J. and Limestone Barrens Species at Risk Recovery Team. 2006. Recovery Strategy for Porsild's Bryum (*Bryum porsildii* (I. Hagen) Cox & Hedderson). Wildlife Division, Department of Environment and Conservation, Government of Newfoundland and Labrador, Corner Brook. v + 12 pp.

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

Porsild's bryum (*Bryum porsildii* (I. Hagen) Cox & Hedderson) is a disjunct moss, which at the time of the preparation of the status report (COSEWIC 2003) was known to occur at 11 locations across Canada. In eastern Canada six of these locations are found on the northernmost tip of the Great Northern Peninsula of Newfoundland. The nearest population to the Newfoundland localities is the Keweenaw Peninsula, Michigan.

Although there are no direct threats specified for this moss in Newfoundland, the small population size makes it vulnerable to extirpation by stochastic events. The species was assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2003 as a Threatened species, and listed as this status under the Newfoundland and Labrador Endangered Species Act in 2005. The recovery goal for Porsild's bryum is to ensure long-term persistence of the natural populations in its Newfoundland range.

This recovery plan outlines seven recovery objectives for Porsild's bryum: 1) to better understand the biology and ecology, 2) to determine the distribution and abundance of Porsild's bryum, 3) to monitor the populations, 4) to provide appropriate habitat protection, 5) to assess anthropogenic and natural threats, 6) to carry out ex-situ conservation and transplantation as necessary, and 7) to carry out appropriate stewardship and protection.

Based on these recovery objectives, 12 recovery actions have been proposed. Due to the remoteness of the locations and the apparent lack of immediate threats, none of these actions have been considered urgent.

PART I. BACKGROUND

1. Species Information

Common Name:	Porsild's Bryum
Scientific Name:	*Bryum porsildii* (I. Hagen) Cox & Hedderson = Mielchoferia macrocarpa (Hook.) Bruch & Schimp.
Assessment Summary:	COSEWIC, November 2003 (New)
Provincial Legal Status:	Threatened
Reason for Designation:	A rare moss with a severely fragmented distribution of 10 confirmed locations in Canada restricted to 5 general areas. The species grows in mainly mountainous areas on wet calcareous cliffs, presence of constant seepage and winter desiccation. Direct threats to populations include natural and human-caused events that destabilize the rock cliff habitat. There has been a recent decline in habitat quality at the two most abundant locations and substantial loss of mature individual plants at one of these. Only one locality is protected. There is uncertainty in the status of northern Canadian populations.
Global Occurrence:	NL (Great Northern Peninsula of Newfoundland). In Canada ,also NU, BC, AB. In the US known from AL, CO, MI, WA. Also in central Asia.
Status History:	Assessed as Threatened by COSEWIC in November 2003 based on a new status report (COSEWIC 2003). Listed as Threatened under the Newfoundland and Labrador Endangered Species Act in January 2005.

2. Distribution

Porsild's bryum belongs to a suite of moss species that show wide gaps in their North American distribution. In Canada, the species occurs at isolated locations in Alberta, British Columbia, Ellesmere Island, and Newfoundland. Elsewhere in North America, Porsild's bryum occurs in Michigan (Keweenaw Peninsula), Montana, Colorado, and Alaska. The distribution pattern (Figure 1) is believed to reflect ice extent during the last glaciation, such that species may have survived the last glaciation in unglaciated enclaves in both eastern and western North America (Belland 1987).

In Newfoundland, Porsild's bryum occupies a small range at the northernmost tip of the Great Northern Peninsula, where it is found associated with cliff habitats along the coast from Cape Onion east to Noddy Bay. The species was first reported for the island from Straitsview by Terry Hedderson in 1982 (Hedderson *et al.* 1982) and subsequently reported from Cape Onion (Brassard & Hedderson 1983). COSEWIC (2003) reported the species for the first time from two additional locations (White Cape and Noddy Bay). The species is not known to occur farther south along the Northern Peninsula, where potential sites with some characteristics similar to the species' more northern habitat are known to occur.

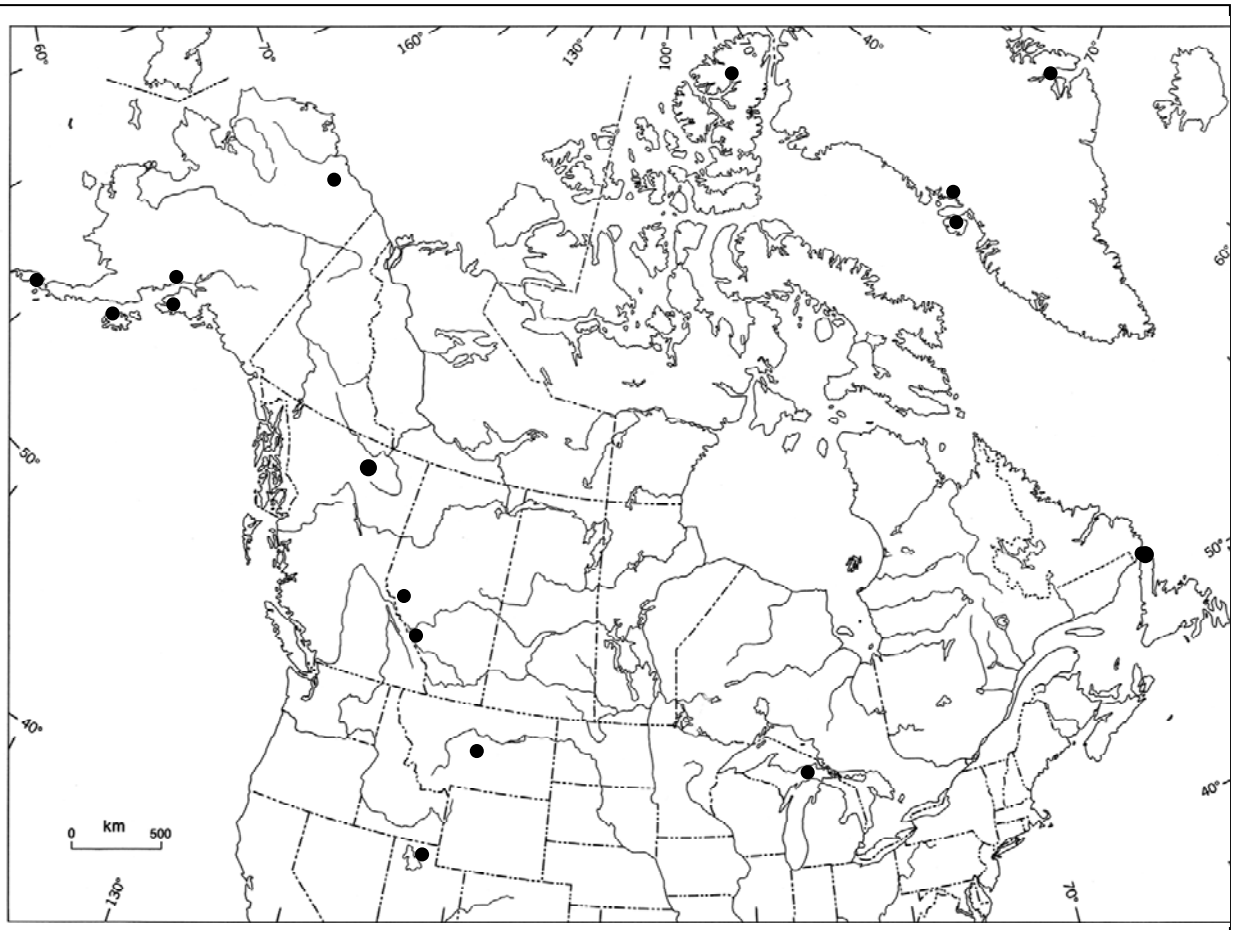

Figure 1. The North American distribution of the Porsild's Bryum (*Bryum porsildii* (I. Hagen) Cox & Hedderson) (from COSEWIC 2003). The Newfoundland dot covers 6 sites.

3. Population Size and Trend

There are no data available to establish long term habitat or population trends for the species in Newfoundland. COSEWIC (2003) indicated a minimum of 191 colonies at 6 sites, with an estimated total area for the colonies of ~959 cm^2 (minimum). The colonies were spread over an area somewhat greater than 18 m^2. Although the number of known sites increased in recent years, COSEWIC (2003) estimated a loss of approximately 190 colonies from the Newfoundland populations, based primarily on the almost total loss of the population at the Straitsview site. It was estimated that prior to 2002 the site harbored at least 200 colonies COSEWIC (2003), but a 2002 survey showed the population had been reduced to only 9 colonies by ice scouring and rock fall in the 2001/02 winter season.

4. Biological Limiting Factors

Intrinsic factors of Porsild's bryum biology and ecology, such as low/slow regeneration, limited dispersal ability, and narrow substrate requirement, limit the species (COSEWIC 2003). In addition, while not explicitly listed as a factor by (COSEWIC 2003), the narrow habitat specificity of the species is also important. Cleavitt (2001, 2002a, 2002b) gives details of the autecology of Porsild's bryum, some highlights of which are summarized in COSEWIC (2003).

***Regeneration*.** In regeneration experiments, Cleavitt (2002a) found that although the species produced sporophytes (spore producing structures) commonly in most populations, experimental germination of spores was usually very low: 56% on agar under controlled conditions and 0% on natural substrates in natural situations. Asexual reproduction by fragments was more successful under field conditions (25% regeneration) but much less so in the laboratory (8%).

Dispersal ability. Although COSEWIC (2003) cites limited dispersal ability of the species as a limiting factor, the evidence for this is indirect and based on the higher viability of fragments stored in air rather than in water. The argument is that since the species is always associated with streams or seepage (i.e., running water), then its most likely mode of dispersal would be via water. However, since fragment viability in water is low, it is surmised that dispersal ability must also be low.

Narrow substrate requirements. Porsild's bryum was previously considered to belong to a group of mosses collectively known as "copper mosses", characterized by their association with soils/rock that show higher than normal heavy metal concentration. Indeed, Shacklette (1967) documented one Alaskan population of Porsild's bryum growing on basalt, a rock that typically has higher than average heavy metal concentrations. Published details of the species substrate requirement show, however, that Porsild's bryum occurs mainly on calcareous substrates although the species can occur on a wide diversity of rock types, including limestone, sandstone, basalt and shale (Brassard & Hedderson 1983; COSEWIC 2003). Moreover, Cleavitt (2001) has demonstrated that the species may be a true "calciphile" and that it has a physiological intolerance to acidic rock types.

***Narrow microsite requirement*.** The species also has restricted microsite requirements. In all sites where it is found, the species occurs in microsites that are kept damp or wet from either seepage or splash (Brassard & Hedderson 1983). Cleavitt (2002b) notes also that, at her study sites, the microsites become dry with the onset of winter freezing, an observation noted earlier by Flowers (1973) for populations in Utah. This suggests that the species may be physiologically adapted to, and even require, a period of winter desiccation.

5. Threats

COSEWIC (2003) listed changes in stream hydrology (especially siltation), resource extraction, and road development as direct threats to Porsild's bryum populations. These threats are relevant mainly to western Canada populations. No direct threats are mentioned for any of the populations in Newfoundland (COSEWIC 2003). However, since the D1 and D2 criteria (small population size) were used in the assessment criteria, the influence of stochastic events on species with small population size was considered to be important. This is certainly true for the Newfoundland populations, in view of the loss in 2001/02 of the largest populations to natural events (ice scouring and rock fall).

A deterioration of habitat quality, such as changes in the quantity and chemistry of seepage water, could potentially become a threat to this species throughout its range. Climate change would likely affect the quantity of seepage water.

6. Habitat Requirements

The specific, microsite habitat requirements for Porsild's bryum have been summarized previously (section 4). At a larger scale, the species' narrow range and restriction to the tip of

the Great Northern Peninsula suggests the species survives within a narrow climatic regime. The species' Newfoundland range falls on the boundary of the hemiarctic and subarctic zones (Damman 1983). The hemi-arctic zone is a transitional boreal sub-zone consisting of a mosaic of taiga and tundra along the northern edge of boreal forest. This presence of the hemi-arctic zone is unique in Newfoundland, where it marks its southernmost extent in eastern Canada. The species' pattern of occurrence parallels that observed in western Canada, where the species occurs mainly in upper sub-alpine regions, near treeline, in areas that can be considered transitional between the alpine and sub-alpine zones. Similarly, the Great Lakes locality is well-known for its disjunct arctic, sub-arctic and alpine plants, many of which persist in part because of the climatic effects of Lake Superior (see for example, www.**keweenaw**land.com/michigan_state/debrab.pdf).

In recent work on the moss flora of the Gulf of St. Lawrence region, Belland (2005) showed that climate (especially as represented by degree-days) is the most important factor explaining moss distribution. Using multivariate analysis, Belland showed distributions to follow a strong S-N climatic gradient running through the region, modified by physiography and geology. In particular, the Great Northern Peninsula was characterized by the largest number of indicator species, mainly arctic/alpine and montane moss elements that are associated with the cool climate and also with calcareous substrates in the region.

The present occurrence of Porsild's bryum in Newfoundland can also be explained by a combination of both climate requirements and autecology of the species. While the hemiarctic region covers a relatively large extent of northern Newfoundland, the species' low dispersal ability, low colonization ability, tendency to grow on calcareous substrate, and restriction to seepage or splash all constrain the species to survival in a narrow, well-defined habitat type. Since there are few areas that demonstrably possess all the characteristics necessary for the survival of Porsild's bryum, all sites in which the species is found can be considered as critical habitat. Since critical habitat appears to be rare based on current knowledge, this suggests that the species has always been rare and has existed as relatively small populations.

7. Ecological Role

Porsild's bryum is one of a suite of arctic or montane mosses that are characteristic of the hemi-arctic vegetation of the Great Northern Peninsula. Other significant species are *Desmatodon leucostoma* and *Mielichhoferia elongata*. These are, like Porsild's bryum, mainly restricted to the northernmost tip of the Northern Peninsula and they occur in some of the same sites (*M. elongata* is also found at Mosquito Harbour, on the Newfoundland South Coast).

Several other arctic-alpine mosses are found in the same sites, or nearby, as those of Porsild's bryum. They include *Amblyodon dealbatus*, *Aulacomnium turgidum*, *Bartramia ithyphylla*, *Dicranoweisia crispula*, *Dicranum angustum*, *Dicranum groenlandicum*, *Hypnum bambergeri*, *Plagiobryum zierii*, *Pseudoleskeella papillosa* (R.J. Belland personal data files). Many of these species are considered to be refugial species that survived the last glaciation close to the areas where they are found today (Belland 1987).

8. Importance to People

The Great Northern Peninsula has long been known to botanists for its unique and varied flora (see reviews in Belland 1987, Rousseau 1974), where the focus has been mainly on the limestone barrens. This habitat is well-known for its arctic-alpine flora, and harbors the largest assembly of such plants south of the Arctic in eastern Canada. The Great Northern

Peninsula limestone barrens represent also the most extensive example of such habitat in Atlantic Canada.

None of the Porsild's bryum sites are in the limestone barrens. However, many arctic-alpine plants are also found in its local area. This latter flora, in combination with that of the limestone barrens, presents a remarkable diversity of arctic and alpine species that represents the result of a unique combination of climate, physiography, geology, and migrational history (Belland 2005).

While the limestone barrens have garnered the greatest botanical and ecological interest, the significance of the entire region, including the range of Porsild's bryum, should be emphasized in discussions of ecotourism, stewardship, or similar endeavors that may involve the natural resources of the region.

9. Actions Already Completed or Underway

Due to the remoteness of the locations and the apparent lack of immediate threats, few recovery actions have been initiated to date. An inventory of the Porsild's bryum sites was initiated in 2002 (COSEWIC 2003).

10. Knowledge Gaps

Several gaps exist in the knowledge about *Bryum porsildii* in Newfoundland, specifically:

1) total population size
2) number of sites within the known range of the species
3) data documenting the substrate and moisture chemistry, climate, and biological factors that limit the species range and occurrence in the region
4) specific threats, anthropogenic or natural, and their potential impacts
5) land ownership at Porsild's bryum sites

Additional information to fill these gaps can be gathered through inventory surveys, monitoring, ecological, geological, geochemical and climatic research, land ownership investigations and threat assessment.

10.1. Survey and Monitoring

Surveys should be initiated to obtain a complete and detailed inventory of the species occurrence within the Newfoundland range where it is currently found. Information gathered should focus on establishing a georeferenced data baseline that can be used specifically to monitor and assess short/long term population trends and habitat changes. Although COSEWIC (2003) gives some population and habitat information for the Newfoundland sites, there is not enough detail for monitoring purposes.

In addition, suitable sites farther south along the Northern Peninsula should be searched for undocumented populations of the species, in particular in the limestone areas of St. John's Highlands, and possibly also in Gros Morne National Park (Western Head, seaward cliffs of Lookout Hills). The basalt portions of the White Hills, Chimney Cove, and Gros Morne National Park (Green Gardens), and the calcareous coastal areas of Southern Labrador, and Belle Isle offer additional possibilities.

10.2. Ecological/Biological/Climate Research

Detailed habitat requirements must be researched in the Newfoundland part of Porsild's bryum's range. Of particular interest are the microclimate limitations of the species and the rate at which the species recovers after the habitat degradation. The former will further constrain the definition of critical habitat for the species, and the latter will help estimate the resilience of the species to disturbance.

Studies should be initiated to determine, in particular, the species' substrate requirements and other microsite/habitat parameters, including microclimate, which would aid in developing a model to predict future population trends in the context of climate warming/change. This study could be modeled after work by Hedderson & Brassard (1990) who studied the microsite requirements of rare species in Terra Nova National Park. An important aspect of this study was the collection of data from sites where the species of interest were not found (i.e., negative data).

Site data could be used to predict trends under varying climatic conditions. In particular, since the species appears to occupy a narrow climatic range, the species may be sensitive to climate change. Therefore long term studies of the effects of climate change may be useful in determining future population trends. Climate research is being conducted for the limestone barrens, and the applicability of this research to Porsild's bryum sites should be investigated.

COSEWIC (2003) suggests initiating a study at the Straitsview site to determine the rate of re-establishment of the species there. Such data would be helpful to determine the impact of stochastic events (e.g., rock falls) on the long-term survival prospects for the species in the region and would also be useful in determining how much, if any, intervention is required to ensure the persistence of the species.

While not critical to recovery, a DNA study of the genetic relationship of the Newfoundland populations to other North American populations would provide insight on their origin of their disjunct distribution pattern. Such a study is possible since recent material is available from all Canadian sites where the species is known. Cleavitt collected material from Newfoundland and British Columbia in preparation of the COSEWIC (2003) report. More recently Belland and Doubt (2005) collected material from Ellesmere Island, and material from Alberta has also been collected.

10.3. Threat Clarification

There were no threats identified in the status report (COSEWIC 2003) for Porsild's bryum in its Newfoundland range. Both natural threats and threats induced by human activity need to be identified, evaluated and addressed by appropriate mitigative measures, if necessary.

10.4 Land Ownership Investigations

The land ownership of Porsild's Bryum sites is currently unknown. It is likely that most, if not all, are located on crown land as the species occurs on cliffs directly adjacent to the ocean. However, a search should be conducted to determine whether any of the sites are located on private land. For any sites on private land the land owners should be identified and contacted.

PART II. RECOVERY

11. Recovery Goal

The recovery goal for Porsild's bryum is to ensure long-term persistence of the natural populations in its Newfoundland range.

Two factors directly affect recovery for this species. The first is that direct, human induced threats to the species have yet to be identified in the region. The second is that current knowledge of the species critical habitat suggests that the species has always been rare and has existed as relatively small populations.

Therefore, maintaining species populations at stable levels will depend on ensuring the continued existence of required habitat by implementing measures that safeguard these sites, i.e., by preventing human activities that might significantly impact them. Furthermore, a fuller understanding of the limiting factors in the species' biology will provide the background information needed to fully characterize Porsild's bryum habitat (including potential habitat), and enable managers to select those sites that need safeguarding.

12. Recovery Objectives

Recovery actions undertaken over the next five years should address the following seven objectives towards the achievement of the long-term recovery goal.

I. To better understand the biology and ecology
II. To determine the distribution and abundance of Porsild's bryum
III. To monitor the populations
IV. To provide appropriate habitat protection
V. To assess anthropogenic and natural threats
VI. To carry out ex-situ conservation and transplantation as necessary
VII. To carry out appropriate stewardship and protection

13. Strategies to Address Recovery Objectives

Priority	Objectives	Actions	Specific Steps	Key Performance Indicators
Necessary	II	Biological surveys	• Survey potential habitat within and around the species' known range to determine complete distribution and population size • Identify and map areas where the species occurs	1. Complete survey of potential habitat within the known range 2. Detailed estimate of population size 3. Geo-referenced data and maps available to managers, stakeholders and enforcement officers
Necessary	I	Ecological research	• Determine the ecological requirements of the species • Identify limiting factors and natural threats, including climate change	1. Description of ecological requirements of the species 2. List of limiting factors and natural threats and their actual and potential effect
Necessary	III	Monitoring	• Establish long term monitoring of selected populations	1. Establishment of monitoring plots 2. Maintenance of an ongoing record of population trends
Necessary	I	Demographic research	• Initiate re-establishment study at Straitsview site to determine rate and success of natural re-colonization	1. Determination of species resilience to disturbance
Beneficial	V	Threat assessment	• Identify potential natural and anthroprogenic threats • Assess the potential impact of each threat	1. Identification of threats 2. Ranking of threats based on an estimate of predicted impact
Beneficial	VI	Ex-situ conservation	• Study the possibility of ex-situ conservation.	1. Collection of material 2. Storage and Propagation in Memorial University Botanical Garden
Beneficial	VI	Transplanting	• Study the possibility of transplantation of ex-situ material to more stable substrates	1. Transplantation of material to alternate areas in its natural range 2. Regular monitoring of transplant sites for establishment success

Priority	Objectives	Actions	Specific Steps	Key Performance Indicators
Beneficial	IV	Habitat protection	• Identify and delineate Critical Habitat and appropriate protection measures	1. Map of Critical Habitat 2. List of protection measures required at each site 3. Initiation of protection process at each site
Necessary	VII	Land ownership investigations	• Determine land ownership at each Critical Habitat area	1. Determination of land ownership 2. Application of appropriate protection measures
Necessary	VII	Stewardship and protection	• Inform land managers, land users and conservation officers of the species and its Critical Habitat • Patrol Critical Habitat areas	1. Creation of awareness of the species' Critical Habitat among land conservation officers, land managers and land users 2. Monitoring of Critical Habitat areas on a regular basis for the purpose of protection
Beneficial	I	Climate research	• Investigate the applicability of existing climate research and climate change model to Porsild's bryum	1. Evaluation of the applicability of existing climate research and climate change models
Beneficial	I	Genetic research	• Determine relationship of Newfoundland populations to others in Canada (i.e. historical factors limiting large scale distribution)	1. Description and discussion of genetic variability within and between Canadian populations

14. Ecological and Technical Feasibility of Species Recovery

The actions in this recovery strategy are eminently possible since the methodology exists and has been used in other studies (e.g., Hedderson & Brassard 1990), including recovery efforts of vascular plants (e.g., Djan-Chékar *et al.* 2003). A significant investment in time and resources will be required, however, to conduct the initial surveys, and to establish the monitoring sites and protocols.

Porsild's bryum will always remain rare and its survival is dependent upon the prevention of anthropogenic and natural threats. Minimizing human impact on Porsild's bryum habitats should not be a difficult task since use of coastal cliffs for any human activity is currently minimal. On the other hand, it will be much more difficult to mitigate the threat of climate change and sea level rise. Such a threat is longer term than the scope of this recovery plan. Nevertheless, collecting climatic data sooner may help indicate future climate trends for consideration in management options.

15. Potential Impacts of Recovery Strategy on Other Species/Ecological Processes

Calcareous cliffs that possess the characteristics needed to support Porsild's bryum are rare in eastern Canada. At least two other rare mosses are known to co-occur with Porsild's bryum, at least at some of the sites: *Miehlichhoferia elongata* and *Desmatodon leucostoma*. Both species occur only in this region of Atlantic Canada, and will benefit from the habitat protection afforded to Porsild's bryum. Moreover, studies conducted on Porsild's bryum will likely include these species as "associates" and in doing, will provide data toward an understanding of their biological limits as well.

Since the coastal cliffs on which Porsild's bryum grows appear to have no economic value to local residents, it is not likely that the recovery process will have a direct impact on local economies.

16. Evaluation

See key performance indicators in Section 13.

REFERENCES CITED

Belland, R.J. 1987. The disjunct moss flora of the Gulf of St. Lawrence region: glacial and postglacial dispersal and migrational histories. *Journal of the Hattori Botanical Laboratory* 63: 1-76.

Belland, R.J. 2005. A multivariate study of moss distributions in relation to environment in the Gulf of St. Lawrence region, Canada. *Canadian Journal of Botany* 83:243-263.

Belland, R.J. & J. Doubt. 2005. The occurrence of *Bryum porsildii* in the Tanquary Fiord area, Quttinirpaaq National Park of Canada, Northern Ellesmere Island: Summary of field work 2004. Unpubl. Report for Parks Canada, Nunavut Unit. 24 pp.

Brassard, G. R. & T. Hedderson. 1983. The distribution of *Mielichhoferia macrocarpa*, a North American endemic moss. *The Bryologis*t 86: 273-275.

Cleavitt, N.L. 2001. Disentangling moss species limitations: the role of substrate specificity for six moss species occurring on substrates with varying pH and percent organic matter. *The Bryologist* 104:59-68.

Cleavitt, N.L. 2002a. Relating rarity and phylogeny to the autecology of mosses: A comparative study of three rare-common species pairs in the Front Ranges of Alberta, Canada. Ph.D. thesis, Department of Biological Sciences, University of Alberta, Edmonton, AB.

Cleavitt, N.L. 2002b. Stress tolerance of rare and common moss species in relation to their occupied environments and asexual dispersal potential. *Journal of Ecology* 90:785-795.

COSEWIC, 2003. COSEWIC assessment and status report on Porsild's bryum *Mielichhoferia macrocarpa* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 22 pp. (www.sararegistry.gc.ca/status/status_e.cfm)

Damman, A.W.H. 1983. An ecological subdivision of the Island of Newfoundland, pages 163-206, *in* G.R. South (ed.), *Biogeography and Ecology of the Island of Newfoundland*. Junk, The Hague.

Flowers, S. 1973. *Mosses: Utah and the West*. Brigham Young University Press, Provo.

Hedderson, T.A., & G.R. Brassard. 1990. Microhabitat relationships of five co-occurring saxicolous mosses on cliffs and scree slopes in eastern Newfoundland. *Holarctic Ecology* 13: 134-142.

Hedderson, T., Brassard, G.R., & R.J. Belland. 1982. New or additional moss records from Newfoundland VIII. *The Bryologist* 85: 442-443.

Rousseau, C. 1974. Géographie floristique du Québec/Labrador. *Distribution des principales espèces vasculaires*. Travaux et documents du centre d'Etudes Nordiques. Les Presses de l'université Laval, Québec. 797 pp.

Shacklette, H.T. 1967. Copper mosses as indicators of metal concentrations. *U.S. Geological Survey Bulletin* 1198-G.