Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Boreal Felt Lichen (*Erioderma pedicellatum*), Atlantic Population, in Canada

Boreal Felt Lichen, Atlantic Population

May 2007

Environment Canada Environnement Canada

Canada

About the *Species at Risk Act* Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is *"to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency, and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (www.sararegistry.gc.ca/the_act/default_e.cfm) spell out both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the SARA Public Registry (www.sararegistry.gc.ca/) and the Web site of the Recovery Secretariat (www.speciesatrisk.gc.ca/recovery/).

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Additional copies:

Additional copies can be downloaded from the SARA Public Registry (www.sararegistry.gc.ca/).

Cover illustration: Boreal felt lichen on balsam fir, eastern shore, Nova Scotia. Photo by Robert Cameron.

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DECLARATION

This recovery strategy has been prepared in cooperation with the jurisdictions responsible for the boreal felt lichen. Environment Canada has reviewed and accepts this document as its recovery strategy for the boreal felt lichen, as required under the *Species at Risk Act*. This recovery strategy also constitutes advice to other jurisdictions and organizations that may be involved in recovering the species.

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.

This recovery strategy will be the basis for one or more action plans that will provide details on specific recovery measures to be taken to support conservation and recovery of the species. The Minister of the Environment will report on progress within five years.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment Canada or any other jurisdiction alone. In the spirit of the Accord for the Protection of Species at Risk, the Minister of the Environment invites all responsible jurisdictions and Canadians to join Environment Canada in supporting and implementing this strategy for the benefit of the boreal felt lichen and Canadian society as a whole.

RESPONSIBLE JURISDICTIONS

Federal:
Environment Canada
Canadian Wildlife Service – Atlantic Region

Provincial:
Nova Scotia Department of Natural Resources
New Brunswick Department of Natural Resources

AUTHOR

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CONTRIBUTORS

The development of this strategy was led and funded by Canadian Wildlife Service – Atlantic Region (Environment Canada) and the Nova Scotia Department of Natural Resources, in cooperation with the New Brunswick Department of Natural Resources. Staff from these agencies invested a great deal of time in the development of this document. The Recovery Team for the Atlantic population of boreal felt lichen has contributed extensively to the writing of this recovery strategy. The members of the Recovery Team include Robert Cameron (Co-chair), Nova Scotia Department of Environment and Labour; Mark Elderkin (Co-chair), Nova Scotia Department of Natural Resources; Andrew Boyne, Environment Canada; Sherman Boates, Nova Scotia Department of Natural Resources; David Richardson, Saint Mary's University; Wolfgang Maass, Retired Research Scientist; Tom Neily, Independent Consultant; Francis Anderson, Independent Consultant; Heather Stewart, Nova Scotia Community College; Pascal Giasson, New Brunswick Department of Natural Resources; and Stephen Clayden, New Brunswick Museum (Observer). Other contributors include Ian DeMerchant, Canadian Forest Service; Tracey Inkpen, Environment Canada; Kim Mahwinney, Environment Canada; Julie McKnight, Environment Canada; Carolyn Seburn, Environment Canada; and Kamila Tomcit, Nova Scotia Department of Environment and Labour.

STRATEGIC ENVIRONMENTAL ASSESSMENT

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below.

This recovery strategy will clearly benefit the environment by promoting the recovery of the boreal felt lichen (Atlantic population). The potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. The reader should refer to the following sections of the document in particular: Description of the species, Description of the biological needs of the species, Examples of activities that are likely to result in the destruction of the critical habitat, and Effects on other species.

RESIDENCE

SARA defines residence as: *a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating* **[Subsection 2(1)]**.

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted on the SARA public registry:
www.sararegistry.gc.ca/plans/residence_e.cfm

PREFACE

The boreal felt lichen (Atlantic population) is under the management jurisdiction of provincial governments. The *Species at Risk Act* (SARA, Section 37) requires the competent minister to prepare recovery strategies for listed extirpated, endangered, or threatened species. The boreal felt lichen was listed as Endangered under SARA in January 2005 and under the Nova Scotia *Endangered Species Act* in 2003. The Canadian Wildlife Service – Atlantic Region (Environment Canada) and the Nova Scotia Department of Natural Resources led the development of this recovery strategy, in cooperation with the New Brunswick Department of Natural Resources. The strategy meets SARA requirements in terms of content and process (Sections 39–41). It was developed in cooperation or consultation with:

- Aboriginal groups –
  Confederacy of Mainland Mi'kmaq
  Maritime Aboriginal People's Council
  MAWIW council
  Millbrook First Nation
  Native Council of Nova Scotia
  New Brunswick Aboriginal People's Council
  Union of New Brunswick Indians
  Union of Nova Scotia Indians

- Environmental non-government groups –
  The Nature Conservancy of Canada, Atlantic Region
  The Nature Trust of New Brunswick

- Industry –
  Bowater
  H.J. Crabbe & Sons Ltd.
  J.D. Irving Ltd.
  Neenah Paper
  New Brunswick Federation of Woodlot Owners
  Nova Scotia Power
  Southern New Brunswick Forest Products Marketing Board
  StoraEnso North America
  York-Sunbury-Charlotte Forest Products Marketing Board

- Other
  Fundy National Park
  New Brunswick Department of Tourism and Parks
  Roosevelt Campobello International Park
  One private landowner

EXECUTIVE SUMMARY

Boreal felt lichen (*Erioderma pedicellatum*) is an endangered cyanolichen. This foliose lichen is most often found on balsam fir in cool, humid, oceanic climates. In 1902, the first sighting of boreal felt lichen in the world occurred on Campobello Island in New Brunswick, but the lichen has not been seen there since. The only known extant sites of the Atlantic population of boreal felt lichen occur in Nova Scotia.

Although 46 sites of boreal felt lichen had been documented in Nova Scotia between 1980 and 1995, only 1 of these sites remained by 2006. Using a geographic information system (GIS) algorithm, the Nova Scotia Department of Environment and Labour located a new site in 2004. In the interim, the algorithm has led researchers to discover seven more sites. As of March 2006, there were nine known occupied sites hosting a total of 31 boreal felt lichen thalli and many sites identified as potential habitat that had yet to be surveyed.

The Atlantic population of boreal felt lichen faces complex threats to its survival: the lichen is cryptic and difficult to identify; the size of the known population is small; air pollution, which contributed to the extirpation of boreal felt lichen from New Brunswick, is both locally occurring and transported from the United States; the species lacks charisma; and there is still much unknown about the species and its habitat. Yet there are also encouraging results from the GIS habitat algorithm, cooperative efforts with forestry companies, and the formation of a Recovery Team for the lichen.

The overall goal of this recovery strategy is a self-sustaining population of boreal felt lichen, Atlantic population, with no reduction of current range. The recovery activities endorsed in this recovery strategy will be carried out in part or in whole within the next five years (2006–2011). The objectives of the recovery strategy are to 1) maintain thalli and habitat at sites where boreal felt lichen is known to occur; 2) mitigate threats to boreal felt lichen; and 3) undertake research to fill knowledge gaps and refine the identification of critical habitat.

These objectives will be achieved through recovery actions that are delineated as research, monitoring, management, education, or stewardship. Recovery actions include the following:

Research

- Determine the life cycle, growth rate, life history, genetic diversity, population dynamics, and minimum viable population size.
- Identify critical habitat (features and characteristics of habitat that are limiting to the species' ability to recover).
- Identify sources of air pollution and the lichen's sensitivity to specific pollutants.
- Identify practices to mitigate human disturbances in and surrounding boreal felt lichen habitat.
- Explore methods of population and habitat enhancement.

Monitoring
- Monitor known occupied sites.
- Monitor threats.
- Monitor habitat characteristics at historical and unoccupied suitable habitat.

Management
- Manage boreal felt lichen habitat at a landscape scale.
- Review forestry management practices as they pertain to boreal felt lichen recovery.

Education
- Provide accessible, high-quality educational materials.
- Raise profile among pollution reduction programs.

Stewardship
- Foster cooperative relationships with landowners, foresters, industry, and volunteers.

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1. BACKGROUND

1.1 Species Assessment Information from COSEWIC

Date of Assessment: May 2002

Common Name: Boreal felt lichen (Atlantic population)

Scientific Name: *Erioderma pedicellatum*

COSEWIC Status: Endangered

Reason for Designation: A population restricted to regions with a cool, humid, oceanic climate, highly sensitive to atmospheric pollutants such as acid precipitation. It has experienced a dramatic decline of over 90% in occurrences and individuals over the last two decades due, in particular, to air pollution and other sources of habitat loss and/or degradation. Extirpation of the few remaining individuals at three sites is imminent.

Canadian Occurrence: New Brunswick, Nova Scotia

COSEWIC Status History: Designated Endangered in May 2002. Assessment based on a new status report.

1.2 Description

1.2.1 Description of the species

Lichens are distinct symbiotic organisms made up from the association of microscopic algae or cyanobacteria and filamentous fungi. Boreal felt lichen (*Erioderma pedicellatum*) is a foliose cyanolichen, with distinctive upturned edges that reveal white undersides. The range of colour of the lichen is determined by the hydration of the lichen body called the thallus. It appears bluish grey when moist and dark grey to greyish brown when dry. Boreal felt lichen most commonly measures 2–5 cm in diameter, although it can be up to 12 cm in diameter. This lichen has a generation time of approximately 30 years. Boreal felt lichen is vulnerable to atmospheric pollution. The habitat for boreal felt lichen occurs in cool, moist, maritime climates. New evidence suggests that the genus may be among the oldest of foliose lichens, perhaps well over 400 million years old (Maass and Yetman 2002).

Special significance

Boreal felt lichen has been coined the “panda bear” of the lichens, acting as a symbol of the immediate and very real threat to the world’s boreal forests (Maass and Yetman 2002). The ability of this species to indicate fluctuations in local air quality makes it valuable as an environmental indicator. Boreal felt lichen appears to have a unique and complex relationship with the liverwort *Frullania tamarisci* ssp. *asagrayana* (discussed in section 1.2.2), which scientists are only beginning to understand.

Global status

- IUCN (International Union for Conservation of Nature and Natural Resources) Red List of Threatened Species: Critically Endangered (Scheidegger 2003)
- NatureServe Global Conservation Status Rank: G1G2Q (Critically Imperiled/ Imperiled; Q = questionable taxonomy) [1]
- Rounded global status[2]: G1 (Critically Imperiled)

Provincial status

- New Brunswick: None
- Newfoundland and Labrador: Vulnerable (boreal population)
- Nova Scotia: Endangered

Populations and distribution

There are two Canadian populations of boreal felt lichen: the boreal population (Newfoundland and Labrador) and the Atlantic population (Nova Scotia and New Brunswick). The 2002 Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Report for boreal felt lichen attributes the distinction to "the fact that they occur in different ecological regions and are subject to different degrees of risk" (Maass and Yetman 2002: p. vii). The Atlantic population is currently found only in Nova Scotia and is believed to be extirpated from New Brunswick.

Boreal population of boreal felt lichen

COSEWIC lists the boreal population of boreal felt lichen as a species of Special Concern, although it is the largest and healthiest known population in the world. Newfoundland and Labrador's population is found mainly in the Avalon Forest and Maritime Barrens ecoregions in the southern half of the island of Newfoundland. The Newfoundland and Labrador Department of Environment and Conservation (2006) is currently preparing a draft management plan for the boreal population of boreal felt lichen. Although the boreal population faces a different degree of vulnerability to threats compared with the Atlantic population, this recovery strategy will provide a valuable tool for recovery planning for both populations.

This document and the recovery strategies discussed within it pertain to the Atlantic population of boreal felt lichen. For more information about the boreal population, consult the COSEWIC Status Report on boreal felt lichen (Maass and Yetman 2002) or visit www.sararegistry.gc.ca/.

Historic distribution of the global population of boreal felt lichen

The first recorded collection of boreal felt lichen occurred in 1902 on Campobello Island, New Brunswick, while the second record of boreal felt lichen was from Norway in 1938 (Clayden

[1] For more information see www.natureserve.org
[2] This value uses an algorithm to evaluate Conservation Status Ranks and systematically produces easier to interpret values without qualifiers or ranges (e.g. G1G2 becomes G1)

1997). Boreal felt lichen has likely been extirpated from Sweden and Norway (Goward *et al*. 1998). Significant efforts by researcher Wolfgang Maass yielded numerous new sites in both Nova Scotia and Newfoundland and Labrador (boreal population) during the 1980s.

Historic distribution of the Atlantic population of boreal felt lichen

Maass and Yetman (2002) recorded 46 sites with a total of 169 boreal felt lichen thalli in Nova Scotia between 1980 and 1995 (Figure 1). Surveying from 1995 to 2002 resulted in the location of only 13 boreal felt lichen thalli at 3 of the original 46 sites, suggesting a population decline (Maass and Yetman 2002). By March 2006, only one of the original sites supported boreal felt lichen.

Although the earliest recorded collection of boreal felt lichen in Canada was from New Brunswick, it is the only observation of the species in the province (Clayden 1997). Moreover, the possibility of finding new occurrences of boreal felt lichen in New Brunswick is believed to be low, given the apparent absence of indicator or associated cyanolichen species on conifers along the Bay of Fundy coast (New Brunswick Department of Natural Resources 2006). The Recovery Team is prepared to initiate recovery actions if there are reports of boreal felt lichen or its indicator species in the province.

Current distribution of the Atlantic population of boreal felt lichen

The only known extant sites of the Atlantic population of boreal felt lichen occur in Nova Scotia. As of March 2006, only 1 of the 46 Nova Scotia locations of boreal felt lichen identified by Maass and Yetman (2002) retained the lichen, but 8 new locations (all unknown when the 2002 COSEWIC Status Report was written) have been identified using habitat suitability maps and systematic surveying (Figure 2; Cameron and Neily 2006).

Figure 1. Distribution of the Atlantic population of boreal felt lichen prior to 1995 (from Maass and Yetman 2002).

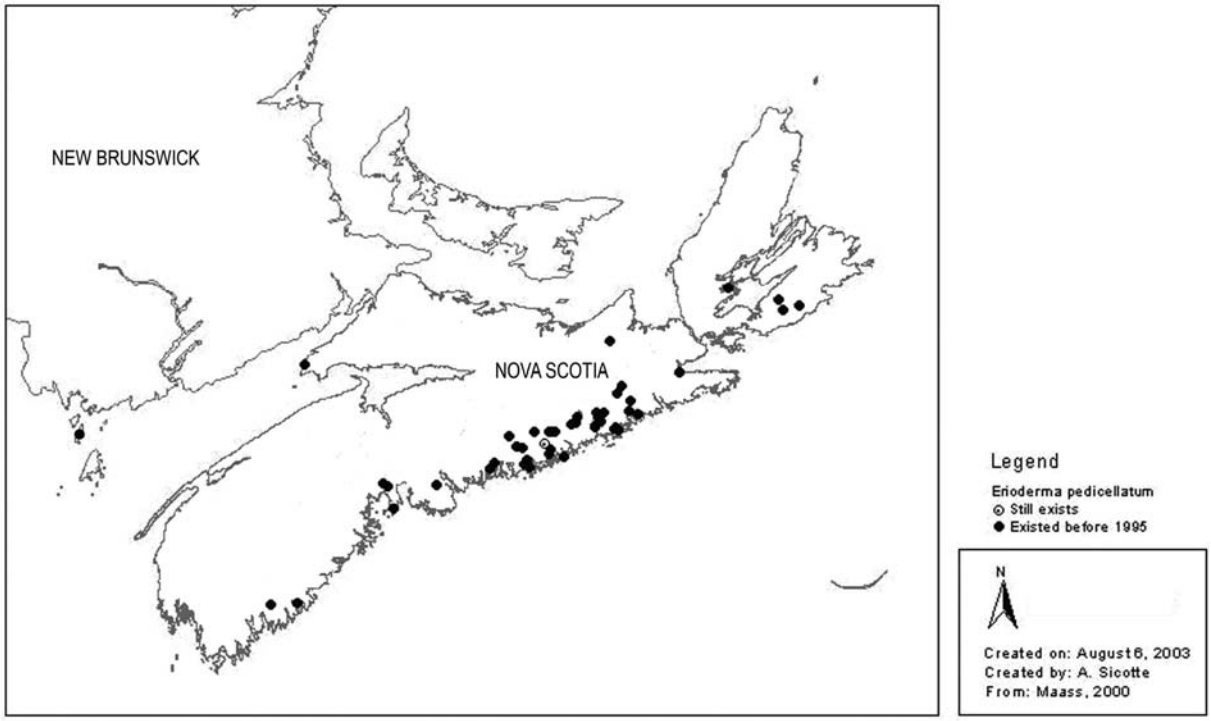
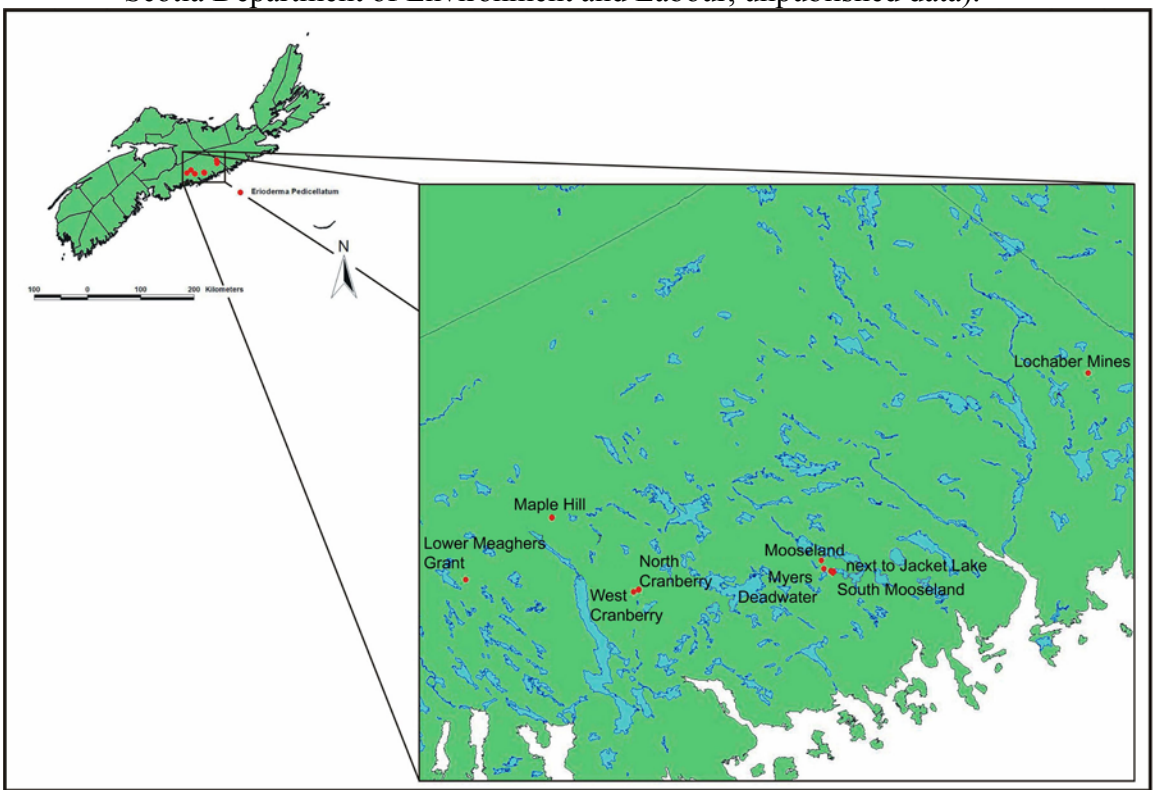


Figure 2. Distribution of the Atlantic population of boreal felt lichen as of March 2006 (Nova Scotia Department of Environment and Labour, unpublished data).



1.2.2 Description of the biological needs of the species

Biological needs, ecological role, and limiting factors

Life cycle

The life cycle of boreal felt lichen is not yet completely understood. In 1996, Christoph Scheidegger hypothesized that the life cycle of boreal felt lichen was linked to the ecological cycle of balsam fir (*Abies balsamea*) habitat (Clayden 1997; Maass and Yetman 2002). His hypotheses were that there is only one generation of *Erioderma* thalli per successional cycle of the balsam fir stand; that the growth rate of boreal felt lichen accelerates during the overmature to decaying phase of the forest (a phase lasting approximately 15–25 years) as a result of advantageous light conditions created by canopy gaps left by dead and decaying trees; that the lichen then releases spores to adjacent younger fir stands; and that a new cycle of boreal felt lichen begins within a few hundred metres of the initial population.

Reproduction and symbiosis

Lichens are formed by the association of a fungus with a bacterium. The bacterium is responsible for producing food for the organism through photosynthesis (Brodo *et al.* 2001). Boreal felt lichen is a cyanolichen, which means that its photosynthetic partner, or photobiont, is a cyanobacterium. *Scytonema* is the cyanobacterium associated with boreal felt lichen. Lichens are named for the mycobiont, the fungal partner, so *Erioderma pedicellatum* is the name that represents both the fungal partner and the lichen. Reproduction of the lichen is achieved sexually, initiated by the chance contact between a group of fungal spores and a strand of *Scytonema* (Maass and Yetman 2002).

While *Scytonema* can grow and reproduce independently, there is no evidence that the mycobiont, *Erioderma pedicellatum*, grows independently (R. Cameron pers. comm. 2006). If the mycobiont does grow independently, it would be theoretically possible for the lichen to regenerate spontaneously after being absent for a period of time, but only if there are *Erioderma pedicellatum* spores available (R. Cameron pers. comm. 2006). *Erioderma pedicellatum* produces spores only when in partnership with *Scytonema* (R. Cameron pers. comm. 2006).

The symbiosis between the photobiont and the mycobiont is complex; owing to the energy consumed by the initial joining of the partners, it is expected that the initial rate of growth is slower than when the lichen becomes visible at 2–3 mm in diameter. Preliminary results of linear growth rate investigations suggest that it takes 7–13 years for thalli to reach maturity once established, but these results are based on only 11 thalli (Cameron and Neily 2006). A more precise understanding of growth rate should emerge with more research.

An intriguing aspect of boreal felt lichen is its relationship with a liverwort, *Frullania tamarisci* ssp. *asagrayana*. The co-occurrence of boreal felt lichen and *Frullania*, coupled with the known occurrence of *Scytonema* within the water sacs of *Frullania*, has led some to suggest that the moisture-rich water sacs of *Frullania* act as a nursery to the lichenization of boreal felt lichen (Scheidegger 1996; Maass and Yetman 2002).

Limiting factors

Boreal felt lichen is biologically limited by the following factors: its globally limited distribution and small population size; its relationship with *Frullania tamarisci* ssp. *asagrayana*; its requirement for bark substrates of a specific acidity; the nature of its life cycle (boreal felt lichen does not produce any type of joint fungal–bacterial propagule; therefore, it must reestablish itself each generation from its separate components); and its apparent hypersensitivity to acidification of its substrates and/or to direct adverse effects of air pollutants such as nitrogen oxides and sulphur dioxide. It is necessary to determine whether or not the quality or quantity of forest habitat available is inherently limiting to boreal felt lichen recovery.

Habitat needs

Boreal felt lichen is relatively specialized in its habitat requirements. Thalli are typically found on north-facing trunks of mature and overmature balsam fir trees (Maass and Yetman 2002; Richardson and Cameron 2004). Suitability of the habitat for occupation by the lichen may be increased if the forest is located on slopes with northern or northeastern exposure. The high relative humidity of these habitats may also be suitable for growth of companion indicator species of beard and hair lichens, such as *Usnea* species, *Alectoria sarmentosa*, and *Bryoria* species (S.R. Clayden pers. comm. 2006). Other characteristics of known sites include cool, moist habitat conditions that remain relatively constant throughout the year, such as those adjacent to *Sphagnum*-rich wetlands that can maintain moisture levels during periods of drought (Maass and Yetman 2002). In Nova Scotia, boreal felt lichen has occasionally been found living on white spruce (*Picea glauca*) and red maple (*Acer rubrum*) substrates in mixedwood stands (Maass and Yetman 2002).

Limited observations suggest that boreal felt lichen most often occurs within 25 km of the sea coast at an elevation up to 500 m above sea level. Forest habitat is described by researchers as having low open crown closure due to natural forest dynamics. Many factors that affect the suitability of habitat for boreal felt lichen are not precisely known, including the temperatures and level of humidity that must be maintained within the habitat and the levels to which the lichen can withstand pollutants such as sulphur dioxide and nitrogen oxides. Regardless, clean air and clean water sources are considered important aspects of boreal felt lichen habitat. Thus, there is some critical but as yet undetermined distance surrounding boreal felt lichen habitat that is essential to the lichen's survival. Structural and functional features of forest habitat believed to be important include moisture retention, forest integrity (total cover, degree of fragmentation or patch continuity, age, composition, etc.), protection from weather events that may cause blowdowns, and the ability to intercept some local air pollution.

Indicator species

Coccocarpia palmicola and *Lobaria scrobiculata* (also cyanolichens) usually occur with boreal felt lichen and may be used as indicator species (Cameron and Richardson 2006).

1.3 Threats

Boreal felt lichen is cryptic and difficult to identify. The species lacks charisma, and there is still much unknown about the species and its habitat. Although these threats may be reduced somewhat through education and research, they contribute to the lichen's vulnerability to physical threats. Physical threats to boreal felt lichen and its habitat are discussed below.

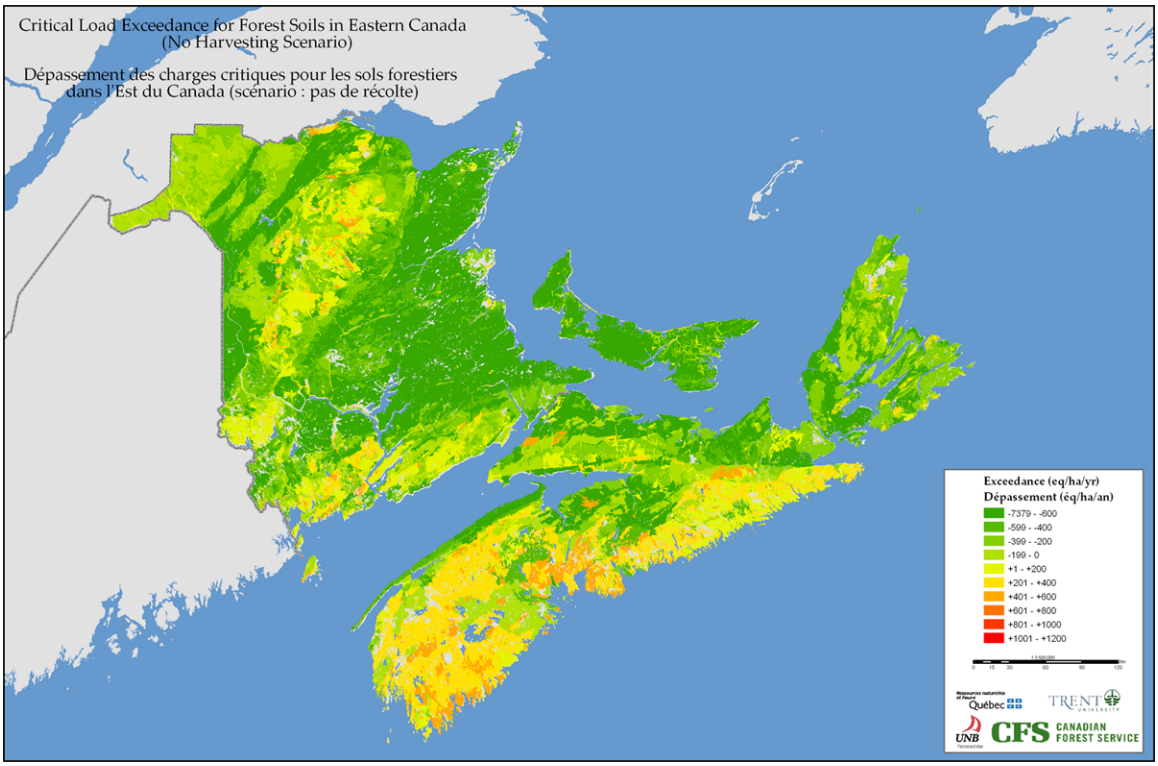
1.3.1 Acid precipitation/air pollution

Acid precipitation is destructive to boreal felt lichen in two ways: it causes immediate damage to the thallus through the uptake of air pollutants (cyanolichens' nitrogen-fixing enzyme is known to be intolerant of sulphur dioxide), the suggested cause of damage to the holdfast mechanism (observed by W. Maass); and it further acidifies the naturally acidic substrates on which the lichen lives, thereby reducing the buffering capacity of the lichen (Maass and Yetman 2002).

The decline in lichen populations has been documented to have occurred in the 1980s (Maass and Yetman 2002), despite the fact that emissions of sulphur dioxide in Canada and the United States actually decreased over this time due to government actions to reduce acid rain (Environment Canada 2004a). This raises the possibility that the lichen or its associated species are also being impacted by other air pollutants, such as nitrogen oxides (T. Inkpen pers. comm. 2006).

The amount of acid deposition that an area can tolerate is known as its critical load. It is calculated as acid equivalents per hectare per year (eq/ha per year). Most of Nova Scotia is highly or extremely acid sensitive (Figure 3). Airflow dynamics carry air pollutants originating from cities such as Boston and New York along the northeast Atlantic coast, as well as pollutants from coal-burning electricity generating stations in the midwestern United States. These pollutants, in addition to local pollution sources, result in acidified precipitation (Beattie *et al.* 2002; Richardson and Cameron 2004). Acid fog is created by the collision between the cold air masses over the Gulf of Maine and the Bay of Fundy and the warm, humid, pollutant-bearing air masses coming upward along the Atlantic coast (Cox *et al*. 1989). Investigation is required to pinpoint local sources.

Figure 3. Critical load exceedance for forest soils in eastern Canada (no harvesting scenario).



Boreal felt lichen populations in Nova Scotia occur in coastal areas subject to extended periods of acid fog, which increases the severity of the threat of acid precipitation to the lichen. The disappearance of boreal felt lichen from New Brunswick has been attributed to the impacts of acid precipitation (New Brunswick Department of Natural Resources 2006).

Initiatives to reduce acid precipitation are already in place through international actions under the Canada–United States Air Quality Agreement and domestic actions under the Canada-wide Acid Rain Strategy for Post-2000 (both documents available at www.ec.gc.ca). It is a recovery priority to better understand the impact of air pollution and acid precipitation on boreal felt lichen. Specific actions to help mitigate this threat are described in more detail in the Recovery section (section 2) and include identifying sources of air pollution and the lichen's sensitivity to specific pollutants; identifying both local and transboundary sources to determine their relative threats; determining practices to mitigate human disturbances in and surrounding boreal felt lichen habitat; monitoring threats (e.g., acid deposition); and alerting those implementing pollution reduction programs to boreal felt lichen so the species may be used to support their programs.

1.3.2 Forest management

Besides acid precipitation, forest practices are considered the other major threat to the Atlantic population of boreal felt lichen. Forest practices may cause fragmentation, alter the age structure, and simplify the biodiversity of forest stands. In Nova Scotia, even-aged management for spruce-dominated forest stands predominates (Canadian Council of Forest Ministers 2005). Entire

locations of boreal felt lichen may be destroyed by large-scale clearcutting, particularly if the presence of boreal felt lichen has not been identified.

The effect of forest fragmentation on epiphytic lichens has been the subject of much work (Esseen and Renhorn 1998; Rheault *et al*. 2003; Pykala 2004; Richardson and Cameron 2004). When lichens are suddenly at the edge of a forest or in a fragmented forest, there is a reduction in dispersal ability and opportunity to recolonize in cutover areas (Rheault *et al.* 2003). Large-scale logging also greatly reduces the ability of a forest stand to buffer against times of low humidity (Maass and Yetman 2002). Some researchers suggest that this was the cause of boreal felt lichen extirpation from Vãrmland, Sweden, where logging took place in the immediate vicinity of the park where boreal felt lichen thalli were known to occur (Maass and Yetman 2002).

In 2005, at the oldest known boreal felt lichen site in Nova Scotia, a lone thallus on the west side of the site was lost to a blowdown (Cameron and Neily 2006). Although blowdowns are not an infrequent event, an adjacent clearcut (estimated to have occurred in 2000 or 2001) likely increased the vulnerability of this site to blowdowns and drought.

In Nova Scotia, harvested stands are usually replanted with unsuitable phorophytes that have more acidic bark than balsam fir, such as black spruce (*Picea mariana*), white spruce, red spruce, and Norway spruce (*Picea abies*) (Canadian Council of Forest Ministers 2005). Even-aged tree plantations are also not favourable to the establishment of new colonies of *Scytonema*, *Frullania*, or juvenile boreal felt lichen because of their low light conditions (Maass and Yetman 2002).

Communication and information sharing with the forestry industry in Nova Scotia are keystones to recovery efforts. Efforts made to alleviate the threat posed to boreal felt lichen by forestry management will be outlined in greater detail in the Recovery section (section 2) and include reviewing literature and best management practices for forest management as they pertain to boreal felt lichen; communicating with stakeholders to develop practical forest practices and recommendations for areas surrounding the lichen and its potential habitats; developing a voluntary stewardship agreement for use with landowners; and offering training to volunteers and foresters to identify boreal felt lichen and potential habitat.

1.3.3 Pest control and the use of harmful aerial sprays

The COSEWIC Status Report for boreal felt lichen outlines the threat posed to a boreal population colony by trichlorfon, a spray reagent approved and considered to eliminate the yellow-headed spruce sawfly (*Pikonema alaskensis*) in 1998 (Maass and Yetman 2002). Because the thallus of boreal felt lichen does not repel water well, the liquid chemical is able to access and damage the cellular membranes of the lichen (Maass and Yetman 2002). Although a far less harmful agent was chosen (azadirachtin, an extract from the Indian neem tree (*Azadirachta indica*)), Maass and Yetman (2002) suggested that trichlorfon would most likely have decimated the area colonies.

There are no records of either of these agents being used in Nova Scotia (W. Fanning, NSDNR, pers. comm. 2006), but trichlorfon was used in New Brunswick in the 1970s (Mitchell and Roberts 1984). The most recent record of its use in New Brunswick was in a small-scale

experiment in 1996 (N. E. Carter, NBDNR, pers. comm. 2006). Both provinces scrutinize all decisions surrounding the use of aerial sprays.

It is often difficult to predict the relative threats to boreal felt lichen of the aerial spray and the pest itself, and every situation may be different (Maass and Yetman 2002). Awareness of any potential pests in the vicinity of boreal felt lichen sites and participating in consultations to deal with such pests will ensure that boreal felt lichen will be considered when deciding whether, where, and what to spray. Environmental protection agencies must be informed of boreal felt lichen's presence so it will be protected from such threats.

1.3.4 Climate: Droughts, hurricanes, forest fires, global warming

Based on field observations, boreal felt lichen cannot endure the desiccation that accompanies extreme weather events such as droughts and hurricanes (Maass and Yetman 2002). A severe storm in Guysborough County, Nova Scotia, created a windfall that destroyed one of the boreal felt lichen populations discovered in the 1980s (Maass and Yetman 2002).

Forest fires may directly destroy boreal felt lichen, and they may also have indirect effects, because nitrogen-fixing lichens (including all cyanolichens) downwind of forest fire smoke can be destroyed by the small concentration of sulphur dioxide contained in the smoke (Maass and Yetman 2002).

Although it is difficult to quantify the effects of global warming on lichens, it is expected that they include reductions in range distributions (Maass and Yetman 2002). Lichens with affinities to particular tree species and lichens that require cool, moist habitats, such as boreal felt lichen, may be particularly sensitive to climate change (Maass and Yetman 2002).

Climatic changes are occurring, and boreal felt lichen may be susceptible to damage from these threats. The best protection against climatic threats that can be offered is to maintain a protective area around lichen sites and to monitor the effects of these events to guide future management decisions. To reduce the impact of climatic threats to boreal felt lichen, human disturbances in and surrounding boreal felt lichen habitat must be mitigated.

1.3.5 Effects of herbivory on the growth of balsam fir seedlings

The 2002 COSEWIC Status Report for boreal felt lichen (Maass and Yetman 2002) discusses the effects of moose browsing on balsam fir, but all observations were reported from Newfoundland and Labrador. In the vicinity of the known Atlantic population locations, there are no recorded observations of moose browsing on balsam fir seedlings. Moose are present throughout both New Brunswick and Nova Scotia, but the mainland population of moose in Nova Scotia is provincially endangered. Any measures to protect boreal felt lichen must carefully consider implications for moose recovery on mainland Nova Scotia. At present, it will be adequate to monitor lichen sites for evidence of herbivory.

1.3.6 Microfauna herbivory

The COSEWIC Status Report for boreal felt lichen recorded that mites and snails have both been observed browsing on boreal felt lichen, and it suggests that they pose only a very minor threat to boreal felt lichen populations (Maass and Yetman 2002). When the Lower Meaghers Grant site was visited in 2004, a boreal felt lichen thallus at the site was being heavily grazed by gastropods (Cameron and Neily 2006). A collected specimen was later identified as *Arion subfuscus*, a non-native introduction from Europe (Cameron and Neily 2006). It is not clear whether this single instance could be considered a population-level threat. Any additional observations of grazing will be recorded and assessed for evidence that such grazing requires further study or action.

1.3.7 Land development

The development of land for activities such as industry, residences, forestry, and agriculture creates disturbance and landscape alterations and also provides access to remote areas for people (Maass and Yetman 2002). The level of threat to boreal felt lichen from land development fluctuates as new sites are discovered and accessibility to sites changes. Boreal felt lichen habitat is protected by the federal *Species at Risk Act* and the Nova Scotia *Endangered Species Act* (NSESA). Specific actions to mitigate this threat include the identification of critical habitat, education, and voluntary stewardship agreements.

1.4 Knowledge Gaps

Knowledge gaps for boreal felt lichen include detailed information on its life cycle, growth rate, life history, genetic diversity, population dynamics, minimum viable population size, sensitivity to individual air pollutants and acid deposition, and sensitivity to specific forest practices. Critical habitat and the importance of unoccupied potential habitat must also be determined. The characteristics and quality of habitat required by boreal felt lichen and the relevant scale of threats to its habitat are not known; it is also not known how these threats to its habitat limit the species' ability to recover.

2. RECOVERY

2.1 Recovery Feasibility

Recovery of the Atlantic population of boreal felt lichen is believed feasible, although the challenges are formidable and the results of overcoming them uncertain. The Atlantic population of boreal felt lichen has an extremely small population size, with only nine sites known as of March 2006 and a total of 31 thalli (Cameron and Neily 2006). The small population size limits the ability of experimental studies to generate meaningful results. With a 30-year generation time, positive results of recovery efforts may not be apparent in the short term. Air pollution originating from coal-burning electricity generating plants and urban centres in the U.S. Midwest is believed to have been a significant factor in the disappearance of boreal felt lichen from New Brunswick (New Brunswick Department of Natural Resources 2006). There are significant challenges associated with reducing air pollution, especially outside Canada.

Although air pollution and forestry management practices are considered the most significant threats, the location and investigation of new discoveries of occupied boreal felt lichen sites may indicate that the additional threats listed in section 1.3, such as herbivory and land development, must be actively mitigated. The impact of droughts, hurricanes, and forest fires can be swift and irrevocable for boreal felt lichen. It is also difficult to predict the presence of a pest that may cause boreal felt lichen to be threatened by a chemical pesticide or herbicide.

Overcoming some of these challenges is possible. A coarse quality filter approach to identifying potential habitat in the form of a habitat algorithm is in development. The geographic information system (GIS) algorithm has identified approximately 188 000 ha within Nova Scotia that may represent suitable habitat (Cameron and Neily 2006). Because eight of the known occupied sites that have been identified since 2004 were located using habitat suitability mapping (Cameron 2004), more sites may be discovered as they are surveyed and as the algorithm is further developed and verified. Two of the known occupied sites have both juvenile and mature thalli, indicating that reproduction is occurring (Cameron and Neily 2006).

Air pollution and forestry management practices have the most potential to harm boreal felt lichen. Air pollutants such as sulphur dioxide and nitrogen oxides are a threat to the health of many other species, including humans, which has resulted in a greater awareness of the problem. Boreal felt lichen benefits from pollution prevention campaigns and industrial technologies to reduce emissions. The forestry industry has already taken an interest in the protection of this lichen, and its input will lead to practical recommendations for forestry practices in the vicinity of boreal felt lichen habitat and unoccupied potential sites.

Cooperative research with managers of the boreal population should enable a number of the knowledge gaps to be filled, resulting in an increased capacity to make management decisions for the Atlantic population. Recovery efforts for boreal felt lichen are seldom invasive or stressful for the species and result in only a low impact on the surrounding environment. If the impact and level of threat posed by acid precipitation and air pollution decrease or do not drastically increase, recovery of the Atlantic population is feasible

2.2 Recovery Goal

The overall goal of this recovery strategy is a self-sustaining population of boreal felt lichen, Atlantic population, with no reduction of current range. The size required for a self-sustaining population cannot be determined at this time due to limitations of the available data.

2.3 Recovery Objectives

The short-term objectives of the recovery strategy for the Atlantic population of boreal felt lichen in Canada from 2006 to 2011 are to:

1) maintain thalli and habitat at sites where boreal felt lichen is known to occur (currently nine sites with a total of 31 thalli);
2) mitigate threats to boreal felt lichen; and
3) undertake research to fill knowledge gaps and refine the identification of critical habitat.

2.4 Broad Strategy to Be Taken to Meet Recovery Objectives

The recovery strategies outlined in this section (Table 1) will facilitate the achievement of the recovery objectives. Recovery strategies will be identified as research, monitoring, management, education, or stewardship. To enable evaluation of recovery efforts, short-term recovery goals have been set and appear at the conclusion of sections 2.4.1 through 2.4.5, under the heading "Outcomes and deliverables by or before 2011." An action plan associated with this recovery strategy will include a detailed and prioritized schedule for these activities (section 2.8).

Table 1. Tabular summary of recovery approaches for the Atlantic population of boreal felt lichen.

Priority[a]	Broad approach/strategy	Objective addressed	General steps	Effect
	RESEARCH			
Urgent	• Determine life cycle, growth rate, life history, genetic diversity, population dynamics, and minimum viable population size	3	• Collaborate with researchers studying boreal population • Design and prioritize experimental studies	Increases knowledge base, guides recovery actions and management decisions
Urgent	• Identify critical habitat	1, 3	• Map habitat suitability to search for potential sites • Identify critical habitat	Increased capacity to protect and enhance habitat
Necessary	• Identify sources of air pollution and the lichen's sensitivity to specific pollutants	2	• Consult national and provincial monitoring programs to identify point sources	Guides management and recovery efforts
Secondary	• Identify practices to	3	• Model historical, current, and	Guides

Priority[a]	Broad approach/strategy	Objective addressed	General steps	Effect
	mitigate human disturbances to boreal felt lichen habitat		potential regional distribution in relation to climate and site factors • Interpretation/reconstruction of historical trends in acidification	enhancement and recovery efforts
Secondary	• Explore methods of population and habitat enhancement	3	• Consult current research on thallus transplantation • Determine feasibility for transplanting within the Atlantic population • Identify other possibilities for enhancement	Potential for population augmentation/ expansion
	MONITORING			
Urgent	• Monitor occupied sites	All	• Develop reliable, repeatable, long-term monitoring tools and techniques to locate, monitor, and assess	Enables evaluation of recovery efforts and guides recovery efforts
Urgent	• Monitor threats	All	• Assess use of available monitoring of threats by other researchers or government departments	Enables evaluation of recovery efforts and guides recovery efforts
Secondary	• Monitor habitat characteristics	All	• Develop monitoring tools and techniques to assess habitat parameters of sites, such as humidity, forest composition, and age structure, and, at the landscape level, monitor changes in balsam fir and age structure	Enables evaluation of recovery efforts and guides recovery efforts
	MANAGEMENT			
Urgent	• Manage boreal felt lichen habitat at landscape scale	All	• Locate boreal felt lichen sites • Communicate with landowners of occupied sites	Helps to maintain current distribution
Secondary	• Review forest management practices as they pertain to boreal felt lichen recovery	All	• Review literature and best management practices as they pertain to boreal felt lichen • Communicate with	Helps maintain existing sites and potential future sites

Priority[a]	Broad approach/strategy	Objective addressed	General steps	Effect
			stakeholders to develop feasible forestry practices and recommendations for the area surrounding the lichen and potential habitats	
	EDUCATION			
Necessary	• Provide high-quality educational materials	All	• Assess current boreal felt lichen communications materials • Reprint and design necessary materials • Create a basic web site • Distribute communications materials	Raises the public profile of boreal felt lichen
Necessary	• Raise profile among pollution reduction programs	2	• Inform organizers of appropriate air pollution reduction campaigns about boreal felt lichen with the intention that they might use the species as another example of the consequences of air pollution	Indirect action to reduce air pollution
	STEWARDSHIP			
Necessary	• Foster cooperative relationships with landowners, foresters, industry, and volunteers	All	• Develop an identification training workshop • Develop a voluntary stewardship agreement	Increases capacity of recovery efforts beyond researchers

[a] Priorities are defined as follows: Urgent = top priority action, without which population will decline; Necessary = action needed to evaluate and guide recovery actions; Secondary = action beneficial if urgent actions are already under way.

2.4.1 Research

Actions completed or under way

Habitat suitability mapping

The predictive habitat model for boreal felt lichen used by Robert Cameron has identified approximately 188 000 ha of habitat in Nova Scotia at 24 000 sites (R. Cameron pers. comm. 2006). This is a coarse filter approach, which is undergoing further development and verification. An improved method of distinguishing balsam fir stands from black spruce stands on aerial photographs is under development and is expected to increase the predictive ability of the algorithm (R. Cameron pers. comm. 2006). Both Stora Enso North America and Bowater Mersey

Paper Company have incorporated the algorithm into their planning strategies (R. Cameron pers. comm. 2005).

Air quality research

The Nova Scotia Department of Environment and Labour is currently undertaking an airshed management framework. The first phase will consist of information gathering (local emission sources need to be identified, qualified, and characterized) and gap analysis. This information will serve as inputs into future airshed modelling.

Once key pollution variables (types, levels, etc.) have been determined and the variables and their importance relative to other boreal felt lichen habitat requirements established, future airshed modelling may give an assessment of which airsheds are best to sustain the lichen. The Nova Scotia Department of Environment and Labour has also completed a provincial lichen air quality monitoring program using permanent sampling plots. This project will measure the effects of air pollution on lichens and may help determine problem areas for boreal felt lichen.

Actions to be initiated

Determine life cycle, growth rate, life history, genetic diversity, population dynamics, and minimum viable population size

The small number of known sites and thalli in the Atlantic population of boreal felt lichen is unlikely to provide enough data to allow the determination of boreal felt lichen life cycle, growth rate, life history, genetic diversity, population dynamics, and minimum viable population size. Collaborative research with individuals and agencies working in Newfoundland and Labrador on the boreal population of boreal felt lichen would strengthen the validity of these experimental studies. The population of boreal felt lichen in Newfoundland and Labrador makes it feasible to undertake experimental studies that would yield a better understanding of areas where there are current knowledge gaps at the population level.

Some of the priority topics for collaborative research in Newfoundland and Labrador and Nova Scotia include assessment of the genetic relationships between the Atlantic and boreal populations of boreal felt lichen, dispersal ability, age to maturity, reproductive life span, growth rate, survivorship of maturity classes, minimum viable population, habitat requirements for all stages of life, whether the population is affected by small population dynamics, the feasibility of *ex situ* propagation and a transplant program, the significance of *Frullania*, and substrate types and characteristics in boreal felt lichen thalli initiation.

Identify critical habitat

For both occupied and unoccupied habitat, the relevant scale for protection and biological requirements as they limit recovery need further research and assessment. Once scalar issues of habitat are resolved and clarified, landscape- and province-level analysis (such as GIS) will be undertaken to understand the quality and quantity of habitat necessary for species recovery. Critical habitat must be identified to ensure an adequate understanding of boreal felt lichen's

habitat needs and to activate the protection and enforcement available through the *Species at Risk Act*. Detailed information on the identification of critical habitat is given in section 2.5.

Identify sources of air pollution and the lichen's sensitivity to specific pollutants

It is important to identify the lichen's sensitivity to specific types and levels of pollutants and under what conditions (timing, duration, life stage of exposure, etc.) these pose the greatest threat. Monitoring local air quality in and around areas where differences in abundance have been noted will provide valuable information to aid this investigation. By identifying local point sources of air pollution coupled with atmospheric conditions, it will be possible to consider the impact of these point sources on the location and survival of boreal felt lichen. There may also be some value in comparing historical levels of pollutants in Nova Scotia and New Brunswick with boreal felt lichen distributions.

Identify practices to mitigate human disturbance to boreal felt lichen habitat

Occupied sites will be monitored for evidence of past or present forest practices to determine how the practices may have impacted the lichen and its habitat. In association with the research necessary to determine critical habitat, a prescribed distance surrounding occupied sites of boreal felt lichen that should be only minimally impacted will be established. In addition, an optimum distance will be determined for use as a recommendation in stewardship agreements, which would likely be a more generous distance than that indicated as critical habitat (and protected by legislation). The purpose of the recommendation is to increase recovery potential and provide the opportunity to monitor adjacent stands for new colonization. Additional practices to mitigate human disturbance will be identified, related to thinning and selective cut tolerances of boreal felt lichen, blowdown reduction guidelines, and road construction for lands surrounding critical habitat.

Explore methods of population and habitat enhancement

To reestablish previously occupied habitat, transplantation may be required. Because the Atlantic population is so small, transplanting thalli from this population is not recommended. Transplanting experiments with individuals from the boreal population may be appropriate. Once a successful technique is developed in Newfoundland, transplanting individuals from the Atlantic population may be considered. More discussion about transplantation and its role for the Atlantic population is required. Other habitat characteristics of boreal felt lichen may also be considered in relation to methods to enhance and restore boreal felt lichen, such as *Frullania* transplantation.

Outcomes or deliverables by or before 2011

- Results of research incorporated into a revised recovery strategy, which should provide insight into the potential for restoring boreal felt lichen and its habitat.
- Evaluation of which pollutants cause the greatest threat to boreal felt lichen.
- Outstanding research topics prioritized and listed in action plan (see section 2.8).
- Critical habitat definition refined.
- Guidelines developed for protecting boreal felt lichen habitat through voluntary actions (for use in habitat stewardship agreements).

- Habitat parameters necessary to determine unoccupied sites with potential boreal felt lichen habitat identified.
- Five unoccupied sites identified with suitable habitat for boreal felt lichen where landowners could be approached to enter into voluntary agreements to protect potential habitat for the species.

2.4.2 Monitoring

Actions to be initiated

Monitor occupied sites

As boreal felt lichen sites are identified, continued monitoring will be necessary to assess the success of recovery efforts and gather data to support research. Monitoring will assess the overall condition of the thalli, habitat characteristics, and apparent threats (see next section). Monitoring the health and succession of individual thalli and colonies as well as the long-term habitat conditions would also address some research questions. Monitoring methods will be determined after reviewing protocols from existing programs, such as the Ecological Monitoring and Assessment Network of Environment Canada.

Monitor threats

Information on monitoring air pollution, acid deposition, and meteorological events is available through federal and provincial environment departments and should be assembled and interpreted as it relates to the recovery of boreal felt lichen. In addition, it will be necessary to undertake focused air quality monitoring around boreal felt lichen sites. Other threats, such as forestry activity and gastropod grazing, will have to be monitored directly.

Monitor habitat characteristics

Microhabitat parameters such as humidity, forest composition, forest age structure, indicator species, and herbivory should be monitored at occupied boreal felt lichen sites to better define what boreal felt lichen needs to survive. It would also be useful to monitor these parameters at unoccupied sites and compare them with those at occupied sites to understand habitat preference throughout the lichen's life cycle and to model predictions about a site's ability to support the lichen through time. This kind of analysis might help determine, for example, if boreal felt lichen occurs in even-aged forests with frequent stand initiating events or if it is generally in uneven-aged forests with infrequent disturbance events. Permanent air quality sampling plots managed by the Nova Scotia Department of Natural Resources since 1965 may provide some insights into the impact of air quality on the distribution and abundance of boreal felt lichen.

Outcomes or deliverables by or before 2011

- Boreal felt lichen monitoring program in place, with distribution and abundance data recorded in the Atlantic Canada Conservation Data Centre database.
- A process for archiving data from threat and habitat monitoring developed.

2.4.3 Management

Actions completed or under way

Conservation and management

Efforts are under way to determine the effects of pollution and forestry management on cyanolichens (Richardson and Cameron 2004). Management options that have been identified include enhancing propagule spread, transplantation, limiting the effects of acid rain, and changing forestry practices (Richardson and Cameron 2004).

Recovery leadership

In September 2004, an organizational meeting was held to facilitate the formation of a Recovery Team for the Atlantic population of boreal felt lichen. The province of Nova Scotia chairs the Recovery Team. The team is made up of government representatives from Nova Scotia and New Brunswick, lichen experts, and academia. More members are being added to the team to ensure that all relevant experts are represented. In the unlikely event that boreal felt lichen is rediscovered in New Brunswick, members of the Recovery Team are prepared to initiate recovery actions in that province. The Recovery Team is also coordinating a program to monitor the status of cyanolichens in Nova Scotia.

Actions to be initiated

Manage boreal felt lichen at landscape scale

Management decisions on boreal felt lichen will be based on two factors: the protection of occupied sites and the protection of a network of unoccupied sites that, on the basis of habitat/vegetation characteristics and consistency with predictive algorithms, may be capable of supporting boreal felt lichen. The latter sites could provide areas for the introduction or relocation of boreal felt lichen in the event that known sites are deemed to be at significant risk. These unoccupied sites may also provide opportunities for protection through stewardship initiatives.

Using habitat suitability mapping, more boreal felt lichen sites are likely to be discovered and protected through legislation and stewardship initiatives. Efforts to communicate with landowners and promote stewardship are as important as legislative protection of habitat. The experience and knowledge of landowners will be important in making management decisions.

Review forest management practices as they pertain to boreal felt lichen recovery

Because boreal felt lichen is an arboreal lichen, forest management practices are important to recovery efforts. A review of literature and best forestry management practices for boreal felt lichen will provide a baseline for discussions with foresters regarding how they can support boreal felt lichen recovery efforts. A review of literature exploring links between acid deposition and forestry practices as they pertain to forest health and productivity outcomes is also very relevant to understanding the dynamics of boreal felt lichen habitat. It will be necessary to

determine best practices for forest management: in the vicinity of boreal felt lichen sites, in unoccupied potential sites, and to maintain balsam fir across the landscape. These practices would be outlined in voluntary stewardship agreements.

Outcomes or deliverables by or before 2011

- Habitat suitability mapping algorithm used to identify 250 sites with potential habitat, which will then be surveyed for boreal felt lichen.
- Best forestry practices developed for boreal felt lichen sites and their surrounding area, as well as for unoccupied potential habitat.

2.4.4 Education

Actions completed or under way

Capacity building

In 2002–03, funding from the Government of Canada's Habitat Stewardship Program for Species at Risk was granted to the Nova Scotia Department of Natural Resources for a project entitled "Building Stewardship Capacity for the Boreal Felt Lichen (*Erioderma pedicellatum*) in Atlantic Canada." This project included a two-day workshop and the creation and distribution of a brochure and identification card for boreal felt lichen. The project laid a foundation for the initial steps towards recovery of the boreal felt lichen (MacGregor *et al.* 2003).

Identification workshop

In 2004, a workshop was given to Stora Enso North America by Robert Cameron of the Nova Scotia Department of Environment and Labour to explain how to identify boreal felt lichen and its habitat. Additional workshops should be organized, particularly with other forestry companies.

Actions to be initiated

Provide high-quality educational materials

A brochure and identification card (created as part of the "Building Stewardship Capacity for the Boreal Felt Lichen (*Erioderma pedicellatum*) in Atlantic Canada" project) are the only communications materials currently available to the public. They provide identification characteristics and other general species information. These will be assessed to see if any changes are needed and, if necessary, will be reprinted. Materials necessary to support stewardship activities, such as presentations, identification workshop materials, and a basic web site, will be designed. Boreal felt lichen lacks charisma and is not well known, but the right educational materials and delivery may induce the interest of industry, foresters, students, and naturalists and stimulate them to search for the lichen.

Raise profile among pollution reduction programs

Boreal felt lichen will benefit from reductions in air pollutants such as sulphur dioxide and nitrogen oxides. It is not reasonable to initiate a massive campaign to reduce local and transboundary sources of pollution for boreal felt lichen. Instead, the organizers of appropriate-scale pollution reduction programs should be informed of the boreal felt lichen so that they can use it as a case study to support their programs.

Outcomes or deliverables by or before 2011

- Educational materials developed or refined.
- Basic web site on boreal felt lichen developed, outlining general species information, identification characteristics, stewardship opportunities, and a summary of recovery efforts.
- At least four pollution prevention programs contacted and provided with boreal felt lichen resources.

2.4.5 Stewardship

Actions completed or under way

Both Stora Enso North America and Bowater Mersey Paper Company have incorporated the algorithm used for the habitat suitability mapping for boreal felt lichen into their planning strategies. This cooperation in searching for new locations has led to improvements in the predictive ability of the algorithm.

Actions to be initiated

Foster cooperative relationships with landowners, foresters, industry, and volunteers

A boreal felt lichen identification workshop will be further developed. Training will allow participants to recognize potential habitat, search for the lichen, and identify it. Workshop participants will be given an opportunity to practise their skills, which will enable them to assist with any of the activities listed above under "Monitoring."

Stewardship is a key component of the recovery of any species at risk that uses habitat on private lands. A stewardship agreement template will be drafted. The agreement will identify the area the steward agrees to protect, suggest the best management practices the steward should use, and list the activities the steward should avoid within that area to support recovery efforts for the lichen. Stewards will include landowners of occupied and unoccupied potential boreal felt lichen sites. These agreements will be voluntary and flexible.

Education and stewardship initiatives are closely linked. It is likely that the educational activities from the previous section will motivate some concerned citizens to take actions that support recovery efforts, by searching for the boreal felt lichen, reducing their contribution to air pollution, or simply telling others about the lichen.

Outcomes or deliverables by or before 2011

- Voluntary stewardship agreements with landowners of occupied and unoccupied habitat prepared.
- Identification workshops held for volunteers, landowners, and foresters upon request.
- Stewardship program developed to communicate the importance of the lichen and ensure that educational materials are available to all stakeholders.

2.5 Critical Habitat

2.5.1 Identification of boreal felt lichen critical habitat

Suitable habitat mapping provides convincing evidence that more sites of the Atlantic population will be found. Current population size and distribution of the lichen must first be determined to adequately describe critical habitat. Ecological requisites and physical attributes of critical habitat in Nova Scotia require further study. Critical habitat is described in this document to the extent possible given the best information available at present, including the locations of the nine known sites.

Critical habitat description

The existing boreal felt lichen sites share the following habitat characteristics:

- They occur within 25 km of the sea coast at an elevation up to 300 m above sea level.
- They are in forested habitats with low open crown closure due to natural forest dynamics.
- They are found typically in balsam fir stands, on north-facing trunks of mature and overmature trees.
- The habitat is cool and moist and remains relatively constant throughout the year.
- The surrounding forest provides moisture retention, forest integrity, protection from weather events that may cause blowdowns, and the ability to intercept some local air pollution.
- They are often located on or at the base of slopes with northern or northeastern exposure.

Identification of critical habitat sites

The federal *Species at Risk Act* defines critical habitat as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species." Information on the implications of the identification of critical habitat is provided in Appendix B.

Under the NSESA, the province of Nova Scotia may identify "core habitat", which is defined in the act as "specific areas of habitat essential for the long-term survival and recovery of endangered or threatened species". The process for identifying core habitat is not yet developed as the emphasis as been on other existing and tested tools for habitat protection. As yet, it is still unclear how the identification of critical habitat under SARA will impact the listing of "core habitat" under the NSESA and vice versa.

As of March 2006, nine sites occupied by boreal felt lichen have been identified, eight of which were unknown when the species' status was assessed by COSEWIC in 2002, and all of which are within 60 km of each other in eastern Halifax County, Nova Scotia (Cameron and Neily 2006). Eight of these sites are on provincial land and one is on private land. Figure 2 shows the general location of known sites of boreal felt lichen. Appendix C, giving the coordinates and directions to the boreal felt lichen sites, has been removed from the public document to protect the species and its habitat.

There is some anecdotal evidence that this forest area surrounding each boreal felt lichen site plays an important role in maintaining the microclimate necessary for the lichen. This area surrounding the boreal felt lichen sites is also identified as critical habitat. It is difficult to determine an exact distance, because this distance may differ for each site based on factors such as topography, forest condition, tree age and health, and soil properties, such as drainage, moisture, and texture.

In 1998, Robertson recommended that a buffer of at least 20 m be observed for the boreal (Newfoundland) population of boreal felt lichen (Robertson 1998). Newfoundland and Labrador's management plan for boreal felt lichen (Newfoundland and Labrador Department of Environment and Conservation 2006) provides guidance to be employed by forest practitioners on a case-by-case basis in the absence of detailed researched management strategies. The recommended practices include placing a 100-m buffer around large (10 or more thalli) sites and a 30-m buffer around small (fewer than 10 thalli) boreal felt lichen sites. Recent studies on other groups of lichens (fruticose) suggest that edge effects caused by forest harvesting can occur up to 50 m into the uncut forest (Esseen and Renhorn 1998; Rheault *et al.* 2003).

Based on these findings, and as recommended by the Recovery Team, a 100-m radius surrounding each occupied boreal felt lichen site is included in the identified critical habitat. Further studies to determine the relevant scales for protection and biological limitations for boreal felt lichen will be used to determine if this distance is adequate. The schedule of studies for critical habitat will include developing a better understanding of the importance of adjacent balsam fir stands for boreal felt lichen reproduction.

If new occurrences are confirmed and documented, the Recovery Team will recommend that the site(s) be identified as critical habitat for boreal felt lichen. If boreal felt lichen no longer occupies a site, the area will be reevaluated to determine if it is critical habitat.

This identification of critical habitat, although incomplete, offers protection to the known sites of the Atlantic population of boreal felt lichen. Results from the activities listed in the schedule of studies (section 2.5.3) will make this definition more complete and precise and will be included in an action plan (see section 2.8).

2.5.2 Examples of activities that are likely to result in the destruction of critical habitat

Boreal felt lichen is highly cryptic and difficult to identify, and the habitat in which it occurs likely has some combination of physical and/or functional factors that are as yet poorly understood or unknown. With this clarification, federal policy (Environment Canada 2004b) defines an activity as detrimental to critical habitat when it alters the conditions of an area identified as critical habitat to the extent to which the capacity of that critical habitat to contribute to the survival or recovery of the species would be compromised.

Human activities likely to result in the destruction of critical habitat are modifications to the physical attributes of critical habitat, such as forest composition, microclimate environment, chemical composition of air or water, topography, geology, soil conditions, vegetation, and surface or ground hydrology.

2.5.3 Schedule of studies

The results for the following schedule of studies will be included in an action plan which will provide a more complete and precise definition of critical habitat (section 2.8).

Study to be undertaken	Should the results of these actions be incorporated in the action plan?	Specific steps	Timeline
Determine distribution and abundance	Yes	• Identify key habitat characteristics necessary for boreal felt lichen	Preliminary complete, ongoing, summary by 2007
		• Develop habitat suitability mapping	Preliminary algorithm currently in use
		• Improve predictive ability of mapping algorithm to extent possible	Under way, completion by 2009
		• Set schedule to survey sites identified as most likely potential habitat	Under way, completion by 2011
		• Locate, monitor, and assess health of sites	Under way, completion by 2011
Improve knowledge base and understanding of habitat needs, characteristics, and threats	Yes	• Interpretation/reconstruction of historical trends in acidification	Complete by 2008
		• Scheduled monitoring of sites to assess presence and level of threats and changes in habitat conditions	Summary of monitoring available by 2010
		• Research/assess scale for protection and biological requirements as they limit recovery (occupied and unoccupied habitat)	Complete by 2010

Study to be undertaken	Should the results of these actions be incorporated in the action plan?	Specific steps	Timeline
		• Following above: landscape- and province-level analysis (GIS, etc.) to understand quality/quantity of habitat necessary for species' recovery	Complete by 2010
		• Confirm or adjust recommendation of 100 m of critical habitat surrounding boreal felt lichen sites	Complete by 2009
		• Determine microhabitat requirements	Complete by 2009
		• Determine extent of impacts of airborne pollutants, acid rain	Complete by 2009
Improve understanding of dispersal dynamics, reproduction requirements	Yes	• Collaborate with boreal population research	Continuous
		• Determine importance of balsam fir stands adjacent to occupied sites	Preliminary study by 2010
		• Determine importance of unoccupied potential habitat	Preliminary study by 2010
		• Determine landscape-level relationships and requirements	Preliminary study by 2010
Further identify activities likely to result in the destruction of critical habitat	Yes	• Review compiled critical habitat data	2007–2011
		• Augment current list as necessary	2011

2.6 Effects on Other Species

It is very likely that the results of recovery efforts for boreal felt lichen will benefit other cyanolichens and species with similar habitat needs. Restriction or alteration of forest management practices harmful to boreal felt lichen could have an indirect positive impact on plants and/or animal species in the vicinity. There will be an environmental impact from boreal felt lichen recovery efforts in terms of increased foot traffic to lichen sites, but this is not likely to be a significant impact.

2.7 Recommended Scale for Recovery

At present, a single-species approach will be pursued for the boreal felt lichen. However, in the future, it may be appropriate to move to a multispecies approach encompassing other rare cyanolichens (such as *Erioderma mollissimum*) if they are deemed "at risk" and require the intervention of recovery efforts to ensure their survival.

2.8 Action Plan

Two action plans will be developed for Boreal Felt Lichen.

Implementation Action Plan

An action plan outlining how this recovery strategy will be implemented will be posted on the *Species at Risk Act* Public Registry within two years of the recovery strategy being posted on the registry. This will include a detailed and prioritized schedule for the implementation of the activities outlined in section 2.4 *Broad strategy to be taken to meet recovery objectives*.

Critical Habitat Action Plan

A second action plan which will provide a more complete and precise definition of critical habitat based on the results of activities outlined in the schedule of studies (section 2.5.3) will be posted on the *Species at Risk Act* Public Registry within six years of the recovery strategy being posted on the registry.

REFERENCES CITED

Beattie, B.L., K.N. Keddy, and F. Chou. 2002. Trends in acid deposition in the Atlantic provinces (1980–2000). Science Report Series 2001–02. Meteorological Service of Canada – Atlantic Region, Environment Canada. 34 pp.

Brodo, I.M., S. Duran Sharnoff, and S. Sharnoff. 2001. Lichens of North America. Yale University Press, New Haven, Connecticut.

Cameron, R. 2004. A second location for the rare boreal felt lichen in Nova Scotia. Evansia 21(1): 40–42.

Cameron, R. and D.H.S. Richardson. 2006. Occurrence and abundance of ephiphytic cyanolichens in protected areas of Nova Scotia, Canada. Opuscula Philolichenum 3: 5–14.

Cameron, R. and T. Neily. 2006. Summary of boreal felt lichen (*Erioderma pedicellatum*) 2005 field research. Report to the Nova Scotia Interim Boreal Felt Lichen Recovery Team, February 22, 2006. Unpublished.

Canadian Council of Forest Ministers. 2005. National Forestry Database Program. www.nfdp.ccfm.org.

Clayden, S.R. 1997. Campobello to Avalon: a lichen saga. New Brunswick Naturalist 24: 72–74.

Cox, R.M., J. Spavold-Tims, and R.N. Hughes. 1989. Acid fog and ozone: Their possible role in birch deterioration around the Bay of Fundy, Canada. Water, Air, and Soil Pollution 48: 263–276.

Environment Canada. 2004a. 2004 Canadian acid deposition science assessment. Meteorological Service of Canada, Environment Canada. www.msc-smc.ec.gc.ca/saib/acid/assessment2004/.

Environment Canada. 2004b. Federal policy discussion paper: Critical habitat (2004). *Species at Risk Act* Public Registry. www.sararegistry.gc.ca/policies/showDocument_e.cfm?id=271.

Esseen, P.A. and K.E. Renhorn. 1998. Edge effects on an epiphytic lichen in fragmented forests. Conservation Biology 12: 1307–1317.

Goward, T., I.M. Brodo, and S.R. Clayden. 1998. Rare lichens of Canada: A review and provisional listing. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario.

Maass, W. and D. Yetman. 2002. COSEWIC assessment and status report on the boreal felt lichen *Erioderma pedicellatum* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario. 50 pp.

MacGregor, M., M. Elderkin, and S. Boates. 2003. Building stewardship capacity for the boreal felt lichen (*Erioderma pedicellatum*) in Atlantic Canada. Project report. Habitat Stewardship Program for Species at Risk, Environment Canada, and Wildlife Division, Nova Scotia Department of Natural Resources.

Mitchell, M.F. and J.R. Roberts. 1984. A case study of the use of fenitrothion in New Brunswick: The evolution of an ordered approach to ecological monitoring. In P.J. Sheehan, D.R. Miller, G.C. Butler, and P. Bourdeau (Eds.). Effects of pollutants at the ecosystem level. SCOPE 22. John Wiley and Sons Ltd., Chichester. pp. 377–402.

New Brunswick Department of Natural Resources. 2006. Recovery strategy for the boreal felt lichen (*Erioderma pedicellatum*) in New Brunswick. New Brunswick Department of Natural Resources, Fredericton, N.B. 7 pp.

Newfoundland and Labrador Department of Environment and Conservation. 2006. A 5 year management plan for the boreal felt lichen (*Erioderma pedicellatum*) in Newfoundland and Labrador. Wildlife Division, Department of Environment and Conservation, Government of Newfoundland and Labrador. Corner Brook, NL. 36 pp.

Pykala, J. 2004. Effects of new forestry practices on rare epiphytic macrolichens. Conservation Biology 18: 831–838.

Rheault, H., P. Drapeau, Y. Bergeron, and P.A. Esseen. 2003. Edge effects on epiphytic lichens in managed black spruce forests of eastern North America. Canadian Journal of Forest Research 33: 23–32.

Richardson, D.H.S. and R.P. Cameron. 2004. Cyanolichens: Their response to pollution and possible management strategies for their conservation in northeastern North America. Northeastern Naturalist 11(1): 1–22.

Robertson, A. 1998. The boreal felt lichen, *Erioderma pedicellatum* (Hue) P.M. Jorg, in Newfoundland. Report to Newfoundland and Labrador Department of Forest Resources and Agrifoods, St. John's, Newfoundland and Labrador. 63 pp.

Scheidegger, C. 1996. Copy of letter sent to the Right Honourable Brian Tobin, Premier of Newfoundland and Labrador, dated October 30, 1996.[3]

Scheidegger, C. 2003. *Erioderma pedicellatum*. In: 2006 IUCN Red List of Threatened Species. International Union of Nature and Natural Resources (World Conservation Union). http://www.iucnredlist.org (downloaded on August 25, 2006).

[3] The letter contained Dr. Scheidegger's ideas about the complex reproductive strategies of *Erioderma*, about the limited life span of its thalli, and about its life cycles being intimately tied to certain ecological stages in growth of coniferous trees within a more or less undistributed forest environment.

APPENDIX A: GLOSSARY OF TERMS

cyanolichen – lichen whose photosynthetic partner is a cyanobacterium (also called blue-green alga)

epiphyte – a lichen that grows on or is attached to another living plant

foliose – flattened and leaf-like in appearance

mycobiont – fungal partner that joins with a bacterium to form a lichen

phorophyte – the host of an epiphyte

photobiont – photosynthetic partner (bacterium) that joins with a fungal partner to form a lichen

thallus (plural form: *thalli*) – name for the vegetative lichen body

APPENDIX B: IMPLICATIONS OF CRITICAL HABITAT IDENTIFICATION

Section 58. (1) of the *Species at Risk Act* (SARA) states that "…no person shall destroy any part of the critical habitat of any listed endangered species or of any listed threatened species…." This prohibition is enacted if:

(a) the critical habitat is on federal land (which includes the internal waters of Canada, the territorial sea of Canada, and reserves and any other lands that are set apart for the use of a band under the *Indian Act*), in the exclusive economic zone of Canada, or on the continental shelf of Canada;
(b) the listed species is an aquatic species; or
(c) the listed species is a species of migratory birds protected by the *Migratory Birds Convention Act, 1994*.

Based on the recommended definition of critical habitat above, Section 58. (1) prohibitions would not immediately be enacted on the critical habitat of Boreal Felt Lichen as none of the known sites occur on federal lands. Legal protection of the critical habitat would be governed by provincial or municipal legislation. Prohibitions under SARA at these sites would come into effect only if it was deemed that these sites were not "effectively protected" by provincial legislation or other means, and then would require that the federal cabinet make an order to do so. This would require consultation with the province and the landowners.

The enactment of prohibitions protecting critical habitat does not automatically prohibit specific activities. Only activities that destroy the habitat would be prohibited. On federal lands, regulations may be enacted to legislate what can and cannot be done on critical habitat, including when and how activities must be conducted.

Information about what is being done to protect critical habitat must be published in the Public Registry every six months until the critical habitat is protected or no longer needs to be protected.

APPENDIX C: SPECIFIC LOCATION OF KNOWN OCCUPIED SITES AS OF MARCH 2006

[Appendix C, which gives the coordinates and directions to the boreal felt lichen sites, has been removed from the public document to protect the species and its habitat.]