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Species at Risk Act
Recovery Strategy Series

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

Boreal Felt Lichen, Atlantic population

2018

Government of Canada
Gouvernement du Canada

Canada

Recommended citation:

Environment and Climate Change Canada. 2018. Amended Recovery Strategy for the Boreal Felt Lichen (*Erioderma pedicellatum*), Atlantic population, in Canada [Proposed]. *Species at Risk Act* Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. viii + 48 pp.

For copies of the recovery strategy, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry[1].

Cover illustration: Boreal Felt Lichen on Balsam Fir, eastern shore, Nova Scotia. Photo by Robert Cameron, used with permission

Également disponible en français sous le titre
« Programme de rétablissement modifié de l'érioderme boréal (*Erioderma pedicellatum*), population de l'Atlantique, au Canada [Proposition] »

ISBN
Catalogue no.

[1] http://sararegistry.gc.ca/default.asp?lang=En&n=24F7211B-1

Amended Recovery Strategy for the Boreal Felt Lichen (*Erioderma pedicellatum*), Atlantic population, in Canada (2018)

The Recovery Strategy for the Boreal Felt Lichen (*Erioderma pedicellatum*), Atlantic population, in Canada (Environment Canada 2007) was posted on the Species at Risk Public Registry in June 2007.

Under Section 45 of the *Species at Risk Act* (SARA), the competent Minister may amend a recovery strategy at any time. This Amended Recovery Strategy for the Boreal Felt Lichen (*Erioderma pedicellatum*), Atlantic population, in Canada (hereafter, "Amended Recovery Strategy") is for the purposes of:

- Amending all sections of the Recovery Strategy for the Boreal Felt Lichen, Atlantic population, in Canada, based on the most current information

- Refining and updating critical habitat throughout the species' recent range in Nova Scotia

Since 2007, when the Recovery Strategy for the Boreal Felt Lichen (*Erioderma pedicellatum*), Atlantic population, in Canada was written, the Guidelines for Completing Federal Recovery Strategy Templates (part of a series of SARA Implementation Guidance documents) have been updated considerably. Hence, this Amended Recovery Strategy has been updated in accordance with the most recent Recovery Strategy Template and the associated guidelines.

This Amended Recovery Strategy replaces the 2007 Recovery Strategy for the Boreal Felt Lichen (*Erioderma pedicellatum*), Atlantic population, in Canada.

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years after the publication of the final document on the SAR Public Registry.

The Minister of Environment and Climate Change is the competent minister under SARA for the Boreal Felt Lichen, Atlantic population, (hereafter Boreal Felt Lichen) and has prepared this recovery strategy, as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Provinces of New Brunswick and Nova Scotia as per section 39(1) of SARA.

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 and Climate Change Canada, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of Boreal Felt Lichen and Canadian society as a whole.

This amended recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment and Climate Change Canada and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

The recovery strategy sets the strategic direction to arrest or reverse the decline of the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When critical habitat is identified, either in a recovery strategy or an action plan, SARA requires that critical habitat then be protected.

In the case of critical habitat identified for terrestrial species including migratory birds SARA requires that critical habitat identified in a federally protected area[3] be described in the *Canada Gazette* within 90 days after the recovery strategy or action plan that identified the critical habitat is included in the public registry. A prohibition against destruction of critical habitat under ss. 58(1) will apply 90 days after the description of the critical habitat is published in the *Canada Gazette*.

[2] http://registrelep-sararegistry.gc.ca/default.asp?lang=en&n=6B319869-1#2

[3] These federally protected areas are: a national park of Canada named and described in Schedule 1 to the *Canada National Parks Act*, The Rouge National Park established by the *Rouge National Urban Park Act*, a marine protected area under the *Oceans Act*, a migratory bird sanctuary under the *Migratory Birds Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act* see ss. 58(2) of SARA.

For critical habitat located on other federal lands, the competent minister must either make a statement on existing legal protection or make an order so that the prohibition against destruction of critical habitat applies.

If the critical habitat for a migratory bird is not within a federal protected area and is not on federal land, within the exclusive economic zone or on the continental shelf of Canada, the prohibition against destruction can only apply to those portions of the critical habitat that are habitat to which the *Migratory Birds Convention Act, 1994* applies as per SARA ss. 58(5.1) and ss. 58(5.2).

For any part of critical habitat located on non-federal lands, if the competent minister forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, or the laws of the province or territory, SARA requires that the Minister recommend that the Governor in Council make an order to prohibit destruction of critical habitat. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

Acknowledgments

This amended recovery strategy was prepared by Brad Toms (Mersey Tobeatic Research Institute), Julie McKnight (Environment and Climate Change Canada – Canadian Wildlife Service) and Rob Cameron (Nova Scotia – Environment) with extensive input from Mark Elderkin (Nova Scotia Department of Natural Resources). Maureen Toner (New Brunswick Department of Natural Resources), Claudia Hanel (Newfoundland and Labrador Department of Environment and Conservation), and André Arsenault (Natural Resources Canada – Canadian Forest Service) provided detailed comments on this amended recovery strategy. The efforts and contributions of the Nova Scotia Cyanolichen Recovery Team are gratefully acknowledged. Appreciation is also extended to Dave Andrews (Environment and Climate Change Canada – Canadian Wildlife Service) for producing the maps in this document.

Executive Summary

Boreal Felt Lichen (*Erioderma pedicellatum*) is a leafy cyanolichen, with distinctive upturned edges that reveal white undersides.

A small population of Boreal Felt Lichen is found in cool, humid coastal coniferous forests in Nova Scotia. The lichen has not been recorded in New Brunswick since the early 20th century (Cameron et al. 2009). The species is listed as Endangered on Schedule 1 of the federal *Species at Risk Act* (SARA).

One of the most important requirements for cyanolichens is the need for a clean environment including pollutant-free air and precipitation that is free of acidifying contaminants. Acid precipitation may negatively impact the colonisation and survival of Boreal Felt Lichen in areas that receive significant and continued acid deposition. In addition to air-borne pollutants, Boreal Felt Lichen is threatened by logging and wood harvesting, invasive non-native species, climate change and severe weather, roads, and housing and urban areas.

The recovery of Boreal Felt Lichen is considered feasible. There are several unknown factors associated with the feasibility of recovering Boreal Felt Lichen. Despite these unknowns, and in keeping with the precautionary principle, a recovery strategy has been prepared as per section 41(1) of SARA.

The population and distribution objectives are to ensure the species' known extent of occurrence (i.e., the area that encompasses the geographic distribution of the population) and the health of the population are not impacted by human-induced habitat deterioration or loss (i.e., through biological resource use (of the species' host tree), transportation and service corridors, or residential and commercial development). Broad strategies to be taken to address the threats to the survival and recovery of Boreal Felt Lichen are presented in the section 6.2: Strategic Direction for Recovery.

Critical habitat necessary for the survival or recovery of Boreal Felt Lichen is updated in section 7.1. Critical habitat for Boreal Felt Lichen is partially identified in this document based on the best available data. As more information becomes available, additional critical habitat may be identified.

One or more action plans for Boreal Felt Lichen will be posted on the SAR Public Registry within the three years following the posting of this amended recovery strategy.

Recovery Feasibility Summary

Based on the following four criteria that Environment and Climate Change Canada uses to establish recovery feasibility, there are unknowns regarding the feasibility of recovery of Boreal Felt Lichen. In keeping with the precautionary principle, this recovery strategy has been prepared as per section 41(1) of SARA, as would be done when recovery is determined to be technically and biologically feasible. This recovery strategy addresses the unknowns surrounding the feasibility of recovery.

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

Unknown. While most of the known individuals in Nova Scotia are mature and have reproductive structures (apothecia), data suggest that reproductive rates may not be high enough to sustain or improve the population (R. Cameron pers. comm.).

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

Unknown. It is unknown whether sufficient suitable habitat is available to support the species, or could be made available through habitat management or restoration. Air pollution and forestry management practices are the primary threats to Boreal Felt Lichen habitat. Although habitat still exists in the form of mature/over-mature forests, air pollution affects this habitat by reducing a phorophyte's (i.e., host tree) bark buffering capacity and increasing its acidity (Farmer et al. 1991). Some habitat exists within protected areas free from development impacts but these areas are still subject to air-borne pollution.

Beneficial forest management practices that protect lichens have emerged and have received some support from the industry in recovery work on Boreal Felt Lichen. These may lead to practical recommendations for best management practices in the vicinity of Boreal Felt Lichen habitat and unoccupied potential sites.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

Unknown. Cyanolichens are extremely sensitive to air-borne pollutants and acid precipitation (Richardson 1992, Richardson & Cameron 2004) due to their reliance on air-borne nutrients and water, as well as lack of protective structures (Richardson & Cameron 2004). Sulphur dioxide dissolved in precipitation, water films, or within moist lichen thalli is highly toxic to cyanolichens and is most toxic under acidic conditions. Boreal Felt Lichen may benefit from pollution prevention campaigns and industrial technologies that reduce emissions. Although there have been significant declines in air-borne pollutants in Atlantic Canada over the last two decades, acid rain and acid fog from transboundary pollution are still negatively impacting the environment (Canadian Council of Ministers of the Environment, 2011, 2013, Cox et al. 1989) and preliminary

estimates indicate that over 38% of Nova Scotia's upland forest receives acid deposition in excess of critical loads (i.e., the amount of acid deposition that a habitat can tolerate without being significantly harmed) (Canadian Council of Forest Ministers 2006).

Formal and informal partnerships with industry, scientists, municipal governments, federal/provincial governments, conservation organizations, land owners, and the public may help achieve the long-term conservation and recovery of Boreal Felt Lichen. Some sites with Boreal Felt Lichen are protected under legislation (e.g., *Nova Scotia Special Places Act*, *Wilderness Areas Protection Act*). Forest management tools are under development.

International agreements, national commitments, forest certification initiatives, and legislation may all contribute to sustainable forestry practices and the conservation of Boreal Felt Lichen through threat reduction/mitigation. In some areas, the forestry industry has taken an interest in the protection of Boreal Felt Lichen, and their input has led to practical recommendations for beneficial management practices in the vicinity of Boreal Felt Lichen habitat and unoccupied potential sites.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

Yes. Some success has been achieved in transplanting Boreal Felt Lichen (Boreal population) in Newfoundland and Labrador (The Gossan 2010). It is reasonable to assume that with further refinement this recovery technique may be a viable option for Boreal Felt Lichen, should it be required.

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1. COSEWIC* Species Assessment Information

Date of Assessment: November 2014 (No Change)

Common Name (population): Boreal Felt Lichen (Atlantic population)

Scientific Name: *Erioderma pedicellatum*

COSEWIC Status: Endangered

Reason for Designation: This species is believed to be extirpated from New Brunswick, and the remaining population in Nova Scotia is small. Intensive monitoring efforts over the past ten years indicate that both the number of occurrences and number of individuals are declining. These declines are projected to continue in the future. The main threats include habitat loss and deterioration as a result of forest harvesting, air pollution, climate change, and predation by introduced slugs.

Canadian Occurrence: NB, NS

COSEWIC Status History: Designated Endangered in May 2002. Status re-examined and confirmed in November 2014.

* COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

2. Species Status Information

In the first status report for the species (Environment Canada 2002), more than 95% of the global population was thought to occur in Canada. Since 2002, the lichen was found in Alaska and Siberia. If the Alaskan population estimates are accurate, it is possible that only 10-20% of the global total population of the lichen occurs in Canada (COSEWIC 2014).

Table 1. Description of various conservation status ranks for Boreal Felt Lichen (NatureServe 2014).

	G- Rank[a]	N-Rank[b]	S-Rank[c]	COSEWIC Status	SARA Status
Boreal Felt Lichen (*Erioderma pedicellatum*) (Atlantic population)	G1 G2Q	N1N2	NB: SH NS: S1S2	Endangered	Endangered

[a] G-Rank — Global Conservation Status Rank: G1 = species is critically imperiled; G2 = species is imperiled; and Q = questionable taxonomy.

[b] N-Rank — National Conservation Status Rank: N1 = population within Canada is Critically Imperiled; N2 = population within Canada is Imperiled.

[c] S-Rank —sub-national (provincial or territorial) ranks: S1 = Critically Imperiled; S2 = Imperiled; SH = species occurred historically in the province, and there is some possibility that it may be rediscovered.

Boreal Felt Lichen (*Erioderma pedicellatum*), Atlantic population (hereafter Boreal Felt Lichen), is listed as Endangered under the New Brunswick *Species at Risk Act* and the Nova Scotia *Endangered Species Act*.

3. Species Information

3.1 Species Description

Lichens are distinct symbiotic organisms made up from the association of microscopic algae or cyanobacteria and filamentous fungi. Boreal Felt Lichen is a leafy lichen, 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-green when moist and dark grey to greyish-brown when dry. The photosynthetic symbiont in Boreal Felt Lichen is a cyanobacterium. Boreal Felt Lichen most commonly measures 2-5 cm in diameter, although it can be up to 12 cm in diameter. The surface of mature thalli[4] develops many red/brown apothecia (fruiting bodies). Soredia/isidia (vegetative propagules) are not present. This lichen has a generation time of approximately 20 to 30 years. Evidence suggests that the genus may be among the oldest of foliose lichens, perhaps well over 400 million years old (Maass and Yetman 2002).

3.2 Species Population and Distribution

Boreal Felt Lichen historically occurred in Europe (Norway and Sweden) and North America (New Brunswick) and persists in Nova Scotia and Newfoundland. New populations have been discovered recently in Alaska (Nelson et al. 2009, Stehn et al. 2013) and Russia (COSEWIC 2014).

In Canada, there are two populations of Boreal Felt Lichen. The Boreal population in Newfoundland, conservatively estimated to be 15,000 mature thalli, is considered to be relatively large and all potential suitable habitat has not been searched (COSEWIC 2014). The Atlantic population was extirpated from Campobello Island, New Brunswick and it has not been recorded in New Brunswick since the early 20th century (Cameron et al. 2009). The Atlantic population in Nova Scotia was estimated to be 317 thalli (19 of which are juveniles) (COSEWIC 2014). Currently, Boreal Felt Lichen is known to be extant at 54 sites and there are another 14 sites where the species is no longer present but conditions remain suitable for its growth (MTRI unpublished data). The population is distributed within 25 km of the Atlantic Ocean and occurs in Shelburne, Queens, Halifax, Guysborough, Richmond, and Cape Breton Counties (Figure 1). While many new sites have been found since the original federal recovery strategy (Environment Canada 2007), declines at known sites continue to occur. The 10 year decline for the species was estimated at 34% (COSEWIC 2014).

[4] The body of a plant that does not have leaves, stems and roots.

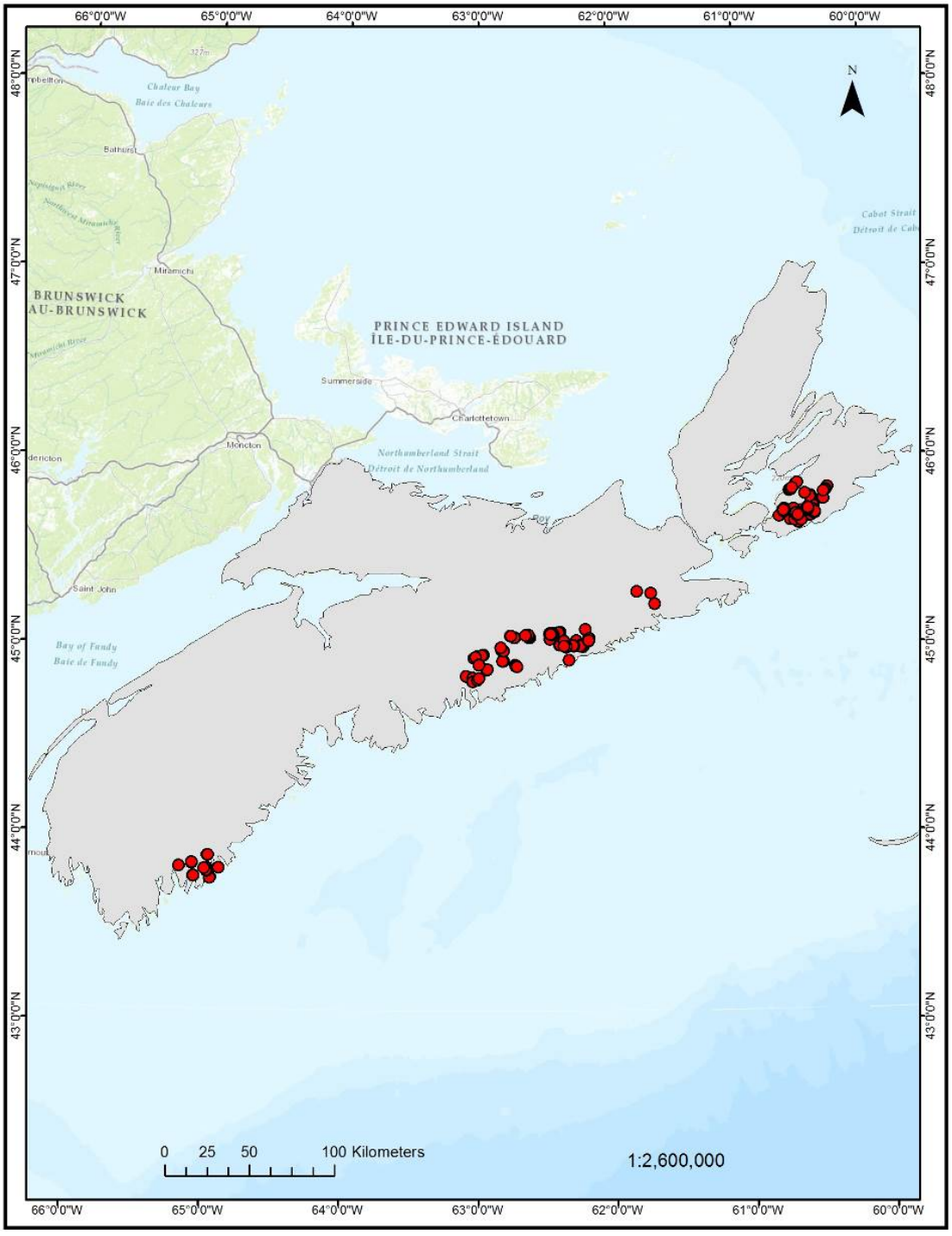

Figure 1. Boreal Felt Lichen distribution in Nova Scotia (2003-2015). Note that some plotted points overlap.

3.3 Needs of Boreal Felt Lichen

In Nova Scotia, Boreal Felt Lichen requires cool, humid, forests containing Balsam Fir (*Abies balsamea*). Historically, in Nova Scotia, it was found on other tree species (Black Spruce (*Picea mariana*), White Spruce (*Picea glauca*), Red Maple (*Acer rubrum*), White Birch (*Betula papyrifera*) but recently has only been observed on Balsam Fir. It is typically found on mature trees on north or northeastern exposure in or adjacent to sphagnum-rich wetlands within 25 km of the Atlantic Ocean and < 200 m above sea level. A wetland is land that is either periodically or permanently saturated with water and sustains aquatic processes (interpreted from the Nova Scotia Wetland Conservation Policy 2011; refer to Appendix C for the provincial definition).

Cyanolichens are particularly sensitive to air-borne pollutants such as sulphur dioxide, nitrogen oxides, and Acid Rain (Hawksworth and Rose 1970, Gilbert 1986, Sigal and Johnston 1986, Hallingback 1989, Richardson and Cameron 2004). The decline of Boreal Felt Lichen in Atlantic Canada has been at least partially attributed to acid rain and air-borne pollutants (Mass and Yetman 2002).

Boreal Felt Lichen is biologically limited by the following factors: its globally limited distribution and small population size; 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 re-establish itself each generation from its separate components); its apparent hypersensitivity to acidification of its substrates and/or to direct adverse effects of air pollutants such as nitrogen oxides and sulphur dioxide; and increasing evidence that it requires a very specific microclimate (Power unpublished data). At this time, it is necessary to determine whether or not the quality or quantity of forest habitat available is inherently limiting to Boreal Felt Lichen recovery.

4. Threats

4.1 Threat Assessment

The Boreal Felt Lichen threat assessment is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system. Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (global, national, or subnational). Limiting factors are not considered during this assessment process. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help understand the nature of the threats are presented in the section Description of Threats.

Table 2. Threat Calculator Assessment (COSEWIC 2014)

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
1	Residential & commercial development	Low	Small	Serious	High
1.1	Housing & urban areas	Low	Small	Serious	High
3	Energy production & mining	Negligible	Negligible	Extreme	Moderate
3.1	Oil & gas drilling	Negligible	Negligible	Unknown	Moderate
3.2	Mining & quarrying	Negligible	Negligible	Extreme	Moderate
3.3	Renewable energy	Negligible	Negligible	Extreme	Moderate
4	Transportation & service corridors	Low	Restricted	Moderate	High
4.1	Roads & railroads	Low	Restricted	Moderate	High
5	Biological resource use	High	Large	Extreme	High
5.3	Logging & wood harvesting	High	Large	Extreme	High
6	Human intrusions & disturbance	Negligible	Negligible	Negligible	High
6.3	Work & other activities	Negligible	Negligible	Negligible	High

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
8	Invasive & other problematic species, genes & diseases	Medium - Low	Pervasive	Moderate – Slight	High
8.1	Invasive non-native/alien species/diseases	Medium - Low	Pervasive	Moderate – Slight	High
8.2	Problematic native species[e]	High	Pervasive	Serious	Moderate
9	Pollution	High - Medium	Large	Serious – Moderate	High
9.5	Air-borne pollutants	High - Medium	Large	Serious – Moderate	High
11	Climate change & severe weather	High - Low	Large - Small	Extreme	High
11.1	Habitat shifting & alteration	High - Low	Large - Small	Serious – Slight	High
11.4	Storms & flooding	Low	Small	Extreme	High

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.

[b] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%; Negligible < 1%).

[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or 3-generation timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71%–100%; Serious = 31%–70%; Moderate = 11%–30%; Slight = 1%–10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

[e] = Problematic native species was not calculated by COSEWIC (2014). New information regarding this threat has become available. The impact of this threat was calculated by R. Cameron

4.2 Description of Threats

Threats with low to high impact are listed as above in the threat calculator assessment table (Table 2) and are described in more detail below.

1.1 Housing & urban areas and 4.1 Roads & railroads: The level of threat to Boreal Felt Lichen from land development fluctuates as new sites are discovered and accessibility to sites changes. The development of land for activities such as industry, residences, forestry, and agriculture creates disturbance, landscape alterations, and affects micro-climates of nearby forests. New road development may alter landscape hydrology (Cameron 2006) and also provides access to remote areas (Maass and Yetman 2002).

5.3 Logging & wood harvesting: In addition to acid precipitation, forestry activities are considered the other major threat to the Atlantic population of Boreal Felt Lichen. Forest practices such as clear cutting or harvesting on a large scale may cause fragmentation, alter the age structure of potential Boreal Felt Lichen habitat, and simplify the biodiversity of forest stands.

Entire locations of Boreal Felt Lichen may be destroyed by large-scale clear cutting, particularly if the presence of Boreal Felt Lichen has not been identified. The effect of forest fragmentation on epiphytic lichens, like Boreal Felt Lichen, has been the subject of some work (e.g., Esseen and Renhorn 1998, Rheault et al. 2003, Pykala 2004, Richardson and Cameron 2004, Cameron et al. 2013a, and Cameron et al. 2013b). 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). Adjacent harvesting can increase the lichen's exposure to the drying effects of sun, wind, and temperature (Hunter 1990, Cameron et al. 2013a) and greatly reduce the ability of a forest stand to buffer against periods of low humidity while at particular seral stages (Maass and Yetman 2002). Such effects have been shown to negatively impact lichens within 50 m of an edge (Eseen and Renhom 1998, Rheault et al. 2003). 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 2008). Although blowdowns are not infrequent events, an adjacent clear cut (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 often replanted with unsuitable phorophyte species that have more acidic bark than Balsam Fir, such as Black Spruce, White Spruce, Red Spruce (*Picea rubens*), 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 *cyanobacteria* or *Rhizonema* (a genus of photosynthetic cyanobacteria), *Frullania* (a type of liverwort), or juvenile Boreal Felt

Lichen because of their low light conditions (Maass and Yetman 2002). Results from a recent habitat supply model (Cameron et al. 2013b) suggest that predicted suitable habitat for Boreal Felt Lichen in Nova Scotia is being harvested faster than stands can regenerate and Cameron et al. (2013b) projected a 25% decline in the amount of suitable habitat between 2005 and 2055 if harvesting continues at the same levels.

8.1 Invasive non-native/alien species/diseases: Many groups of arthropods including mites, springtails, and slugs are known to graze on mosses, bark, and lichens (COSEWIC 2014). The effects of browsing on Boreal Felt Lichen are evident at some sites and may pose a serious problem for the lichen in Nova Scotia. Evidence of gastropod grazing on Boreal Felt Lichen was recorded in Nova Scotia (Cameron 2009) and between 2004 and 2013, 24% (n=449) of lichens monitored showed evidence of grazing. Three species of gastropods were found feeding on cyanolichens (Cameron 2009): *Pallifera dorsalis*, a small native gastropod; and *Arion subfuscus* and *Deroceras reticulatum*, larger aggressive species introduced from Europe (Davis 1992). Mollusc grazing can play an important part in shaping the epiphytic vegetation of deciduous forests and juvenile thalli seem to be at particular risk (Asplund and Gauslaa 2008). A Boreal Felt Lichen thallus near Lower Meaghers Grant was in the process of being heavily grazed by gastropods during a site visit in 2004 (Cameron and Neily 2008). A collected specimen was later identified as *Arion subfuscus*, a non-native introduction from Europe (Cameron and Neily 2008).

8.2 Problematic native species: Spruce Budworm (*Choristoneura fumiferana*) is one of the most damaging natural pests of mature softwood forests in eastern Canada (NRCAN 2014). The insect's preferred host is Balsam Fir (Miller 1963) and severely defoliated trees will die within three to four years. Outbreaks are projected to occur in the near future as part of the insect's natural outbreak cycle (COSEWIC 2014).

9.5 Air-borne pollutants: Cyanolichens are extremely sensitive to air-borne pollutants and acid precipitation due to their reliance on air-borne nutrients and water, as well as their lack of protective structures (Richardson and Cameron 2004). Sulphur dioxide dissolved in precipitation, water films, or within moist lichen thalli is highly toxic to cyanolichens and is most toxic under acidic conditions. Sulphur dioxide and nitrogen oxides emitted during the high temperature burning of coal or oil remain in the atmosphere for relatively long periods of time before being washed out by rain and forming acid rain. Acid precipitation is destructive to Boreal Felt Lichen in three ways: it causes immediate damage to the thallus through uptake of air pollutants which is suggested to be the cause of damage to the holdfast mechanism (observed by W. Maass); it affects the cyanolichen nitrogen fixing enzyme which is intolerant of sulphur dioxide; and it further acidifies the naturally acidic substrates (Maass and Yetman 2002).

Although there have been significant declines in air-borne pollutants in Atlantic Canada over the last two decades, acid rain and acid fog from transboundary pollution are still negatively impacting the environment (Canadian Council of Ministers of the Environment, 2011, 2013, Cox et al. 1989). The amount of acid deposition that an area

can tolerate is known as its critical load. Nova Scotia has among the lowest critical load thresholds in eastern Canada (Nova Scotia Environment 2015) and at present, it is predicted that many areas in New Brunswick and Nova Scotia receive acid deposition in excess of critical loads (Environment Canada 2004). Airflow dynamics carry air pollutants originating from cities along the northeastern United States and southern Ontario (COSEWIC 2014). 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 cold air masses over the Gulf of Maine and the Bay of Fundy and warm, humid, pollutant-bearing air masses coming upward along the Atlantic Coast (Cox et al. 1989). Acid fog is additionally problematic for the species as it envelops the lichen for extended periods of time (Cox et al. 1998, Kouterick et al. 1998), thus increasing exposure. Future industrial developments may further negatively impact the species and its habitat.

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).

11.1 Habitat shifting and alteration and 11.4 Storms & flooding: Forest fires may directly destroy Boreal Felt Lichen. They may also have indirect effects because nitrogen-fixing lichens (including all cyanolichens) downwind of forest fire can be destroyed by the small concentration of sulphur dioxide in the smoke (Maass and Yetman 2002).

Although it is difficult to quantify the effects of climate change 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). If predicted changes occur with shifting tree species (Auclair 1987, Auclair et al. 1992, Braathe 1995) as a result of climate change, species like Boreal Felt Lichen that depend on a particular tree species could be negatively affected. Modelling by Bourque et al. (2010) suggests that Balsam Fir may retreat to the coolest portions of Nova Scotia and the area occupied by Balsam Fir will decline by over 90% by 2100 as a result of a changing climate. This would severely limit the available habitat for Boreal Felt Lichen as Balsam Fir is currently its only known host.

Based on field observations, Boreal Felt Lichen cannot endure the heat-induced desiccation that accompanies extreme weather events such as droughts and hurricanes (Fos et al. 1999, Maass and Yetman 2002). Boreal Felt Lichen is also susceptible to high winds which could cause tree falls (Boyce 1988). A severe storm in Guysborough County, Nova Scotia, created a windfall that destroyed one of the Boreal Felt Lichen occurrences discovered there in the 1980s (Maass and Yetman 2002). Recent analysis indicates that fog frequency has declined along the Atlantic coast of Nova Scotia (Beauchamp et al. 1998, Muraca et al. 2001). Boreal Felt Lichen, like several other cyanolichens that mainly occur in coastal fog forests, is very drought–sensitive, and could be negatively impacted if a decline in fog continues.

5. Population and Distribution Objectives

The objectives of this strategy are to ensure the species' known extent of occurrence (i.e., the area that encompasses the geographic distribution of the population) and the health of the population is not impacted by human-induced habitat deterioration or loss (i.e., through biological resource use (of the species' host tree), transportation and service corridors, or residential and commercial development).

Habitat suitability modeling (Cameron and Neily 2008) and recent discoveries of Boreal Felt Lichen suggest that its population size and distribution is likely larger than is currently known. Between 2003 and 2012, only 17% (832 polygons searched of 13,852 predicted polygons) of predicted habitat was searched for Boreal Felt Lichen (COSEWIC 2014).

Proposed recovery actions and existing legislation may be insufficient to prevent the loss of Boreal Felt Lichen from Nova Scotia via air-borne pollutants, including acid rain/fog.

6. Broad Strategies and General Approaches to Meet Objectives

6.1 Actions Already Completed or Currently Underway

In Nova Scotia, lichen inventories, surveys, pre-harvest forest surveys, and opportunistic searching have been ongoing since 2003. Informal outreach has been underway since 2006.

A habitat suitability model, developed in 2006 (Cameron and Neily 2008) and refined in 2010, is used in Crown land harvest planning and environmental assessments to mitigate impacts to potential habitat and guide searches for new Boreal Felt Lichen sites.

The Nova Scotia Department of Natural Resources has developed a Special Management Practice for Boreal Felt Lichen which protects a 100 m forested 'no take' buffer. There is also a requirement for pre harvest surveys on Crown land where harvest blocks overlap with the predictive habitat model.

All Boreal Felt Lichen sites were monitored annually until 2012 when it became unfeasible to reach all sites each calendar year. A collaborative study investigating the influence of harvest regimes on temperature and humidity at Boreal Felt Lichen sites was initiated in 2013 by the Nova Scotia Department of Natural Resources, Mersey Tobeatic Research Institute, Environment Canada (now Environment and Climate Change Canada), and Nova Scotia Environment and is ongoing. A

Nova Scotia Department of Natural Resources study investigating habitat characteristics and forest ecosystem classification is ongoing in Richmond County.

The Nova Scotia Department of Natural Resources undertook an extensive study with available GIS data to determine if predictive habitat model improvement could be completed. Results suggest the current model cannot be improved given the available data, but more research is needed to statistically test explanatory variables. Monitoring data collected over the last 10 years provides a rich database for analyses of population dynamics. For example, annual population rate of change has been calculated and a deterministic population model developed. Other valuable analyses that can be done using these data are juvenile and adult growth and survival rates and generation time analysis.

There are other recovery and guidance documents pertaining to cyanolichens in Atlantic Canada that propose additional activities and measures that may be pertinent for the conservation of Boreal Felt Lichen: the *Recovery Strategy for the Vole Ears Lichen,* (Environment Canada 2014), the *Management Plan for the Blue Felt Lichen [DRAFT]* (Environment and Climate Change Canada, in prep), the *Management Plan for the Boreal Felt Lichen, Boreal population* (Environment Canada 2010), a *Five Year Management Plan for the Boreal Felt Lichen in Newfoundland and Labrador* (Keeping and Hanel 2006), and *Endangered Boreal Felt Lichen Special Management Practices* (Nova Scotia Department of Natural Resources 2012).

6.2 Strategic Direction for Recovery

Table 3. Recovery Planning Table

Threat or Limitation	Priority[a]	Broad Strategy to Recovery	General Description of Research and Management Approaches
All	High	Law and policy	• Engage in existing pollution reduction programs for local and transboundary pollution and greenhouse gasses • Review and revise beneficial management practices (BMPs)/ Special Management Practices (SMPs) for the species and habitat, where necessary • Engage forest certification systems to implement voluntary standards and codes governing private sector practice that are beneficial for the species • Monitor and enforce compliance with relevant laws, policies, and regulations, and voluntary standards and codes
All	Medium-High	Education and awareness, stewardship, and partnerships	• Foster cooperative relationships with landowners, foresters, industry, and volunteers to maintain habitat • Promote volunteer participation in surveys and monitoring • Promote ecosystem conservation through forest certification, if deemed effective for recovery of the species • Promote compliance with Federal, Provincial, and Municipal Acts and Policies as well as BMPs/SMPs that protect the species and its habitat • Promote the species as an indicator of healthy coastal rain forests
Logging and wood harvesting, Storms and flooding, Invasive non-native/alien species/diseases, Housing and urban areas	Medium	Habitat and species protection and management	• Conserve habitat for the species • Prevent gastropods from ascending phorophytes • Develop a protocol for transplanting cyanolichens if a phorophyte is lost

Threat or Limitation	Priority[a]	Broad Strategy to Recovery	General Description of Research and Management Approaches
Knowledge gaps	High	Monitoring and Research	• Implement inventory and monitoring protocols • Determine the necessity of protecting suitable unoccupied habitat for connectivity and colonisation
	Low-Medium		• Research (Appendix B)

[a] "Priority" reflects the degree to which the broad strategy contributes directly to the recovery of the species or is an essential precursor to an approach that contributes to the recovery of the species.

6.3 Narrative to Support the Recovery Planning Table

Law and policy

Boreal Felt Lichen will benefit from reductions in air-borne pollutants such as sulphur dioxide and nitrogen oxides. It is not feasible to initiate a massive campaign to reduce local and transboundary sources of pollution specifically for the benefit of lichens. Instead, partnerships should be strengthened with government departments to encourage compliance with the *Canadian Environmental Protection Act* and to continue implementing the Canada-Wide Acid Rain Strategy for Post-2000, the Nova Scotia Energy Strategy, the Nova Scotia Climate Change Action Plan, the Newfoundland and Labrador Climate Change Action Plan, and the New Brunswick Climate Change Action Plan.

Special Management Practices (SMPs) were developed for Boreal Felt Lichen in Nova Scotia and apply to provincial Crown lands (Nova Scotia Department of Natural Resources 2012). These SMPs require expert-conducted pre-cut surveys on all areas predicted with a high potential for Boral Felt Lichen occurrence (by the Boreal Felt Lichen habitat model (Cameron and Neily 2008)). Currently, a 100 m forested buffer is enacted and maintained around each Boreal Felt Lichen phorophyte and, where the phorophyte occurs within, or immediately adjacent to, a wetland, a forested buffer of 20 m or greater must be maintained around the perimeter of the delineated wetland. As part of these SMPs, maintenance inspections are to be conducted on all harvested Crown lands at sites which overlap areas with predicted high potential for Boreal Felt Lichen to ensure maintenance of forested buffers around the phorophyte and wetland (Nova Scotia Department of Natural Resources 2012).

The Canadian government supports third-party forest certification as a tool to promote modern sustainable forest management (Canadian Council of Forest Ministers 2015). Thirty-five percent of Nova Scotia is Crown land (Nova Scotia Department of Natural Resources 2013) which can now only be leased for forestry by third-party forest-certified industrial partners (J. Weldon-Genge pers. comm.). Certification standards include precautionary measures to identify and conserve endangered species such as Boreal Felt Lichen and their habitats.

Education and awareness, stewardship, and partnerships

Efforts to communicate with landowners, resource users, developers, land managers, and other stakeholders to promote stewardship and private land conservation are an important part of conserving habitat. It will be necessary to liaise with stakeholders regarding beneficial practices for forest management in the vicinity of Boreal Felt Lichen sites, in unoccupied potential sites adjacent to critical habitat, and to maintain Balsam Fir across the landscape. The experience and knowledge of stakeholders will be important in making management decisions on private and public lands. Protected areas, as well as private lands conserved through private land conservation

mechanisms also have a role to play in the conservation of lichens and should be pursued where feasible.

Cyanolichens can be difficult to identify and often take considerable effort to study and learn, but the right educational materials and delivery may pique the interest of industry, foresters, land managers, students, and naturalists. Identification workshops and seminars for various cyanolichens species will provide a foundation for initial steps towards recovery.

Boreal Felt Lichen is often found in association with other lichens at risk and can be an indicator of a rich lichen community. Boreal Felt Lichen can also be an indicator of the health of Atlantic coastal rain forests.

Habitat and species protection and management

Habitat conservation is required for the survival and recovery of this lichen and to that end, occupied habitat should be secured where possible. Efforts to communicate with landowners and promote stewardship may prove as important as legislation for the recovery of the species' (see previous section).

Gastropods will ascend trees to graze lichens. The climbing of trees can be prevented by a variety of devices such as collars, tapes and traps. These devices can be applied to phorophytes to determine the most effective method to prevent gastropod access to Boreal Felt Lichen. Given the very specific microclimate requirements of the species, research is required to understand the implication (e.g., to the pH of the substrate) of attaching structures to the phorophyte. Research to this end should be undertaken.

Researching a successful protocol for transplanting cyanolichens to nearby host trees when a parent tree is threatened by uncontrollable factors (e.g., storms, blow-downs) may be necessary for the maintenance of this lichen at some sites. Transplantation may also provide a means for rescuing rare populations or maintaining the species' range, but would only be considered in exceptional circumstances. Some success has been achieved in transplanting Boreal Felt Lichen, Boreal population in Newfoundland and Labrador (The Gossan 2010).

Monitoring and research

Monitoring is necessary to evaluate the success of recovery efforts. Monitoring with established protocols will assess the abundance, overall condition of the thalli, habitat characteristics, and apparent threats. Monitoring the health and succession of individual thalli and colonies as well as the long-term habitat conditions will also address some research questions.

Since the distribution-prediction model suggested that other Boreal Felt Lichen locations may exist, continued lichen inventories are necessary to gain accurate distribution

information for the species. Where appropriate, the model results can be used to prioritize new survey locations.

It is important to identify the lichen's sensitivity to specific types and levels of pollutants and determine under what conditions (e.g., timing, duration, life stage of exposure) these pose the greatest threat. Through identification of local point sources of air pollution and atmospheric conditions, the impact of these point sources on the location and survival of cyanolichens can be assessed. Permanent lichen pollution sampling plots managed by Nova Scotia Environment may provide some insights into the impact of air quality on the distribution and abundance of cyanolichens.

Information regarding air-borne pollutants, 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 cyanolichens. Other threats, such as forestry activity and gastropod grazing, will be researched and monitored directly.

Microhabitat parameters such as humidity, forest composition, forest age structure, and indicator species should be monitored at occupied sites to better define the conditions the species requires.

Other knowledge gaps to recovery that should be addressed, such as life cycle characteristics and dispersal distance, are identified in Appendix B.

7. Critical Habitat

The original recovery strategy identified critical habitat for Boreal Felt Lichen at nine sites. The lichen at one of the nine sites identified in the original recovery strategy was misidentified as Boreal Felt Lichen and as a result, the site is no longer identified as critical habitat.

Identification is considered to be partial at this time because additional information is required to determine whether the critical habitat identified below is sufficient to meet the population and distribution objectives.

Section 41(1)(c) of SARA requires that the recovery strategy include an identification of the species' critical habitat, to the extent possible, as well as examples of activities that are likely to result in its destruction. Critical habitat is identified in this document to the extent possible given the best available information. A schedule of studies was developed to provide the information necessary to completely identify the critical habitat sufficient to meet the population and distribution objectives.

7.1 Identification of the Species' Critical Habitat

The currently known Boreal Felt Lichen sites share the following biophysical attributes (Cameron and Power, unpublished data, COSEWIC 2014):

- they occur within 25 km of the Atlantic coast at an elevation less than 200 m above sea level;
- they have mature and overmature Balsam Fir tree trunks (i.e., mean standard age of 71.03 years but always > 50 years old and with significantly more dead trees) with *Frullania tamarisci* and very frequently have *Coccocarpia palmicola* growing on them;
- they occur in habitat that is cool and moist that remains relatively constant throughout the year (i.e., annual precipitation between 1200 and 1600 mm with a mean July temperature of less than 16°C and a mean January temperature that is not colder than -6°C);
- they have surrounding forest that is able to provide the constant humid environment that is required by intercepting wind and sunlight, provide protection from weather events that may cause blowdowns, and have the ability to intercept some local air pollution (i.e., distance between trees is a maximum of 5.55 m and crown closure is relatively open (mean = 31.72%));
- they have a floor of sphagnum moss and very often Cinnamon Fern *(Osmundastrum cinnamomeum)*; and
- they are most often located on or at the base of slopes with a north aspect (i.e., > 315 degrees and ≤ 44 degrees) and always within or adjacent to wetlands.

Critical habitat description

Critical habitat is identified in Figures 3-19. At each site, critical habitat for Boreal Felt Lichen is identified as:

- the substrata/phorophyte for growth of Boreal Felt Lichen (at present, only known to be trees and most sites are comprised of very few trees; often only one);
- the wetland (as determined through wetland boundary delineation) in which the substrata/phorophyte occurs, or is adjacent to (refer to Appendix C for the definition of a wetland and information on wetland delineation); and
- a critical function zone[5]. The critical function zone is necessary to maintain the hydrology of the wetland, microhabitat characteristics (especially moisture attributes) required for the survival of the lichen, and to allow for colonization. Based on the best available information, the critical function zone is identified as 500 m around the lichen and its substratum/phorophyte (based on work by Cameron et al. (2013b)) and an area around the wetland in which it occurs, or is adjacent to, dependent on wetland size as follows:
    - for wetlands smaller than 100 m^2, a critical function zone of 100 m radius surrounding the wetland is identified; and
    - for wetlands greater than 100 m^2, a critical function zone of 50 m surrounding the wetland is identified (see Figure 2).

[5] A critical function zone encompasses the area necessary to maintain biophysical functions and/or attributes directly related to the persistence of the lichen. It is not a buffer, but rather a functional extension of the wetland into adjacent lands.

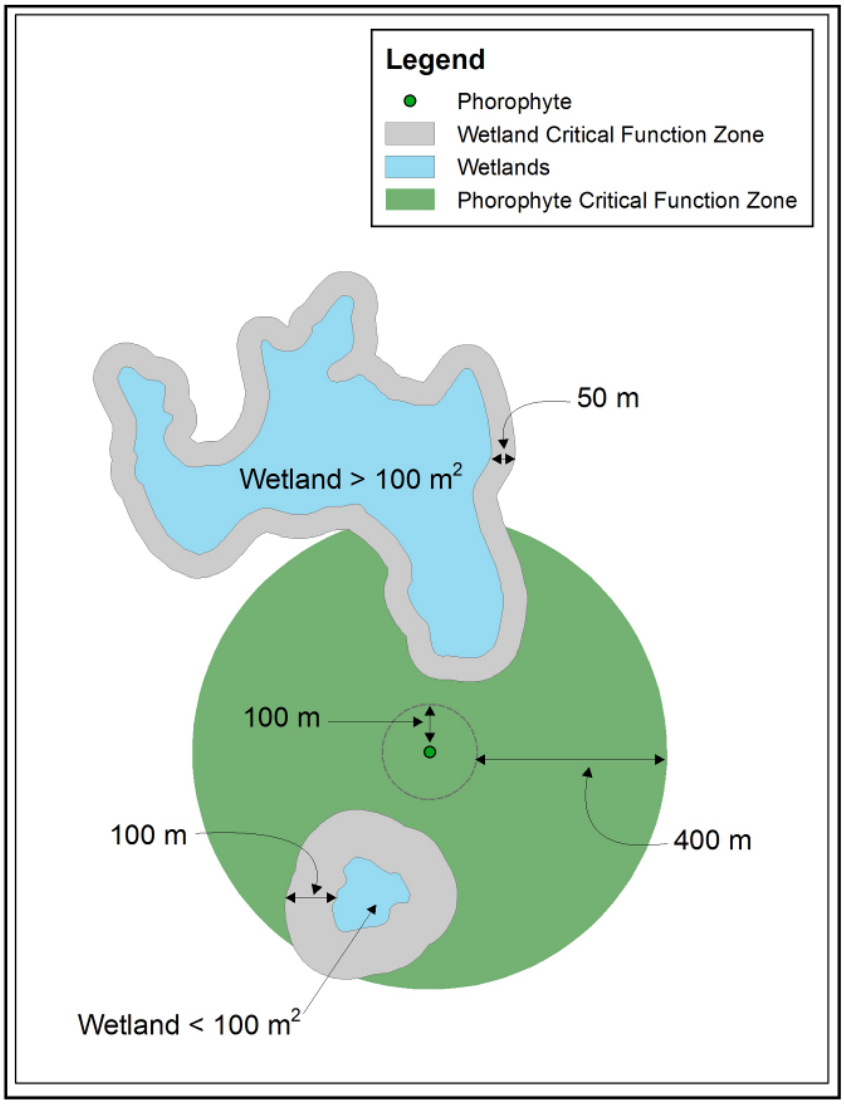

Figure 2. Simplified examples of critical habitat; all areas shaded in light grey or green and the wetland (in blue) are included as critical habitat.

Sites where Boreal Felt Lichen is thought to be lost since 2003 (the year data collection was standardized for the species) are identified as critical habitat as long as the necessary biophysical attributes are still present. This includes fifty-eight trees at 14 sites that have apparently lost their lichens to date but the necessary building blocks (cyanobacterium and filamentous fungi) may still be present at the site and able to colonize given intact biophysical attributes, and juveniles are difficult to inventory until they reach a certain size.

This is considered a partial identification of critical habitat because additional work is required to determine if the critical function zone is large enough to maintain wetland hydrology and essential microhabitat characteristics (see schedule of studies).

The areas containing critical habitat for Boreal Felt Lichen are presented in Figures 3-19. Critical habitat for Boreal Felt Lichen in Canada occurs within the shaded yellow polygons (units where the critical habitat criteria and methodology described in this section are met). The UTM grid overlay shown in the figures is a standardized national grid system that indicates the general geographic area containing critical habitat. More detailed information on the location of critical habitat to support protection of the species and its habitat may be requested, on a need-to-know basis, by contacting Environment and Climate Change Canada's Recovery Planning section at: ec.planificationduretablissement-recoveryplanning.ec@canada.ca.

The identification of critical habitat for Boreal Felt Lichen is updated in this amended recovery strategy based on the best available information as of December 2015 and now includes 68 sites (Figures 3-19) representing 13,201 ha.

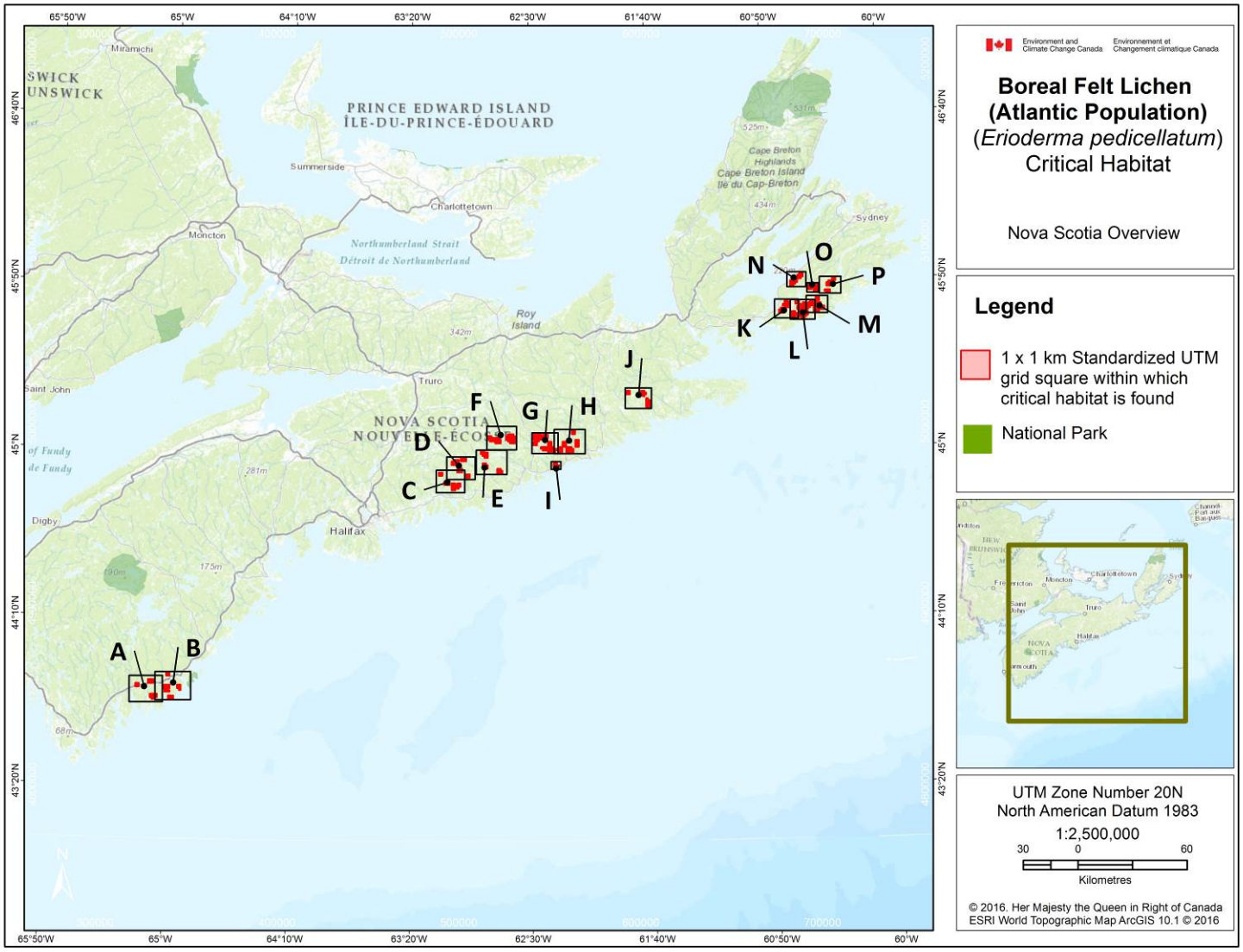

Figure 3. Overview map of critical habitat for Boreal Felt Lichen in Nova Scotia. Refer to figures 4-19 for detailed representations of critical habitat.

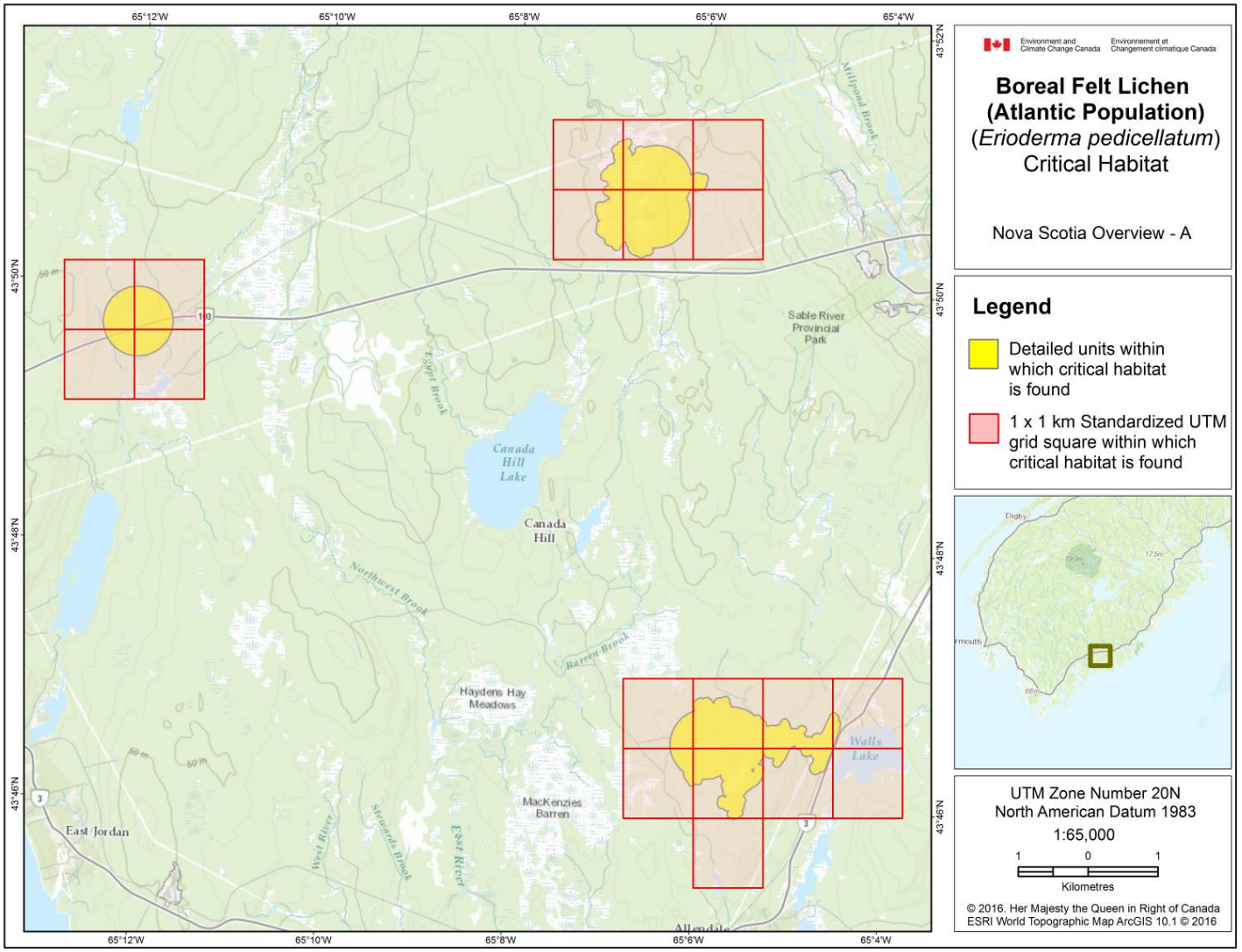

Figure 4. Critical habitat for Boreal Felt Lichen in Shelburne County (see Nova Scotia overview map area A) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

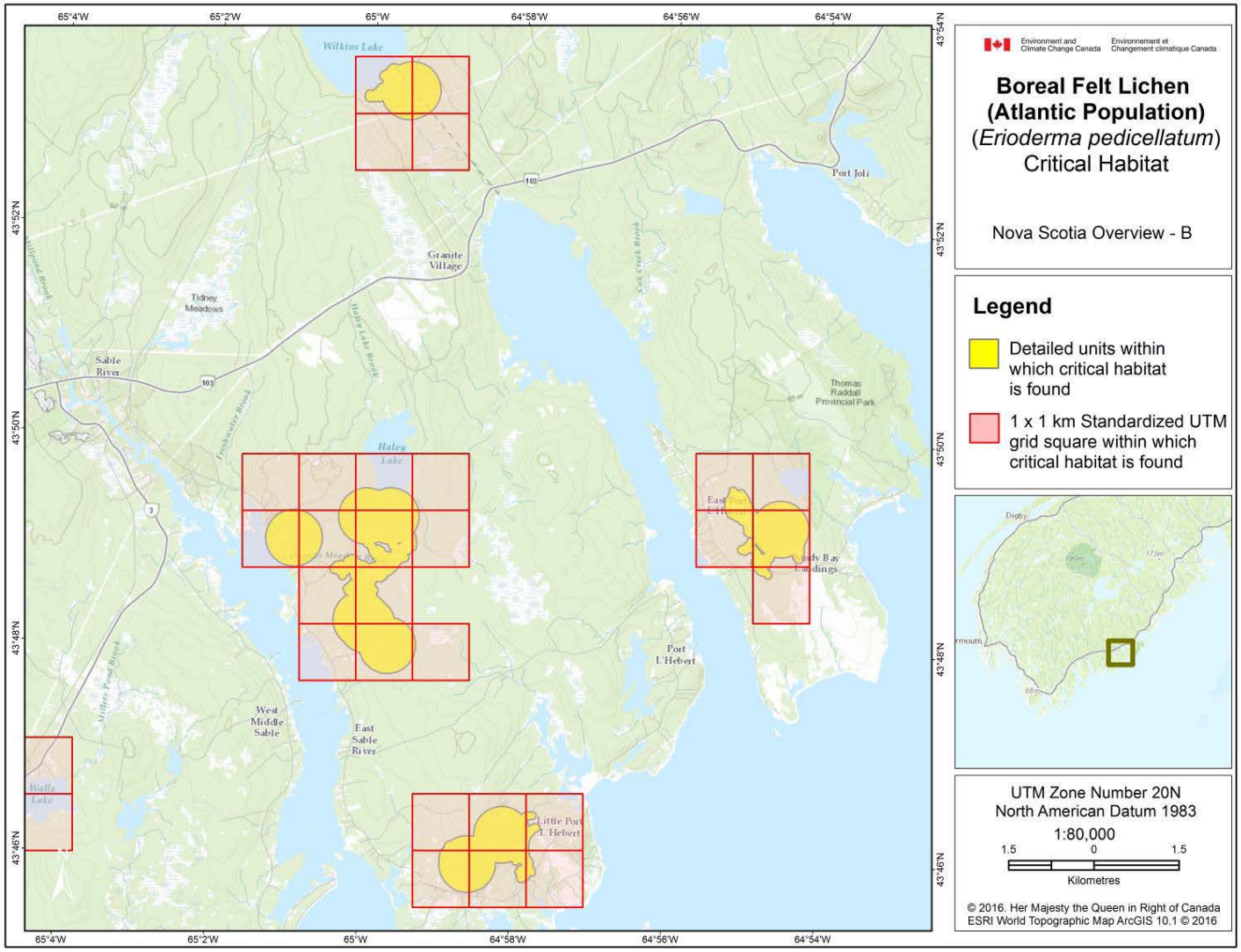

Figure 5. Critical habitat for Boreal Felt Lichen in Shelburne County (east) and Queens County (see Nova Scotia overview map area B) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

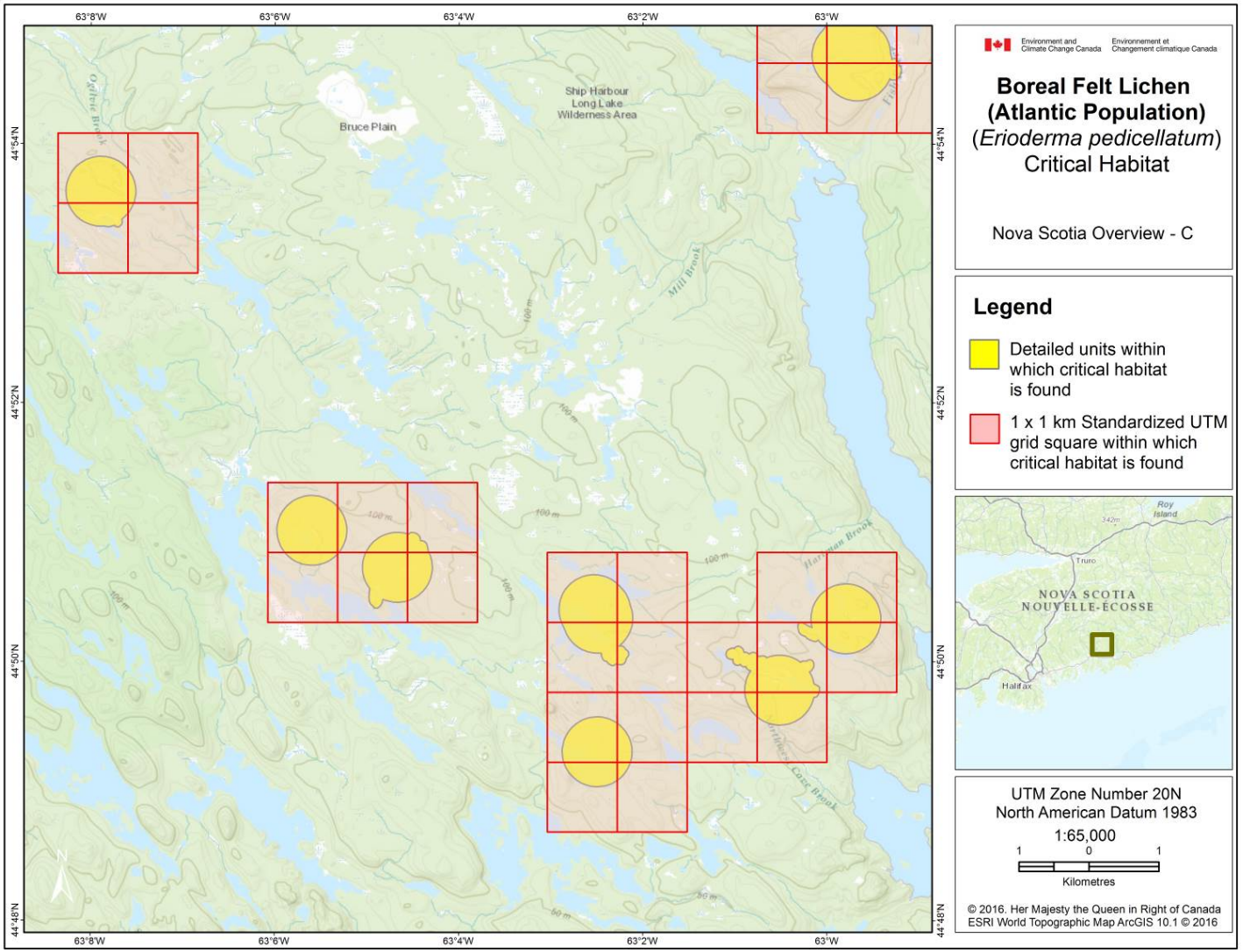

Figure 6. Critical habitat for Boreal Felt Lichen in Halifax County (see Nova Scotia overview map area C) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

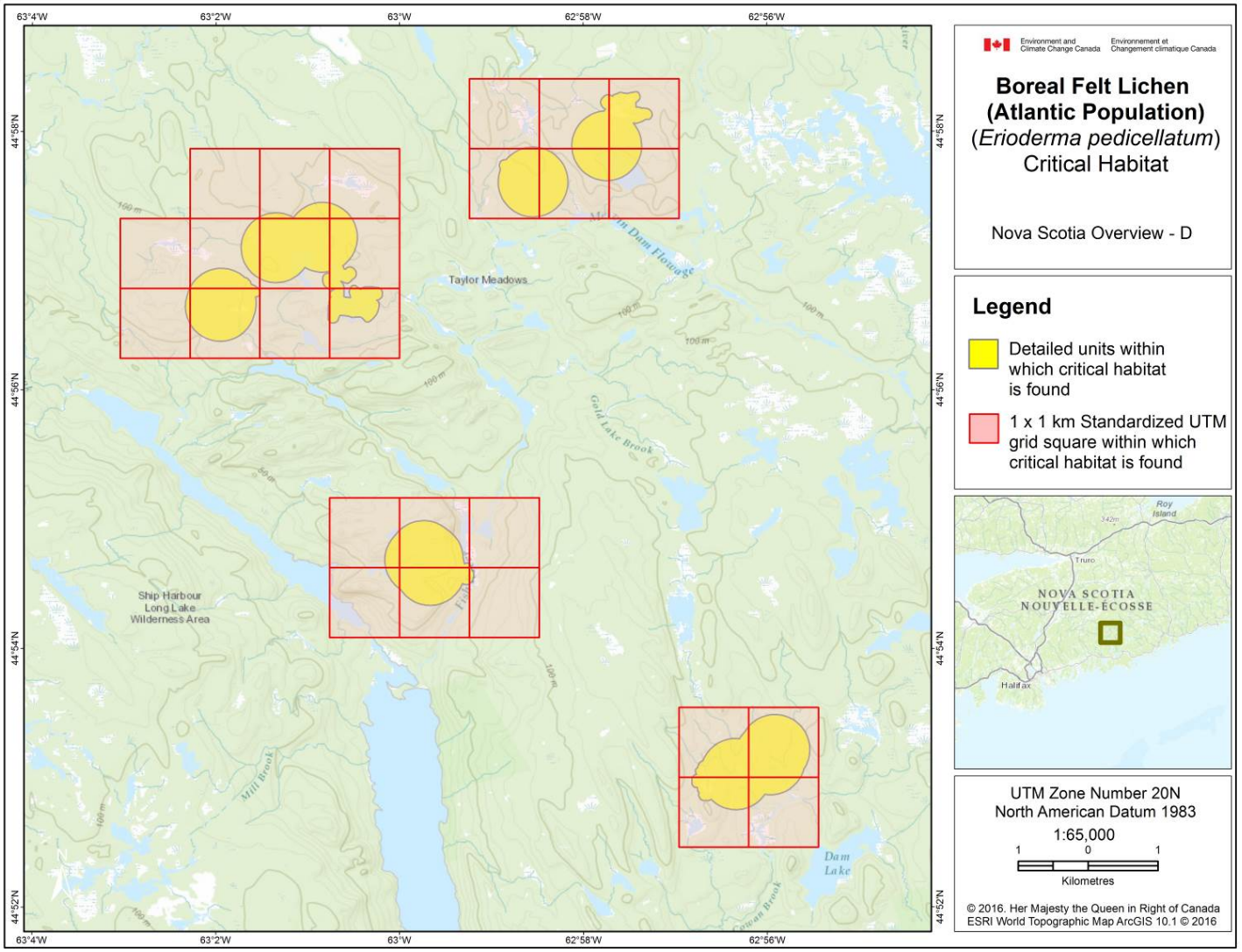

Figure 7. Critical habitat for Boreal Felt Lichen in Halifax County (see Nova Scotia overview map area D) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

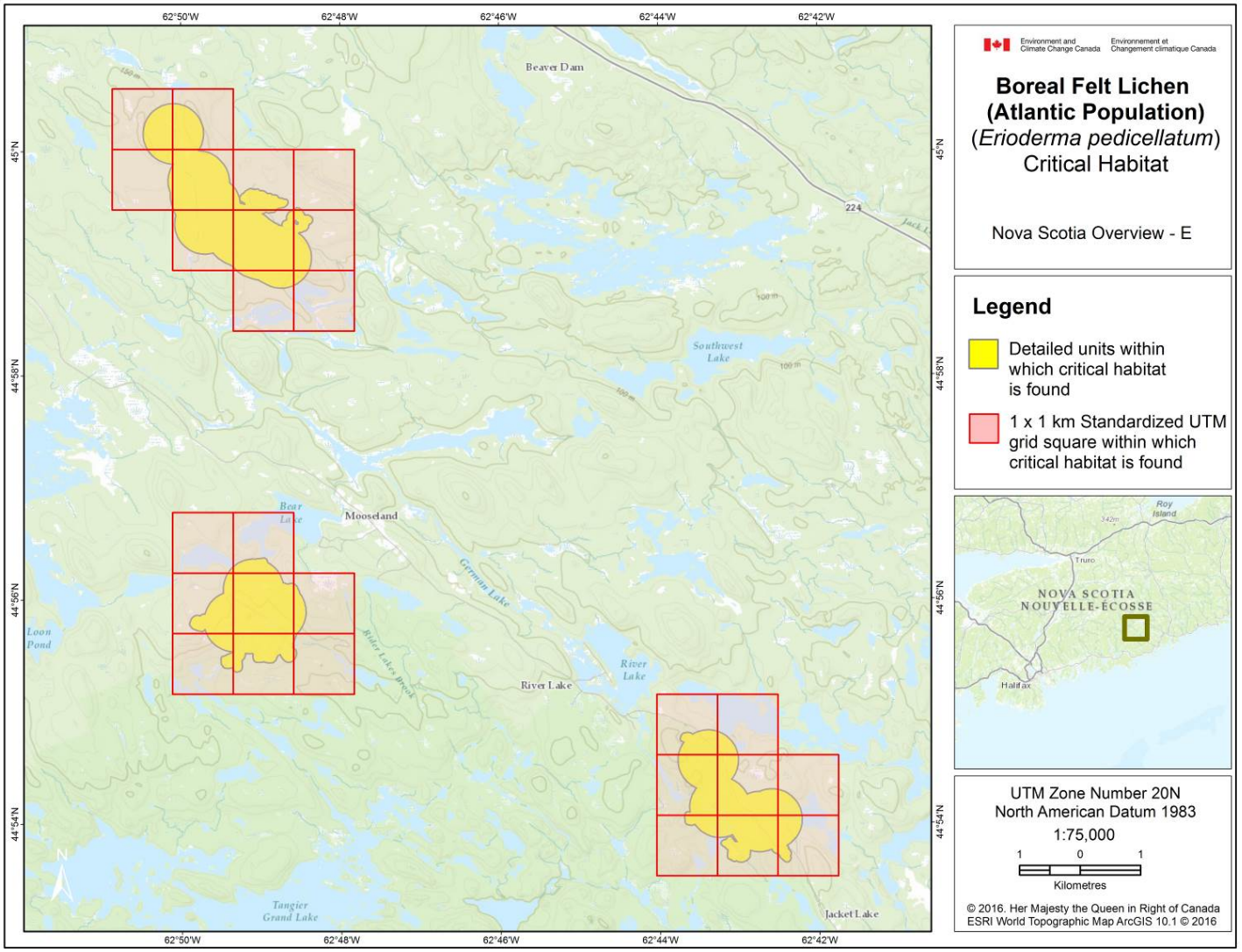

Figure 8. Critical habitat for Boreal Felt Lichen in Halifax County (see Nova Scotia overview map area E) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

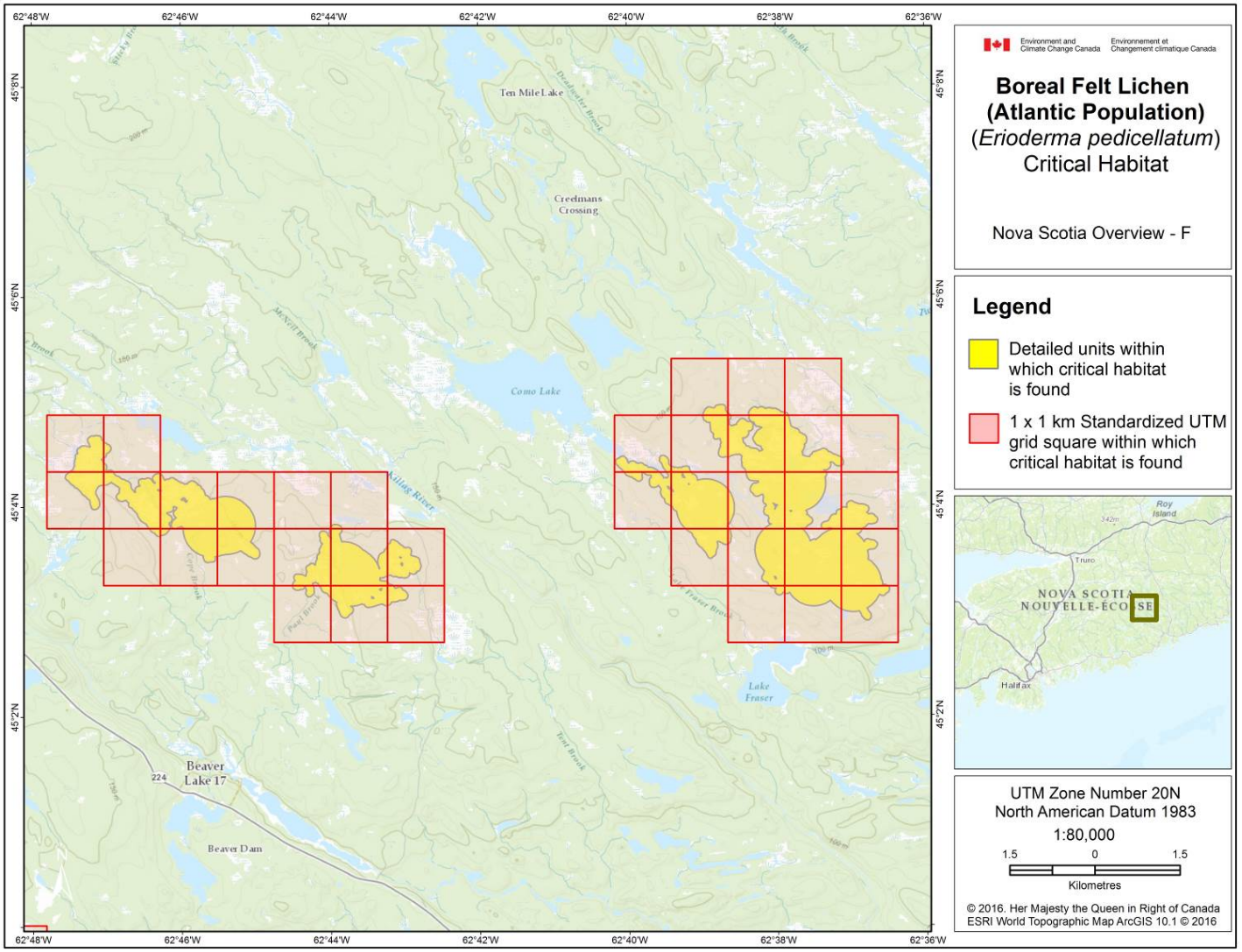

Figure 9. Critical habitat for Boreal Felt Lichen in Halifax County (see Nova Scotia overview map area F) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

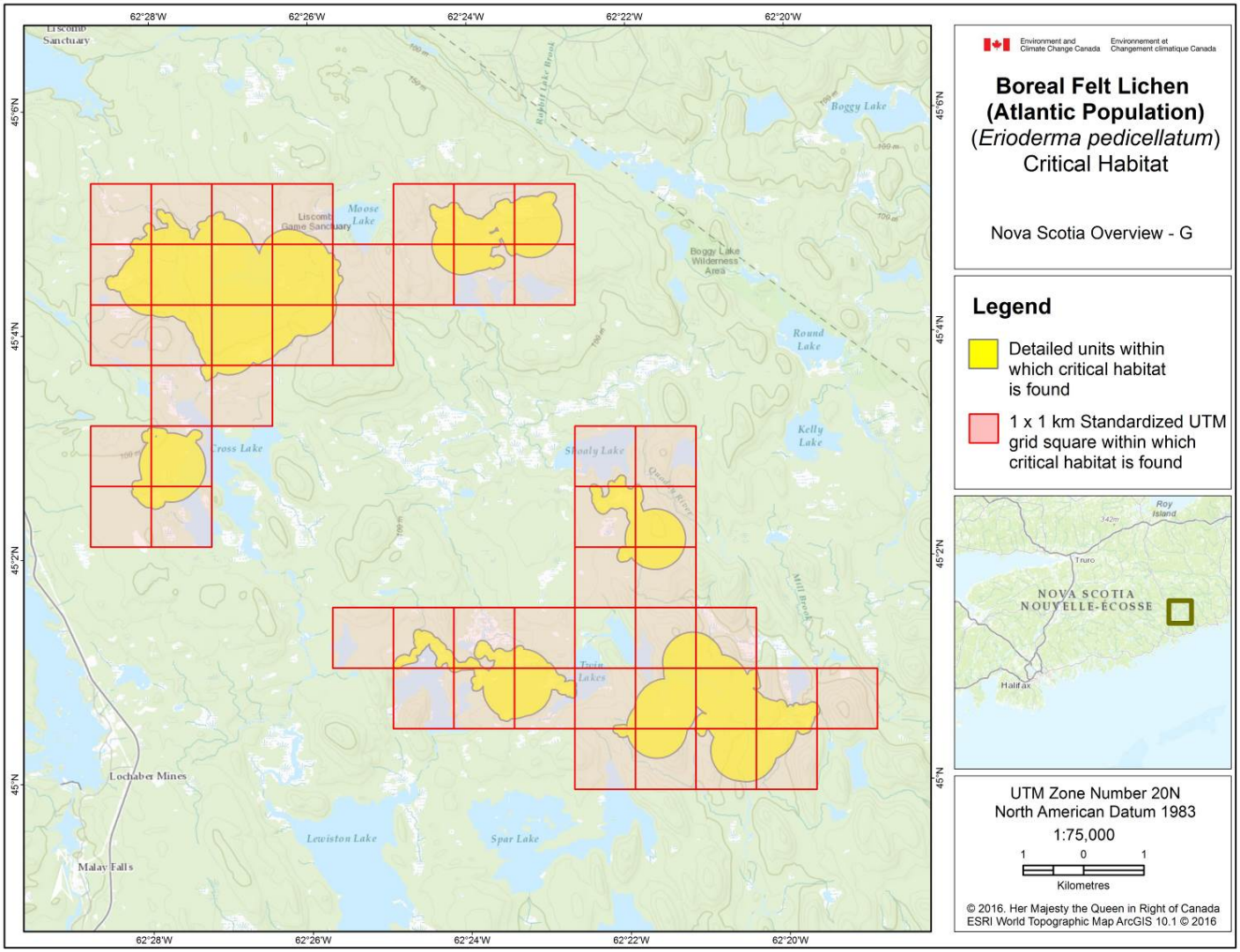

Figure 10. Critical habitat for Boreal Felt Lichen in Halifax County (see Nova Scotia overview map area G) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

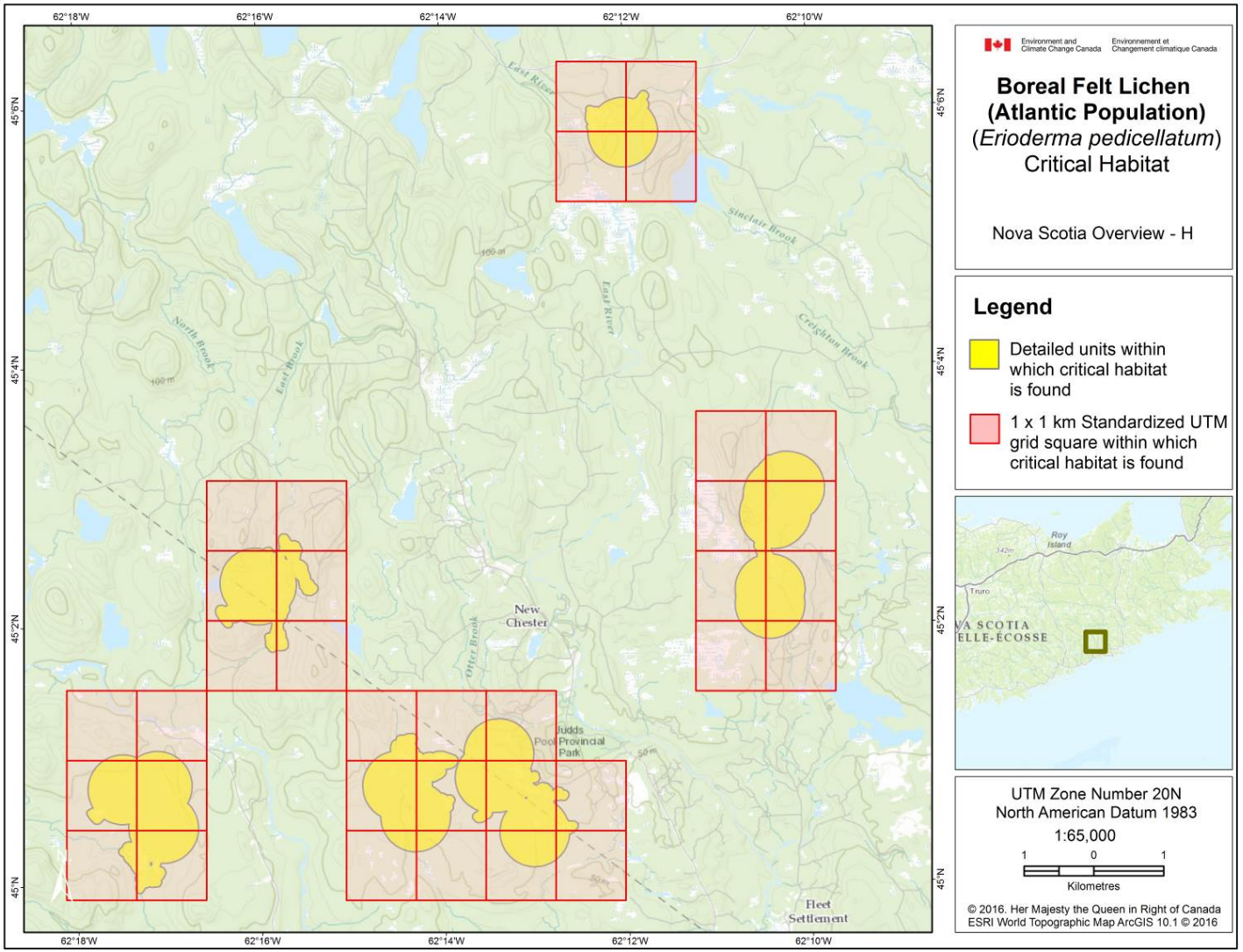

Figure 11. Critical habitat for Boreal Felt Lichen in Halifax County (east) and Guysborough County (see Nova Scotia overview map area H) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

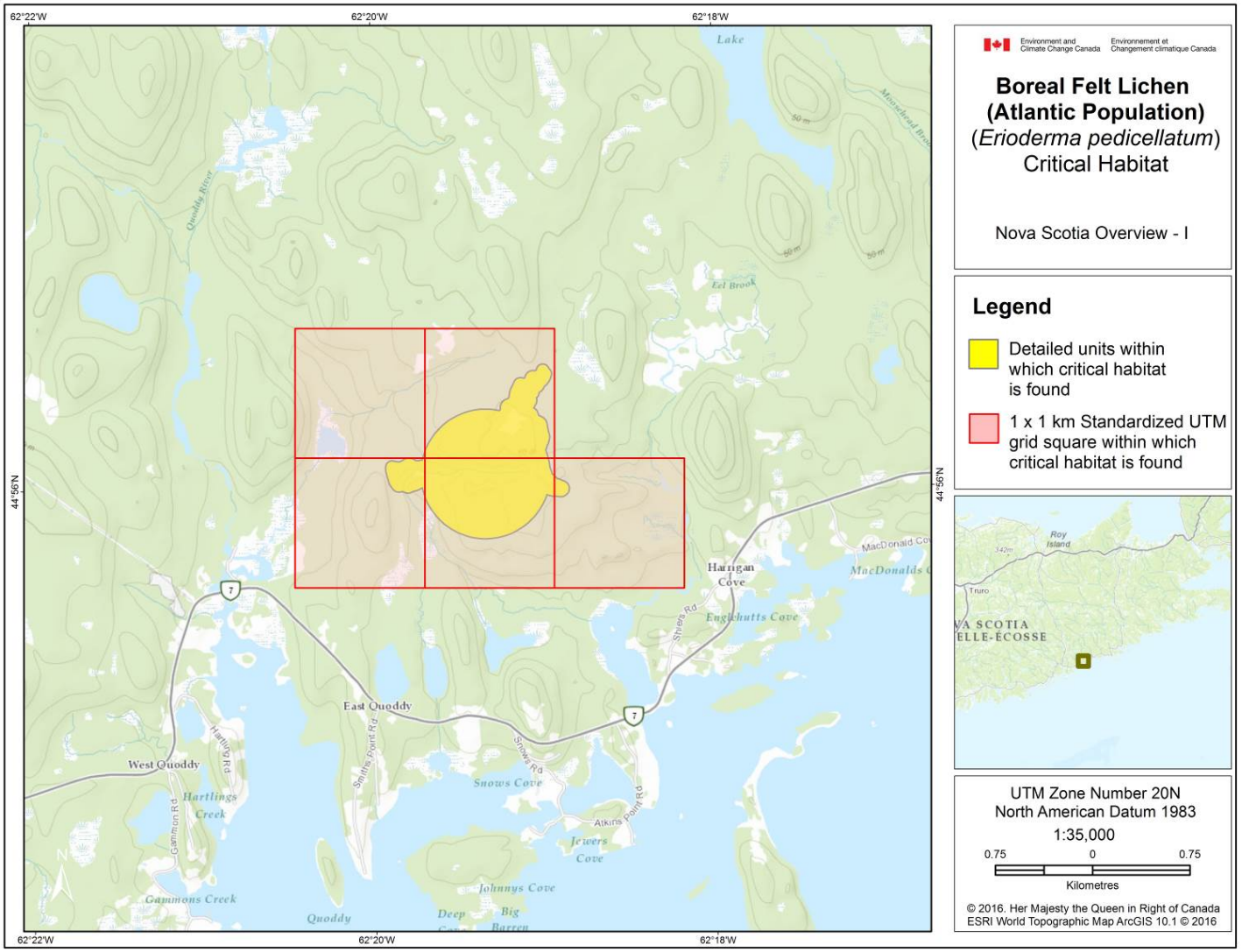

Figure 12. Critical habitat for Boreal Felt Lichen in Halifax County (see Nova Scotia overview map area I) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

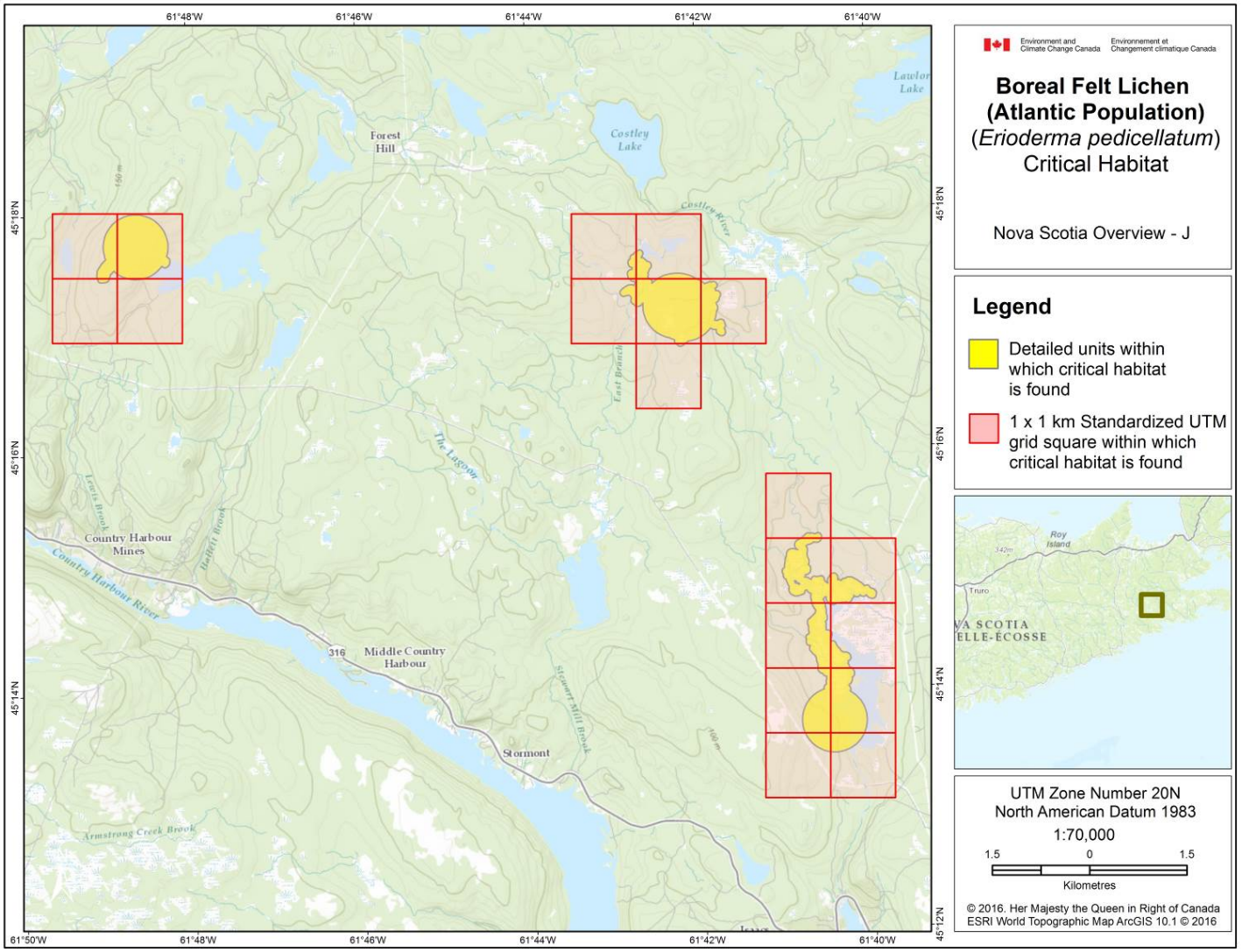

Figure 13. Critical habitat for Boreal Felt Lichen in Guysborough County (see Nova Scotia overview map area J) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

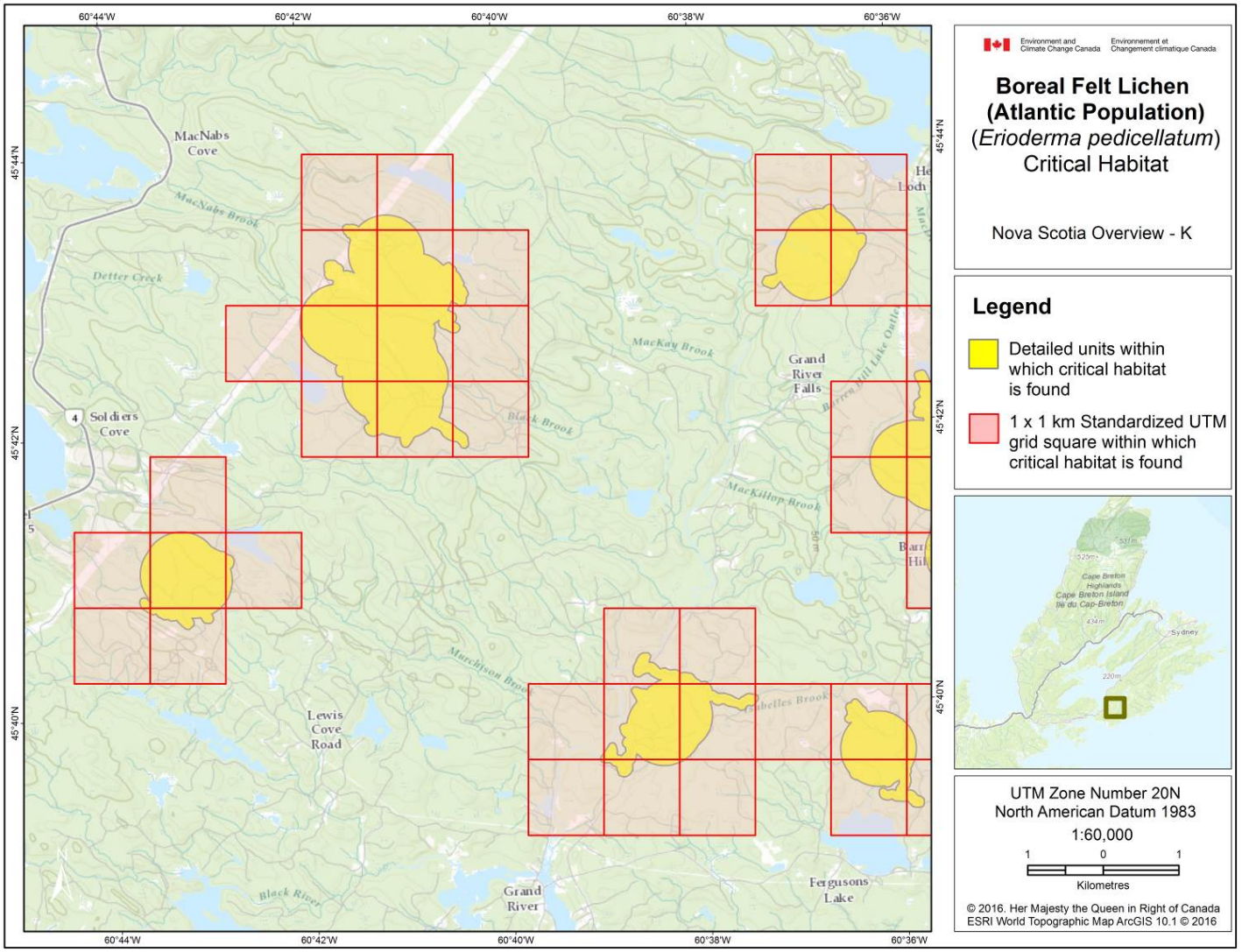

Figure 14. Critical habitat for Boreal Felt Lichen in Richmond County (see Nova Scotia overview map area K) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

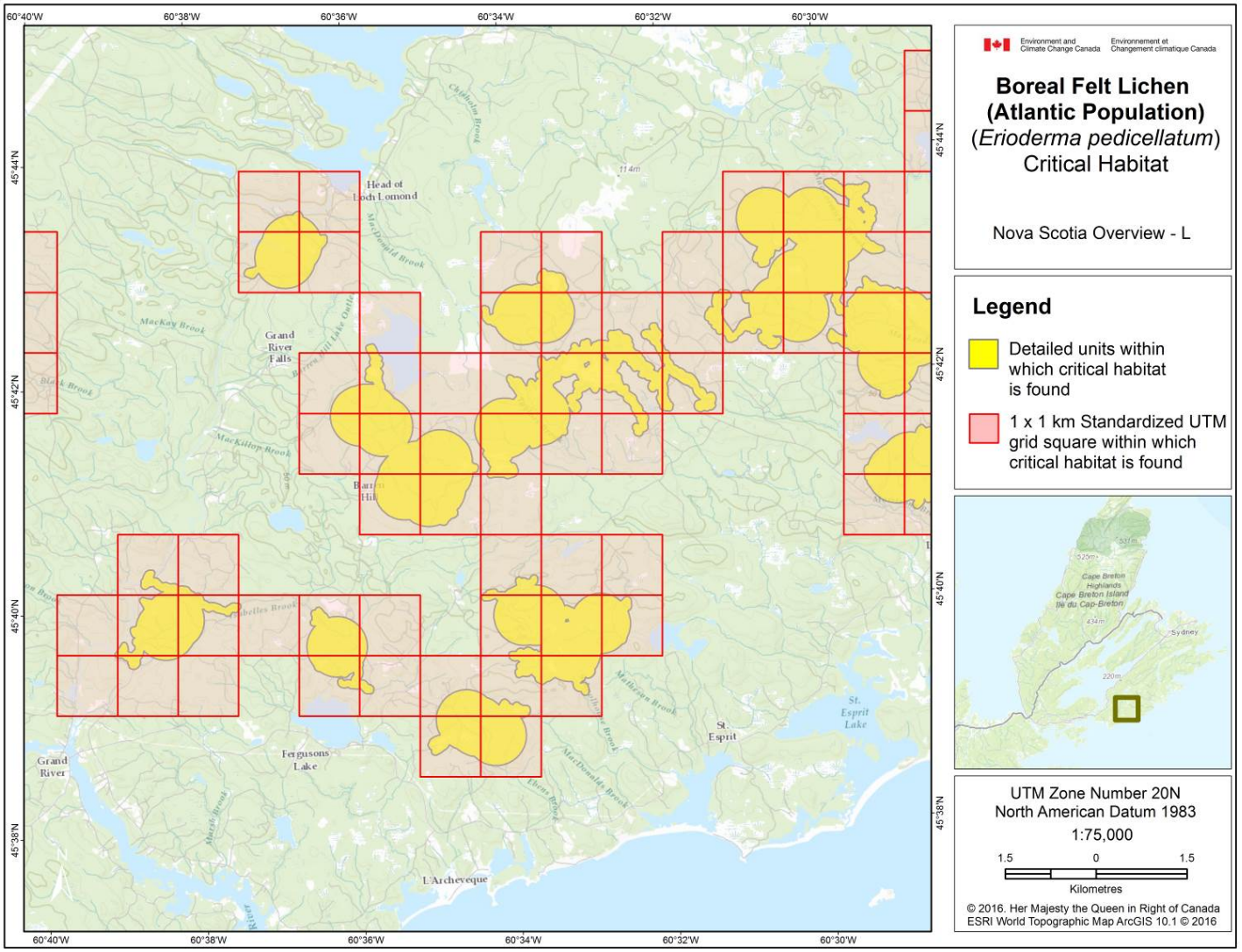

Figure 15. Critical habitat for Boreal Felt Lichen in Richmond County (see Nova Scotia overview map area L) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

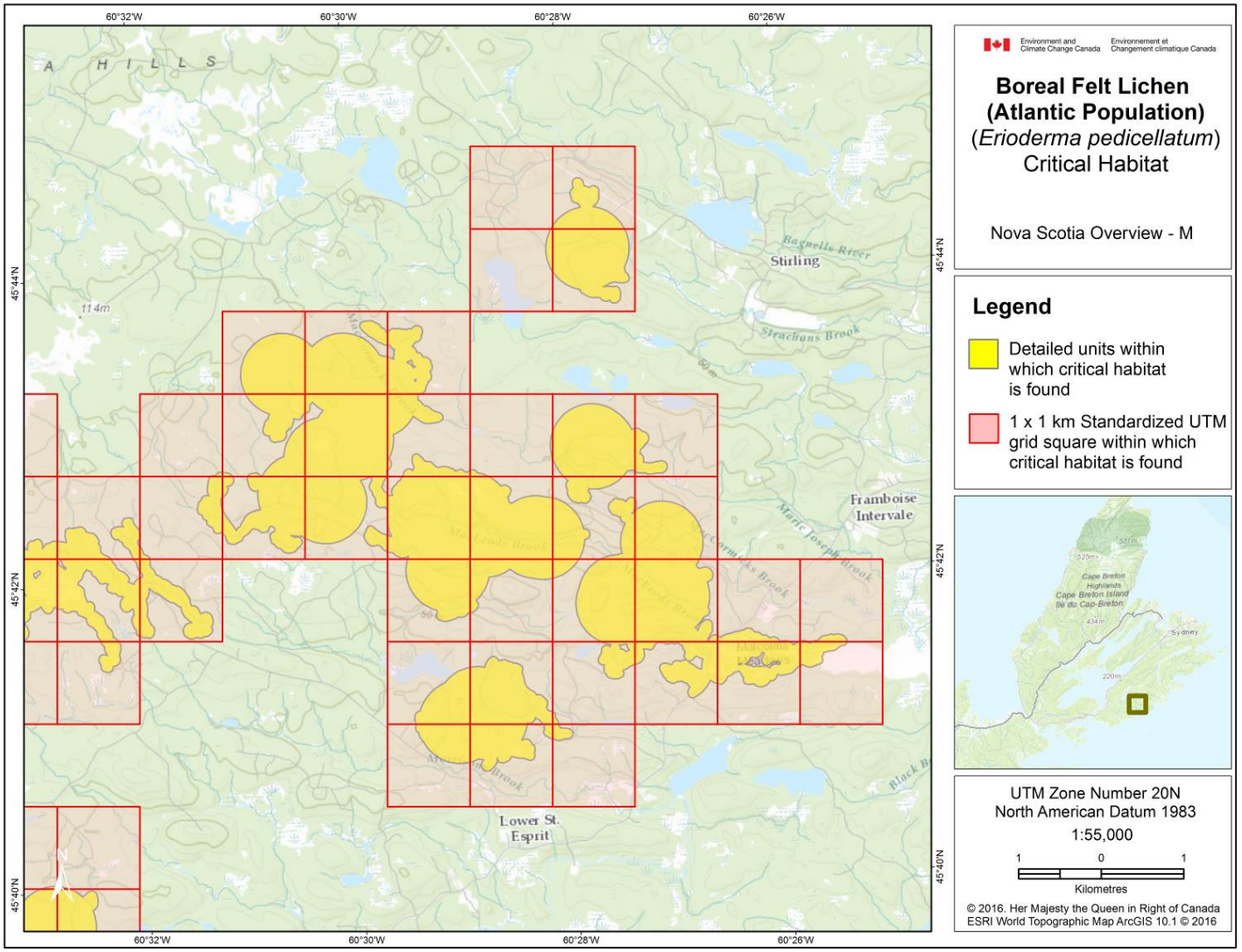

Figure 16. Critical habitat for Boreal Felt Lichen in Richmond County (see Nova Scotia overview map area M) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

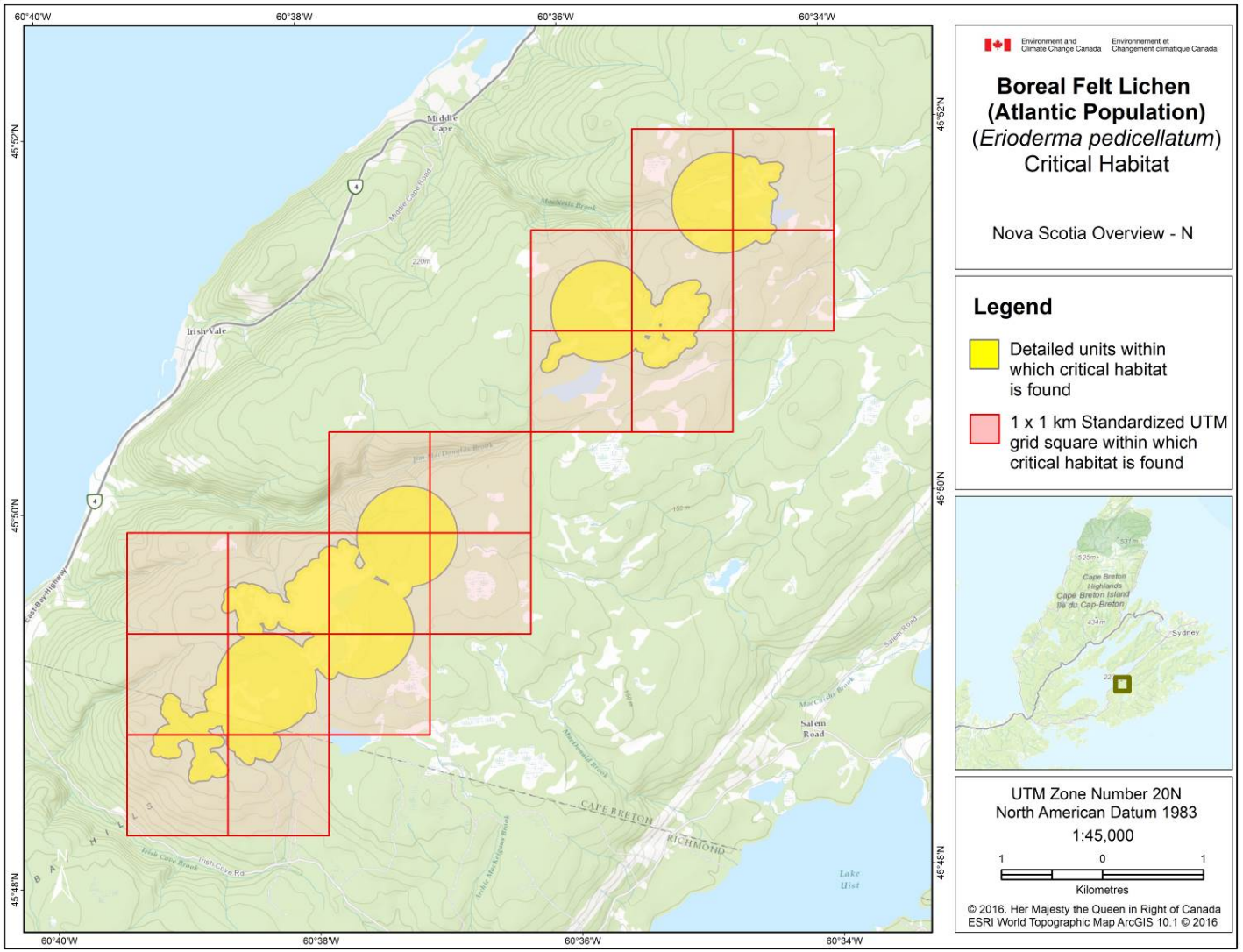

Figure 17. Critical habitat for Boreal Felt Lichen in Richmond and County (east) and Cape Breton County (see Nova Scotia overview map area N) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

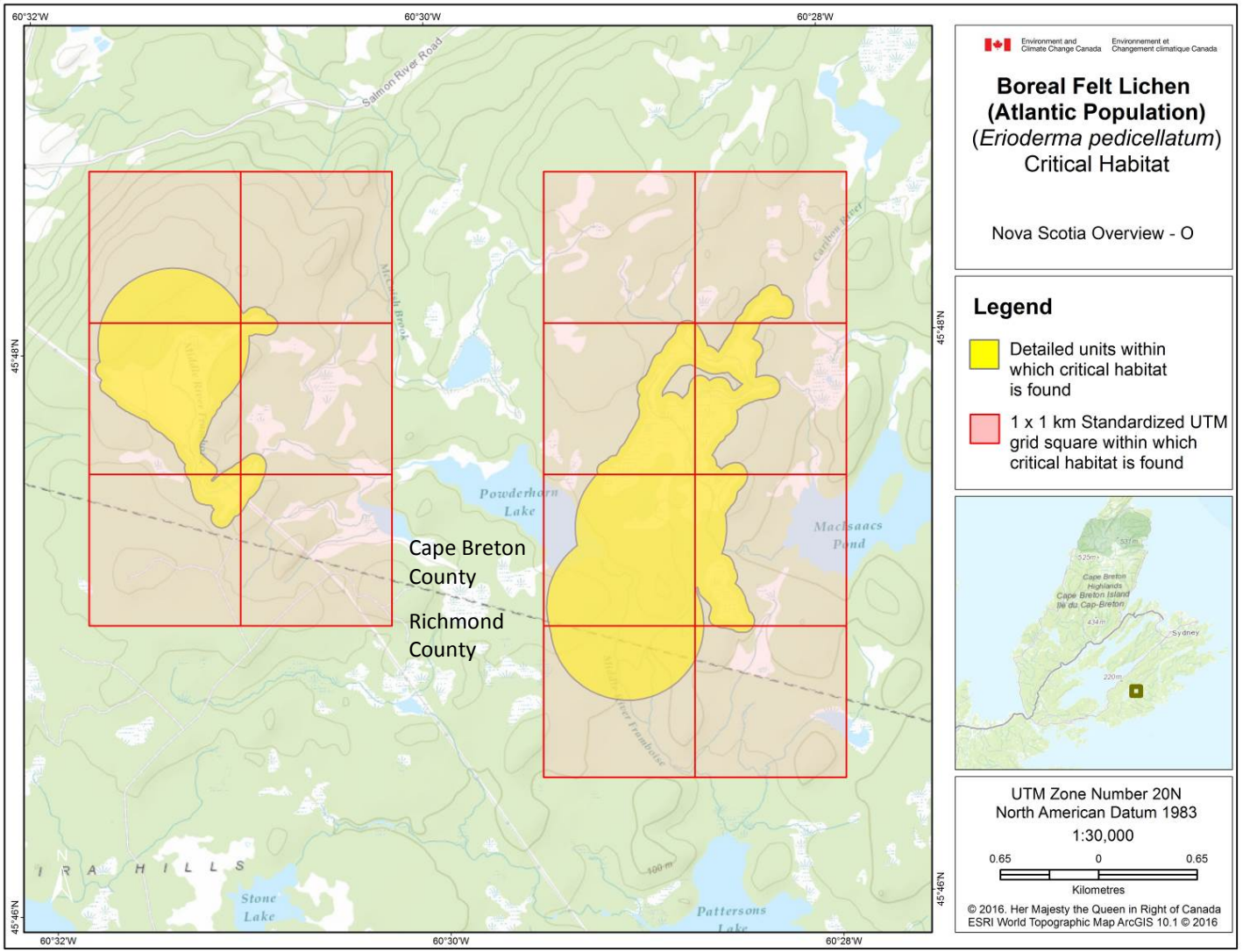

Figure 18. Critical habitat for Boreal Felt Lichen in Richmond County and Cape Breton County (see Nova Scotia overview map area O) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

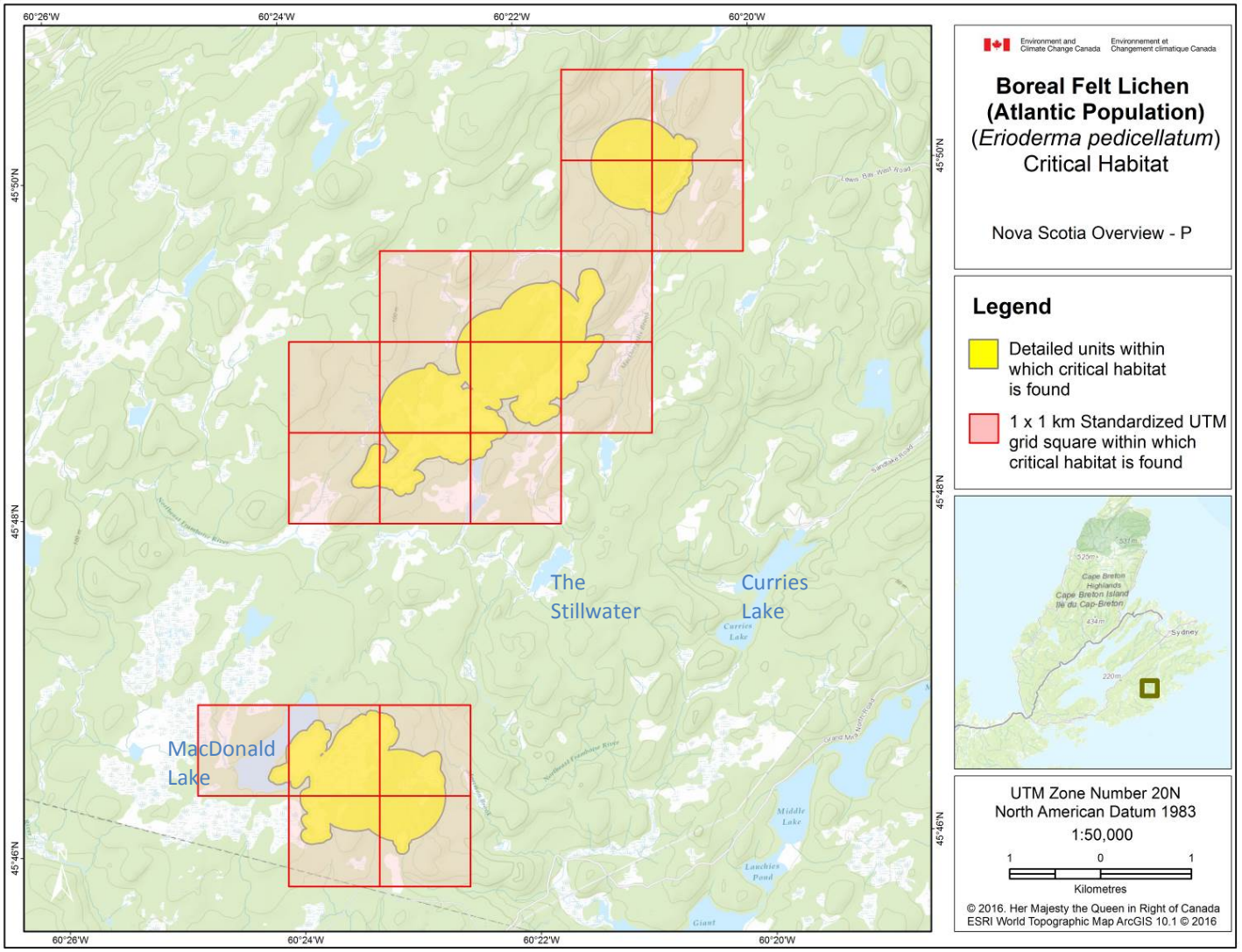

Figure 19. Critical habitat for Boreal Felt Lichen in Cape Breton County (see Nova Scotia overview map area P) is represented by the yellow shaded polygons where the criteria and methodology set out in section 7.1 are met. The 1 km × 1 km UTM grid overlay shown in this figure is a standardized national grid system that indicates the general geographic area within which critical habitat is found. Areas outside of the shaded yellow polygons do not contain critical habitat.

7.2 Schedule of Studies to Identify Critical Habitat

Table 4. Schedule of Studies to Identify Critical Habitat

Description of Activity	Rationale	Timeline
Assess the relationship between wetland size and recharge area required to maintain wetland functionality. Assess the relationship between critical function zone and persistence of the lichen.	To ensure the long-term viability of extant sites, it is necessary to determine if the current zone surrounding the phorophyte and the wetland is sufficient to maintain presence of the lichen, protect wetland function, and mitigate effects of fragmentation.	2023

7.3 Activities Likely to Result in the Destruction of Critical Habitat

Destruction of critical habitat is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single or multiple activities at one point in time or from the cumulative effects of one or more activities over time. When critical habitat is identified in a recovery strategy, examples of activities that are likely to result in its destruction will be provided. Activities likely to result in destruction of critical habitat include, but are not limited to those set out in Table 5.

Table 5. Activities likely to result in the destruction of critical habitat.

Description of activity	Description of effect in relation to function loss	Details of effect
Activities that result in the removal of phorophytes, such as tree blazing, clear cutting, logging and tree harvesting	Phorophytes are essential for growth, survival and reproduction of the lichen, or may alter the suitability of the tree as a host for the lichen.	These activities are likely to result in destruction of critical habitat, regardless of what time of year they occur.
Activities that result in the loss of trees within critical habitat such as clear cutting, logging, tree harvesting, road construction, and cottage development in adjacent areas	The loss of trees in critical habitat may reduce the availability of potential host trees and may indirectly lead to a decrease in bark pH in the remaining softwoods (Richardson and Cameron 2004). Such removal may also decrease humidity and increase wind-speeds (and associated wind-throw damage) within critical habitat. Activities that result in the loss or removal of trees within critical habitat are particularly likely to destroy critical habitat (i.e., removal of trees within 100 m of a phorophyte, removal of any potential habitat identified in the field within 500 m of a phorophyte that is suitable for colonization, or removal of a > 150,000 m^2 block from within the 100-500 m critical function zone around a phorophyte).	It may be possible that additional blocks could be removed from the 100-500 m critical function zone around a phorophyte once the previously cut block becomes fully stocked with regenerating trees at least 3 m in height. This will be assessed on a case by case basis by species experts. Additional guidance regarding the management of these activities will be developed once the schedule of studies for Boreal Felt Lichen is complete.
Activities that alter the hydrology of the site and wetland such as road construction, infilling, clear cutting, tree harvesting, and cottage development.	These activities are likely to alter the hydrology of the wetland adjacent to, or hosting the lichen, resulting in temperature and moisture conditions not suitable for growth and colonisation by the lichen.	These activities are likely to result in destruction of critical habitat, regardless of what time of year they occur.

8. Measuring Progress

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives.

- Extant sites remain throughout the known extent of occurrence for the lichen.
- No adult thalli are lost due to human-induced habitat deterioration or loss.

This recovery strategy and supporting action plan(s) will be subject to an adaptive management approach, whereby new information will be integrated on an ongoing basis.

9. Statement on Action Plans

One or more action plans will be completed within three years of the final version of this recovery strategy being posted on the Species at Risk Public Registry.

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Appendix A: Effects on the Environment and Other Species

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*[6]. 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 and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[7] (FSDS) goals and targets.

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 upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

This recovery strategy will clearly benefit the environment by promoting the recovery of Boreal Felt Lichen. 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 effects on other species were also considered. Boreal Felt Lichen is one of a suite of rare cyanolichens, many of which occur in similar habitats within the humid Atlantic forest region of Nova Scotia. Because these species share similar habitat requirements, actions directed towards better understanding ecosystem-level associations and securing habitat for Boreal Felt Lichen will almost certainly result in the protection of populations of other rare cyanolichens. At a regional level, any progress in reducing air-borne pollutants will benefit not only Boreal Felt Lichen, but most (if not all) of the flora and fauna of the Atlantic forest region as well.

[6] www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[7] www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1

Appendix B: Knowledge Gaps to Recovery

- Identify life cycle of the species and critical life stages
- Genetic diversity (Newfoundland and Labrador vs. Nova Scotia)
- Dispersal distance: distance and mechanisms
- Track resilience of the lichen
- Identify microclimate requirements and specific effects of pollution and acid deposition
- Identify microclimate requirements and effects of adjacent tree harvesting
- Identify mortality factors and determine their population effect
- Effects of gastropod herbivory

Appendix C: Provincial Definitions of a Wetland

As defined under the *Environment Act* (Nova Scotia) a wetland is a marsh, swamp, fen or bog that either periodically or permanently has a water table at, near or above the land's surface or that is saturated with water, and sustains aquatic processes as indicated by the presence of poorly drained soils, hydrophytic vegetation (*Sphagnum* species and Cinnamon Fern) and biological activities adapted to wet conditions.

Wetlands are identified and delineated based on three diagnostic environmental characteristics: hydrophytic vegetation, hydric soil, and wetland hydrology (U.S. Army Corps of Engineers 2012). Nova Scotia Environment provides wetland professionals with resources and references to identify and delineate wetland boundaries at: http://www.novascotia.ca/nse/wetland/delineating.wetland.boundaries.asp