COSEWIC
Assessment and Status Report

on the

Porsild's Bryum
Mielichhoferia macrocarpa

in Canada

THREATENED
2003

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

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COSEWIC
Assessment Summary

Assessment Summary – November 2003

Common name
Porsild's bryum

Scientific name
Mielichhoferia macrocarpa

Status
Threatened

Reason for designation
A rare moss with a severely fragmented distribution of 10 confirmed locations in Canada restricted to five general areas. The species grows in mainly mountainous areas on wet calcareous cliffs, in the presence of constant seepage and winter desiccation. Direct threats to populations include natural and human-caused events that destabilize the rock cliff habitat. There has been a recent decline in habitat quality at the two most abundant locations and substantial loss of mature individual plants at one of these. Only one locality is protected. There is uncertainty about the status of northern Canadian populations.

Occurrence
Alberta, British Columbia, Newfoundland-Labrador, Nunavut

Status history
Designated Threatened in November 2003. Assessment based on a new status report.

COSEWIC
Executive Summary

Porsild's bryum
Mielichhoferia macrocarpa

Species information

Although this species is currently placed in the genus *Mielichhoferia*, interpretations of recent molecular data suggested a closer relationship with members of the genus *Bryum* for this species. Pending publication, the correct name for *Mielichhoferia macrocarpa* will be *Bryum porsildii*. The most notable macroscopic characteristics for species recognition include the small size, lax shiny leaves, growth in dense cushions and often copious sporophyte production.

Distribution

The species is widely disjunct throughout northern latitudes and this distribution is referred to as holarctic disjunct. There are ten known localities for *Mielichhoferia macrocarpa* in Canada and twenty-seven locations in North America. The majority of known sites are associated with western mountain ranges.

Habitat

Consistent aspects of *Mielichhoferia macrocarpa* habitats include the presence of constant seepage through the rock substrate during the growing season coupled with complete desiccation (due to water freezing) during the winter season. The rock is generally calcareous, but this has not been documented at all collection sites. All of the rock cliff habitats visited are also prone to seasonal disturbance from ice scouring and rock fall.

Biology

Mielichhoferia macrocarpa is capable of both sexual and asexual reproduction and production of spores is frequent when plants of both sexes are present at a site. Survival of individual colonies is controlled more strongly by the rock cliff disturbance regime than by competition with other colonies. On the other hand, competition may be more important during the establishment stage. Much of the existing physiological data for *M. macrocarpa* suggests that this species is adapted to alternating between long periods (months) of photosynthetic activity and long periods of inactivity in a desiccated state.

Population sizes and trends

Populations (defined subjectively by spatial discontinuity between groups of colonies) differ in the rate of colony mortality. During periods of rock cliff stability, mortality can be as low as 14% over three years. However, when sites are unstable one catastrophic event can reduce a population of hundreds of colonies to near extirpation, and this has been documented in a Newfoundland population. The longest (minimum) record for continued existence of colonies at the same location is 75 years for a Greenland population.

Limiting factors and threats

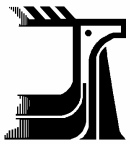
This moss may be limited by suitable habitat availability and dispersal and establishment ability. Threats to populations of this species include any natural or anthropogenic events that could destabilize its rock cliff habitats. For example, recent natural disturbance events have resulted in a net loss of approximately 15% of the known colonies in Canada.

Special significance of the species

Mielichhoferia macrocarpa was hypothesized to belong to an ancient and once widespread flora and has great scientific value for answering questions relative to this flora in terms of the origins of local populations and species.

Existing protection or other status designations

There is no existing legal protection for this species. It has been ranked as S1 (less than 5 occurrences in Province/State) and G2 (globally rare) on both Alberta and Montana natural heritage program tracking lists. None of the known populations occur in National Parks.



COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species and include the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal organizations (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership, chaired by the Canadian Museum of Nature), three nonjurisdictional members and the co-chairs of the species specialist and the Aboriginal Traditional Knowledge subcommittees. The committee meets to consider status reports on candidate species.

DEFINITIONS
(After May 2003)

Species	Any indigenous species, subspecies, variety, or geographically or genetically distinct population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* Formerly described as “Vulnerable” from 1990 to 1999, or “Rare” prior to 1990.

** Formerly described as “Not In Any Category”, or “No Designation Required.”

*** Formerly described as “Indeterminate” from 1994 to 1999 or “ISIBD” (insufficient scientific information on which to base a designation) prior to 1994.

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2003

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SPECIES INFORMATION

Name and classification

There is no officially recognized common name for this moss species in either English or French. Recent DNA sequencing data and phylogenetic analyses have shown *Mielichhoferia macrocarpa* (Hook.) Bruch & Schimp. belongs in the genus *Bryum* (Cox et al. 2000). *Mielichhoferia macrocarpa* resolves in a clade with members of section *Bryum,* and a new name, *Bryum porsildii* (I. Hagen) Cox & Hedderson, has been submitted for publication in the Journal of Bryology (C. Cox and T. Hedderson, pers. comm.). Hedderson and Cox have provided the following protologue:

Bryum porsildii (I. Hagen) Cox & Hedderson, nov. comb.

Basionym: *Mielichhoferia porsildii* I. Hagen, Meddelelser om Grønland 26: 437. 1904

Synonyms: *Weissia macrocarpa* W. J. Hooker ex Drummond, Musci Americani, Specimens of the Mosses Collected in British North America 74. 1828, non *Bryum macrocarpum* Hedwig, Species Muscorum 178. 1801, nec Withering, Systematic Arrangement of British Plants ed. 4, 3: 805. 1801, hom. illeg., nec (Hoppe & Hornschuch) Bridel, Bryologia Universalis 1: 648. 1826, hom. illeg., nec R.Br.ter, Transactions of the New Zealand Institute 31: 455. 1899, hom. illeg.; *Mielichhoferia macrocarpa* (W.J. Hooker ex Drummond) Bruch & W. P. Schimper, London Journal of Botany 2: 665. 1843; *Mielichhoferia nitida* var. *macrocarpa* (W.J. Hooker ex Drummond) Müller Hal., Synopsis Muscorum Frondosorum 1: 235. 1848. *Mielichhoferia nitida* var. *gymnostoma* Mitten ex W. J. Hooker, Journal of the Linnean Society, Botany 1:119 .1857. *Bryum nelsonii* Kindberg, Revue Bryologique 36: 98. 1909. *Mielichhoferia macrocarpa* var. *pungens* E.B. Bartram, Bulletin of the Torrey Botanical Club 54: 33. 1927.

Description

Mielichhoferia macrocarpa plants are relatively small (0.3 to 1.0 cm high) and grow tightly together such that their much branched stems form short, compact cushions (Figure 1). These cushions are bright green and have a "spongy texture" as noted by Flowers (1973). Individual stems are reddish brown and branch by innovations (Figure 2 a,b). The older portions of the stems are covered in dense red rhizoids and often the leaves have lost their chlorophyll and appear colorless except for the costa, which becomes red with age. The leaves are somewhat concave and recurved and appear shiny due to the lax thin-walled cells (Figure 2 c,d). The leaves vary between 0.6 and 1.5 mm long. The species is dioicous, that is, there are separate male and female (gametophytic) plants. The male gametophytes are smaller than the females and have a more rosette-like arrangement of crowded concave leaves at the stem apex (Figure 2a). The female plants are larger and have longer leaves that are less concave

and more evenly spaced on the stems (Figure 2b). Cushions of female plants often produce copious sporophytes and the setae of the sporophytes are largely hidden by the newest stem innovations (Figure 3). The capsules (sporangia) are somewhat globose because they round to a relatively narrow mouth. The species is fairly distinct and uniform in North America, although the populations seen from Colorado differed in their relatively larger plants having long, almost linear leaves with frequently excurrent costae.

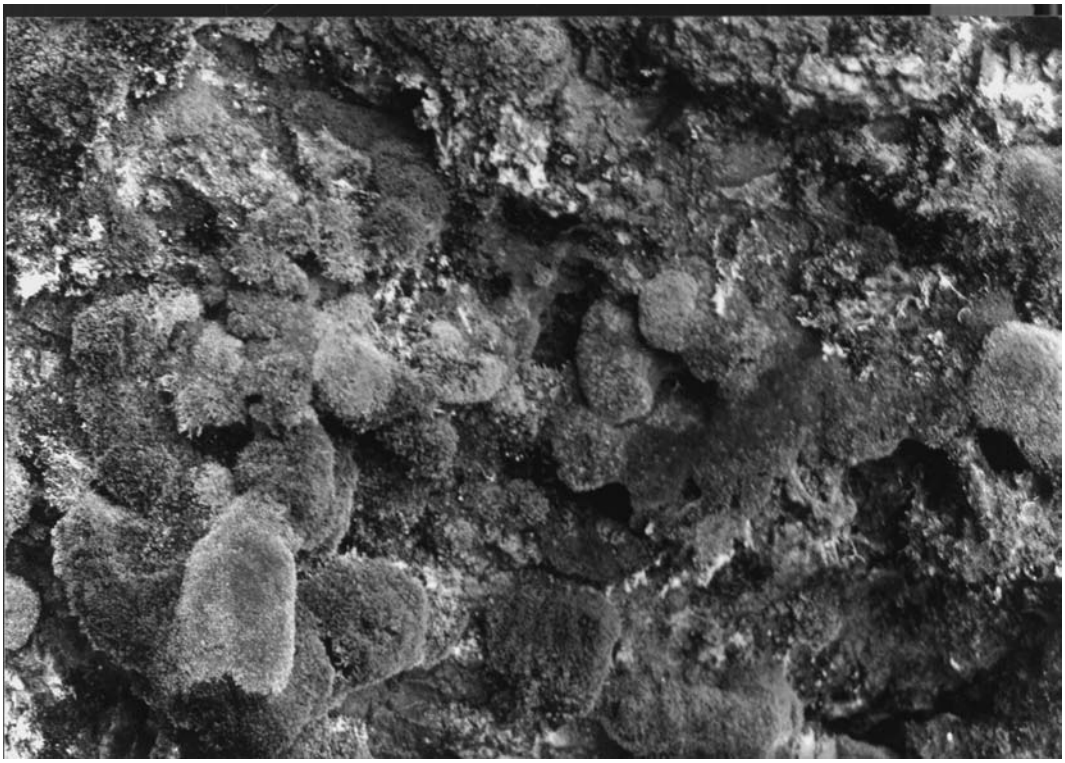

Figure 1. Closeup of Mmac1 population in Mountain Park, Alberta showing the deep, spongy cushions of *Mielichhoferia macrocarpa*.

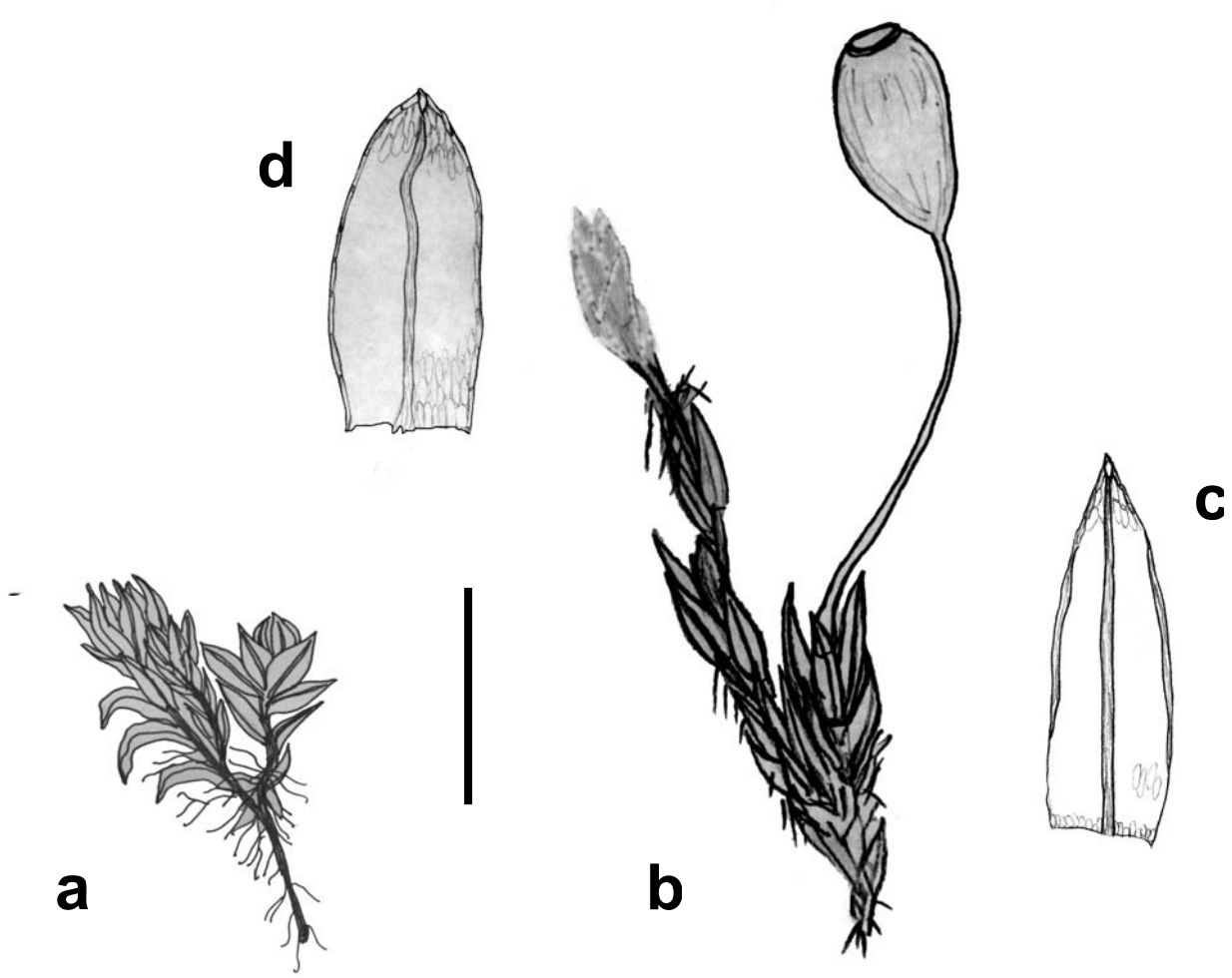

Figure 2. *Mielichhoferia macrocarpa* details drawn from plants of the Whitehorse Creek Rapids population. **a** male plant. **b** female plant. **c** older leaf taken from base of the sporophyte. Note the recurved margins and loss of color in all but the costa. **d** younger leaf from shiny green new growth of stem. Note lax leaf cells and plane, entire margins with longer thinner cells. Scale bar: 0.4 cm for **a** and **b** and 0.6 mm for **c** and **d**.

DISTRIBUTION

Global range

Mielichhoferia macrocarpa is known from North America, southern Siberia, the southern Ural Mountains in Kazakhstan, and the Sayan Mountains of central Asia. Its distribution may be described as holarctic disjunct (Figure 4).

Figure 3. Closeup photograph of a *Mielichhoferia macrocarpa* colony growing along Whitehorse Creek with copious sporophytes and the setae largely hidden by the new stem growth of the colony.

North American Range

Brassard and Hedderson (1983) produced the most recent published distribution map for *Mielichhoferia macrocarpa* when the species was still thought to be endemic to North America. A notable addition to their distribution map discovered in the preparation of this report includes a specimen from Pictured Rocks National Seashore on the south shore of Lake Superior in Michigan collected by A. Jonathan Shaw (1990, see collections examined) (Figure 5). There are currently 27 known locations in North America.

Canadian range

Ten localities occurring in five areas of Canada were verified for this report. Total area of occupation was estimated by measuring colony sizes and density at each site (see Appendix 1). Localities are defined as areas with predictable occurrence of the

species and populations were delimited by spatial separation. The localities for *M. macrocarpa* include one in British Columbia (northface of Mt. Socrates, total area occupied <1m^2), three in Alberta (Cadomin, Whitehorse Creek [six populations, total area occupied 20m^2], Mountain Park [one population, total area occupied 10m^2], and Kananaskis Country [one population, total area occupied ~7m^2],) six in Newfoundland in the area of the Great Northern Peninsula (total area occupied 18m^2, see Appendix 1), and one in Nunavut Territory on Northern Ellesmere Island (one population, area unknown) (Figure 5). There may still be undiscovered populations in northern Canada.

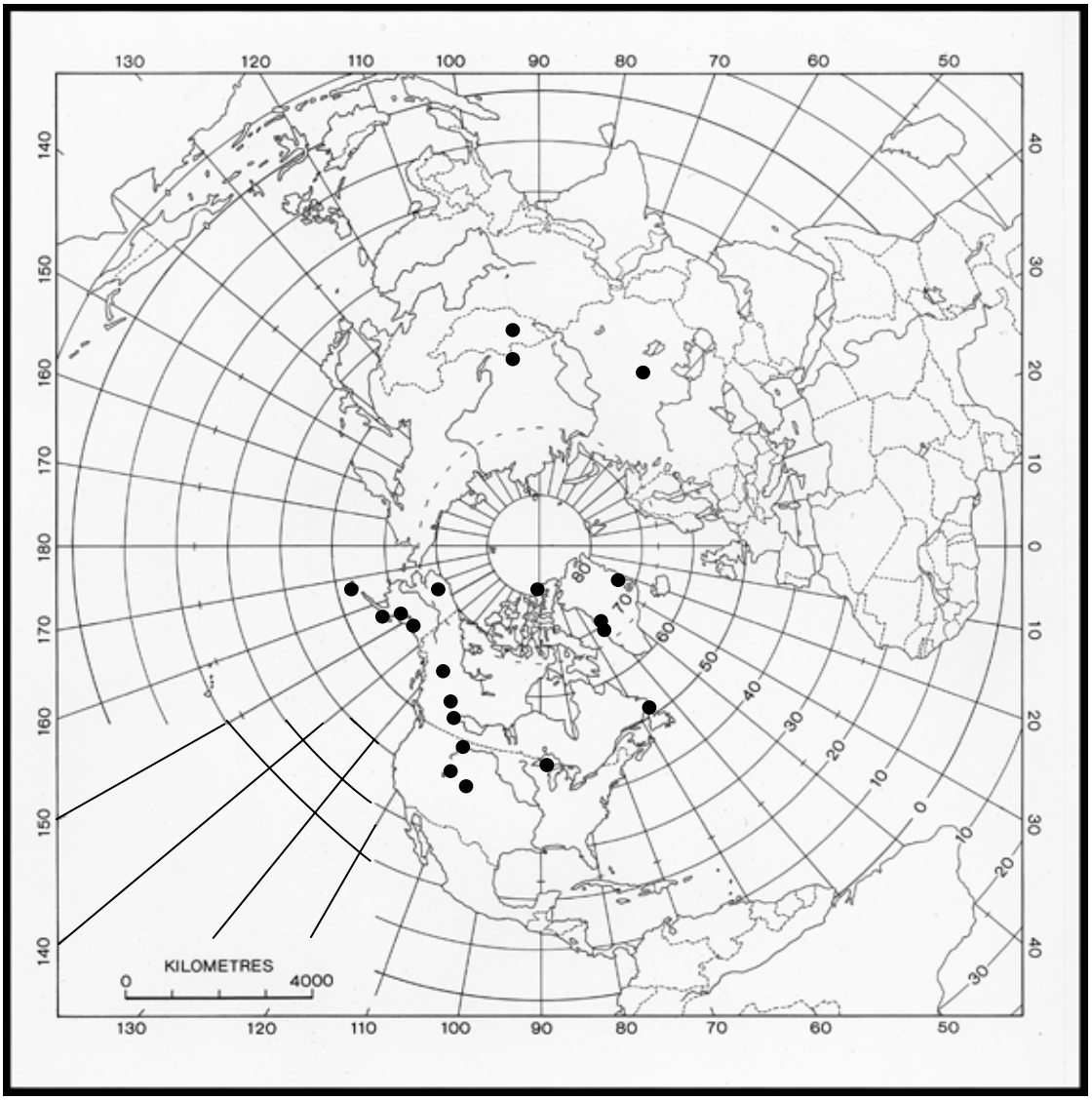

Figure 4. Global distribution of *Mielichhoferia macrocarpa* showing holarctic disjunct pattern.

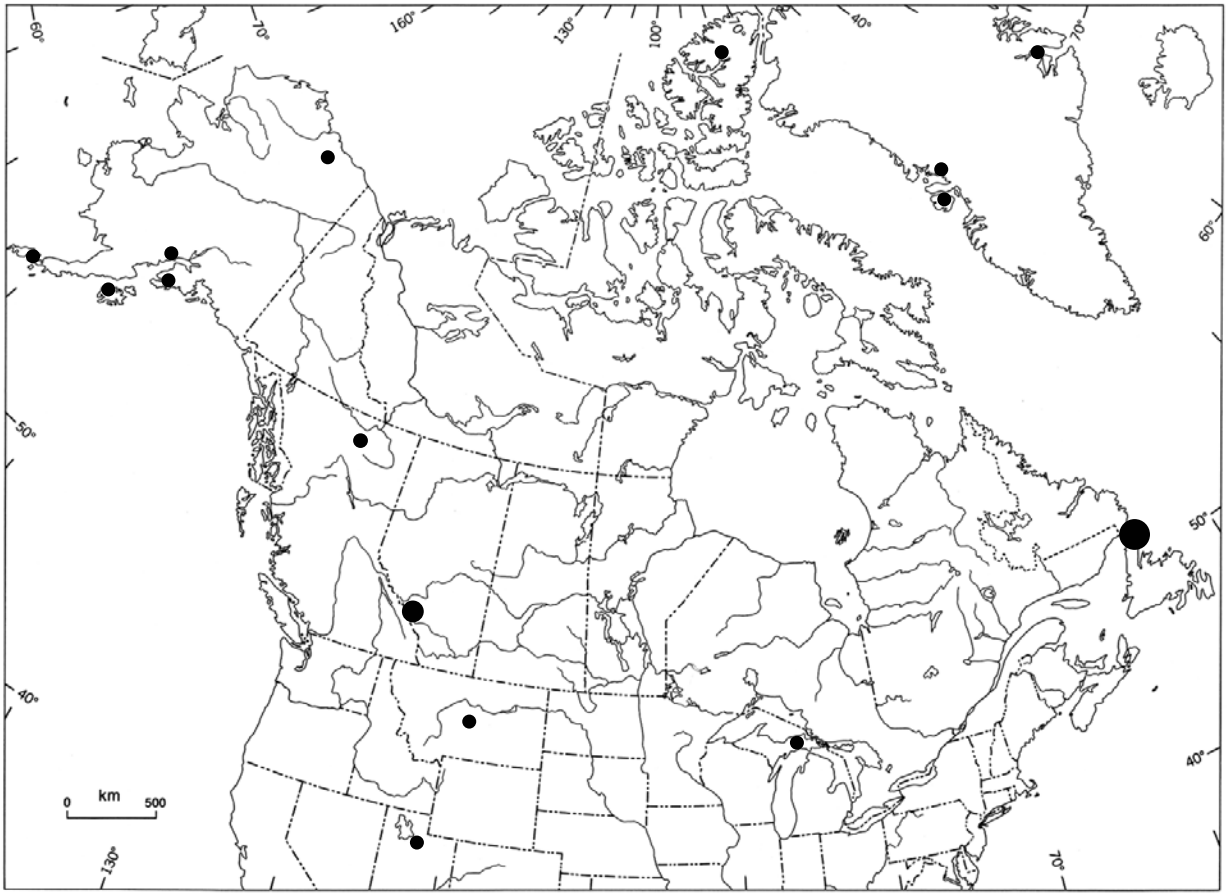

Figure 5. Canadian and northern United States distribution of *Mielichhoferia macrocarpa*. Note the locality on Lake Superior in Michigan, which represents a newly recorded disjunct location for this species in North America. The recent British Columbia locality fills part of the previous disjunction between Alberta and Alaska. The larger dot in Alberta covers two sites and the largest dot on the Great Northern Peninsula covers six sites.

HABITAT

Habitat requirements

Brassard and Hedderson (1983) remarked that *Mielichhoferia macrocarpa* sites are constantly moist with seepage or splash. This is true for all sites seen during the growing season; however, Cleavitt (2002a) has noted that their sites become dry seasonally when water at the sites is frozen (i.e., usually November to late June). Flowers (1973) also noted this for sites in Utah, and this period of freezing-desiccation may represent an important aspect of 'suitable habitat' for *M. macrocarpa* for two reasons. This moss may be physiologically adapted to this environmental regime (see section on Physiology) and the disturbance caused by the ice actually may reduce competition with other species (see section on Interspecific Interactions).

Mielichhoferia macrocarpa has been collected from mainly montane areas on limestone, basalt, sandstone and shale (Brassard & Hedderson 1983). At the Alberta study sites, it occurs on silt in cracks of calcareous conglomerate, limestone, and shale. Despite the observation of Shacklette (1967) on one population growing on basalt in Alaska, from which he concluded that the species was found only on substrates with greater than average concentrations of heavy metals, the bulk of collection information does not support such a substrate restriction. Experimental confirmation of this would require chemical analysis of substrates and heavy metal toxicity experiments. The substrates reported in herbarium collections encompass many rock types, although they tend to be calcareous (Brassard & Hedderson 1983; Cleavitt pers. obs.). In an experiment comparing establishment on native versus non-native substrates (in this case, acidic substrate high in organic matter), *M. macrocarpa* had significantly lower regeneration on the acid substrate and is therefore demonstrably a calciphile, i.e. requiring basic substrates by physiological intolerance of other substrates (Cleavitt 2001).

Trends

Although the re-collection of the species at the same sites over time suggests long-term habitat stability, there are exceptions. The Straitsview population in Newfoundland was recently reduced from several hundred colonies to nine colonies. This site was noted by Hedderson (pers. com.) as harboring the largest known Newfoundland population. Local people commented that the winter of 2001-2 was particularly bad for ice scouring and rock fall in that area. Populations in Alberta were damaged during 2002 by drought conditions. Several of the populations in the Cadomin area had decreased in size since their last documentation in 2000. It is not known how fast *Mielichhoferia macrocarpa* populations can recover from these disturbances.

Protection/ownership

This section largely discusses the visited sites and position information for these sites is given in Appendix 1. Several Alberta populations are known to be in designated protected areas. Part of the Cadomin - Mountain Park populations are located in the Whitehorse Creek Wildland Park established in 2000. However, several important populations remain unprotected and vulnerable to damage by recreational use or development of the area. Most notably a population currently located by a fire pit in the Whitehorse Creek campground was recently threatened by road building development relating to the Cheviot Mine Project (development application still active as of 2003). The location fits the description of Pegg's 1966 collection record, and the Mountain Park population first collected by Vitt in 1984. The Trolls Falls population is located in the Kananaskis Country Provincial Park, although the site currently has very high visitor traffic and no special restrictions against disturbing the rock cliff. The recently discovered British Columbia population is located in an area between and outside Muncho Lake and Stone Mountain Provincial Parks. Because the sites are opposite a parking area along the Alaska Highway, they are likely to attract a good number of unmonitored visitors who may inadvertently scrape populations from the rocks. The

Newfoundland populations are on Crown land with no protection status (Djan-Chékar, personal communication). The two largest populations are at Cape Onion and White Cape.

BIOLOGY

Reproduction

Despite its dioicy, *Mielichhoferia macrocarpa* produces sporophytes in most populations (Cleavitt 2002a, Brassard & Hedderson 1983). Sporophytes occurred on 10.7% of the mapped colonies with high variation between sites (Cleavitt 2002a). Spore germination for *M. macrocarpa* on agar was 55.7±4.1% (mean±stdev), and no spores germinated on natural substrate. Gametophore growth from protonema was very low. Further experimentation on reproduction from spores is needed for this species.

Cleavitt (this report) also observed asexual reproduction by this species. The leaves of the original gametophyte fragment always go chlorotic and then secondary protonema grow out from the red stem. The protonema produce rhizoids and gametophore buds. Direct sprouting from the stem has also been observed, but it is less common than regeneration via secondary protonema (Cleavitt 2002a). Evidence for occurrence of asexual reproduction was provided by one population of genetically homogeneous male plants found in the study area (Cleavitt unpbl. isozyme data). *Mielichhoferia macrocarpa* had significantly lower regeneration than five other moss species with only 25% (±30) fragments established in the field and 8% (±7) established under growth chamber conditions (Cleavitt 2002a).

Survival

Short-term (three-year) monitoring of three Alberta populations in the Cadomin vicinity has revealed that 52.9%(±6.15) (mean±stdev) of the colonies grew from 1997 to 2000. In the same period, 13.6%(±3.82) remained the same size, 18.8%(±8.01) became smaller and/or died, and 14.7%(±4.41) disappeared from the cliff. There was also evidence of replacement for lost or dead colonies as several new colonies were also found in these populations in 2000.

Mielichhoferia macrocarpa was compared to a common congener, *Bryum pseudotriquetrum*, in terms of colony growth and survival of reciprocal colony transplants. Percentage of expanded colonies for *M. macrocarpa* was higher than for *B. pseudotriquetrum* (Cleavitt 2002a). However*, Bryum pseudotriquetrum* transplants had higher survival than *Mielichhoferia macrocarpa* at both *M. macrocarpa* and *B. pseudotriquetrum* sites. *Mielichhoferia macrocarpa* does not survive transplantation well (Cleavitt 2002a). Reconnaissance work on populations in 2002 revealed the susceptibility of *M. macrocarpa* populations to disturbance by drought and ice scouring. These natural and unpredictable disturbances strongly decrease survival of individual colonies, but long-term herbarium records suggest that the populations on the whole are resilient.

Physiology

The physiology of this species is quite complex and cannot be inferred from habitat data (Cleavitt 2002b). As noted previously, the species is physiologically restricted to basic substrates (Cleavitt 2001). *Mielichhoferia macrocarpa* had significantly higher photosynthetic yield (a proxy for the efficiency of photosynthetic machinery) than the common *B. pseudotriquetrum* (Cleavitt 2002b). In an experimental comparison between six moss species, *M. macrocarpa* had the slowest rate of photosystem recovery (50 minutes to reach ½ pre-treatment levels) after rehydration of plants that had been subjected to three days in a dry state. However, within 24 hours the colonies did recover to levels not significantly different from pre-drying levels and constantly hydrated control samples (Cleavitt 2002b). The ability to recover from desiccation was greater when plants were desiccated as colonies rather than as fragments (Cleavitt 2002b).

The temptation to infer physiological tolerance from habitat characteristics should be avoided. Although *Mielichhoferia macrocarpa* occurs in wet, dark sites, the species was not physiologically limited by either desiccation tolerance or light levels (Cleavitt 2002b). This finding is somewhat counter-intuitive given that there is ample evidence for a correlation between habitat moisture regime and bryophyte desiccation tolerance (Brown & Buck 1979, Seel et al. 1992, Oliver et al. 1993, Deltoro et al. 1998, Csintalan et al. 1999, Robinson et al. 2000). This departure from the usual relationship between habitat and desiccation tolerance may be explained if habitat moisture regimes are more rigorously classified. For instance, although *M. macrocarpa* occurs at sites that are hydric throughout the growing season, these sites dry out in autumn when the seep water freezes and remain dry without protection from snow cover until late spring/early summer (pers. obs.). Therefore, this species would be expected to possess some type of desiccation tolerance.

There are two types of desiccation tolerant plants, poikilochlorophyllous and homoiochlorophyllous, and both types occur in bryophytes (Tuba *et al*. 1998). Poikilochlorophyllous bryophytes experience breakdown of their chlorophyll in response to drying-wetting cycles and survive in habitats that are generally mesic and slow drying such that drying-wetting cycles tend to be both longer in duration and less frequent (Oliver et al. 1998, Tuba et al. 1998). Homoiochlorophyllous bryophytes retain their chlorophyll through drying-wetting cycles and occupy more xeric, exposed habitats that experience more frequent, brief, rapid drying events; however, even for these mosses fast desiccation leads to a prolonged recovery period (Oliver et al. 1998). Therefore, the frequency, rate and duration of habitat drying throughout the year are important in accurately describing the relationship between desiccation tolerance and moss habitats (Oliver et al. 1993, Oliver et al. 1998, Tuba et al. 1998). Based on the facts that *Mielichhoferia macrocarpa* is desiccation tolerant and that it occurs in habitats which dry out infrequently for long periods of time, this moss is most likely poikilochlorophyllous. This hypothesis is also supported by *M. macrocarpa's* relatively slow rate of recovery in photosynthetic yield after rehydration (Cleavitt 2002b).

Movements/dispersal

Cleavitt (2002b) investigated the dispersal ability for gametophyte fragments of this species via air and water. *Mielichhoferia macrocarpa* had higher fragment viability after storage in air rather than water after four months, but there was no difference between fragment viability in air versus water after only one month (Cleavitt 2002b). The likelihood of water transport for this species depends on the number of vertical rock seeps encountered by a waterway along which it occurs. The unexpected high viability of fragments stored dry makes transport by wind, especially during the winter, another plausible mode of asexual dispersal for *M. macrocarpa*. Unpublished evidence for *M. macrocarpa* indicates that this species can establish at suitable, but unoccupied field sites. However, the potential for *M. macrocarpa* to increase its area of occupancy is hampered by the apparent inability for successful dispersal. Population genetic studies would greatly increase our understanding of dispersal in this species.

Interspecific interactions

There have been no experimental tests of the importance of interspecific interactions for this species. Because vascular plant cover in *Mielichhoferia macrocarpa* habitats is negligible, the most likely competitors are other bryophytes. In scoring neighbor contact for several moss species, *M. macrocarpa* had relatively lower frequency of neighbor contact than the common *B. pseudotriquetrum* (Cleavitt 2002a). By the same method, *M. macrocarpa* had a relatively low number of encounter losses (times when it was overgrown by another species) suggesting that competition may play a relatively small role in the persistence of this species at a site. However, experimental evidence is needed to verify this hypothesis.

From additional plot data comparing attributes of suitable occupied and unoccupied sites for *Mielichhoferia macrocarpa*, we know that the species was absent from sites with higher percent cover of other moss species. Sites with *M. macrocarpa* had a higher percentage of bare rock (73%±28) than sites without *M. macrocarpa* (17%±22) (Cleavitt, unpub. data). Together these results point to the importance of competition in determining where *M. macrocarpa* will establish rather than affecting its continued persistence at a site where it currently exists.

Continued exploration into ecological limitations of *Mielichhoferia macrocarpa* should include the relative effects of environmental parameters and neighbors on the rates of establishment from gametophyte fragments and spores and subsequent colony expansion. The most important point is that this species has great difficulty establishing new populations, but seems capable of long-term local persistence once it has established. Therefore, habitat preservation is crucial and transplantation of populations is not recommended.

POPULATION SIZES AND TRENDS

Sites here are defined by the existence of a group of *M. macrocarpa* colonies that is discontinuous from any other such nearby groups. All areas in between sites that are less than 15 km apart have been thoroughly searched by Natalie Cleavitt (in 1997-2002) for any additional colonies. Sites measured in Alberta tend to be quite small (0.71 m^2 ± 0.31), although site coverage is fairly high for a moss (0.15%) (Cleavitt 2002a). Colonies have a mean size of 22 cm^2 (± 27) and the number of colonies for those populations counted varied from 3 to 260 colonies at a site. The Newfoundland populations tended to be smaller and more patchily distributed than Alberta populations (see Appendix 1). Hedderson (2002, pers. com.) had previously remarked that the only large population of the four known in northern Newfoundland was the Straitsview population and this population now consists of only nine colonies (see Appendix 1). However, Hedderson (pers. com.) later noted that he had seen the size of this population fluctuate in the past. Currently the largest population documented in Newfoundland was a newly discovered population at White Cape (see Appendix 1). The total gain in population size from work leading to this report was at least 117 colonies.

Based on label information for *Mielichhoferia macrocarpa* specimens that indicate collections taken from the same site (and presumably population) over time (three sites total) the long-term trend has been population stability. Three recently studied (1997-2000) populations near Cadomin have documentation dating from 1966, 1977 and 1984 (see collections examined). The one site in Kananaskis has been known since 1982. All four of these sites had healthy populations as of 2000. The Montana site at Silver Gate in Park County has been collected in 1948, 1953, 1973 and 1992 (Brassard & Hedderson 1983; see collections examined). Brassard and Hedderson (1983) further noted the stability of a population on Disko Island in Greenland where the species was collected in 1898 and 1973 (75 years apart). However, as mentioned previously under Habitat Trends, the Newfoundland and Alberta populations were observed to decline over the winter of 2001-2 (an estimated 296 colonies). This decline represents a 15% decrease in known population size. Population monitoring would help to establish how well this species recovers from severe population reduction at a site.

LIMITING FACTORS AND THREATS

Mielichhoferia macrocarpa is limited by a number of factors relating to establishment of new populations including dispersal, substrate restriction and intrinsically low or slow establishment that limits the species to sites unoccupied by other mosses.

In the Cadomin area of Alberta, the occupied seepy cliff sites are very vulnerable to changes in upstream hydrology such as siltation of streams caused by excessive off-road vehicle use in headwaters. In this area outside the Wildland Park, coal mining exploration (planned Cheviot Mine) and road development have also threatened

populations, notably the population called Mac1, which is the largest contiguous population of the species in Canada (Appendix 1). Road construction and blasting could cause large pieces of the intrinsically unstable rock to fall from cliff habitats taking *Mielichhoferia macrocarpa* colonies with them. Populations of the species in Alberta and British Columbia are certainly in the greatest danger from development and recreational use of habitats.

SPECIAL SIGNIFICANCE OF THE SPECIES

Mielichhoferia macrocarpa was hypothesized to belong to an ancient, once widespread flora that survived glaciation in refugia such as Beringia (Steere 1978). This rare species is probably a relatively old species adapted to habitats that have become patchily distributed on the landscape. Isozyme analysis of Alberta populations suggests that the population genetics of this species may be quite complex and distance between populations did not correspond well with genetic similarity (Cleavitt, *unpubl. data*). Because of its holarctic disjunct distribution this species is a valuable candidate for phylodemographic work and studies of cryptic speciation.

EXISTING PROTECTION OR OTHER STATUS

There is currently no legal protection for this species anywhere within its range. NatureServeExplorer (2003) ranks *Mielichhoferia macrocarpa* as G2 globally, and S1 in each of Alberta, British Columbia, Newfoundland (island), and Montana. The Montana Natural Heritage Program (2001) also notes no status for this species under U.S. governmental agencies. The majority of known populations are within Canada and Alaska (Figures 4 & 5).

SUMMARY OF STATUS REPORT

Porsild's bryum is a highly disjunct (fragmented populations), globally rare, moss that is known from 26 sites in North America, and restricted to 10 locations in Canada. The Canadian localities are restricted to five general areas. The species grows in mainly mountainous areas on wet cliffs characterized by calcareous substrate, presence of constant seepage and winter desiccation. Species presence is limited by habitat availability, dispersal and poor establishment ability; population survival is limited by cliff stability. Direct threats to populations include natural or anthropogenic events that destabilize the rock cliff habitat. Several populations have declined from their prior population sizes including populations in Alberta that suffered desiccation damage during the winter of 2001-2002 and a Newfoundland population that was nearly extirpated by ice scouring and rock fall in the same winter season. Imminent threats are coal mine and road development to some Alberta populations.

TECHNICAL SUMMARY

Mielichhoferia macrocarpa (=Bryum porsildii)
Porsild's Bryum Bryum de Porsild
Range of Occurrence in Canada: AB, BC, NL, NU

Extent and Area Information	
• *Extent of occurrence (EO)(km²)*	> 1,000,000 km²
• *Specify trend in EO*	Stable
• *Are there extreme fluctuations in EO?*	No
• *Area of occupancy (AO) (km²)*	<< 1 km²
• *Specify trend in AO*	Declining
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	10
• *Specify trend in number of locations*	Increase? (3 new discovered in 2002)
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Unknown
Population Information	
• *Generation time (average age of parents in the population)*	Unknown
• *Number of mature individuals*	1005+/- colonies
• *Total population trend:*	Decreasing (ca 15 % in 3 years) Net loss of ~179 colonies (SEE NOTES BELOW)
• *% decline over the last/next 10 years or 3 generations.*	n/a
• *Are there extreme fluctuations in number of mature individuals?*	No
• *Is the total population severely fragmented?*	Yes - 10 locations in five widely separated regions: Alberta, BC, NF, NU
• *Specify trend in number of populations*	Decline. 6 new populations at 3 locations discovered in 2002 but overall decline in number of colonies
• *Are there extreme fluctuations in number of populations?*	No
• *List populations with number of mature individuals in each:*	See Appendix 1
Threats (actual or imminent threats to populations or habitats)	
In Alberta, Cadomin area, the cliff sites are very vulnerable to changes in upstream hydrology such as siltation of streams caused by excessive off-road vehicle use in headwaters. In this area outside the Wildland Park, coal mining exploration (planned Cheviot Mine) and road development have also threatened populations, notably the population called Mmac1, which is the largest contiguous population of the species in Canada and the largest in Alberta (Appendix 1). Road construction and blasting could cause large pieces of the intrinsically unstable rock to fall from cliff habitats taking *Mielichhoferia macrocarpa* colonies with them. British Columbia population potentially threatened by tourist activities.	

Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?*	S1 (Montana, NatureServe Explorer 2003)
• *Is immigration known or possible?*	Not known. Possible but not probable
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Yes
• *Is rescue from outside populations likely**?***	No
Quantitative Analysis	n/a
Current Status	G2 (global, NatureServe Explorer 2003)

NOTES: Population trends assessed as follows:

Losses:	"several hundred" colonies lost at Straitsview	**200** (estimate)
	10-25% of area at Mmac2 (pers comm with author)	0.25* 58 = **14** colonies
	10-25% of area at Mmac3 (pers comm with author)	0.25* 260 = **65** colonies
	< 10% of area at Mmac1 (pers comm with author)	0.10* 177 = **17** colonies
	TOTAL LOSSES	~ **296** colonies
Gains:	Mt Socrates	**18** colonies
	Noddy Bay	**13**+ colonies
	White Cape	**86**+ colonies
	TOTAL GAIN	**117+** colonies

NET LOSS: **179** colonies

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** Met criteria for Endangered, C2a(i), but was designated Threatened, B2ab(ii,iii,v); C2a(i); D1, because the species is not at imminent risk of extirpation.

Reasons for Designation:
A rare moss with a severely fragmented distribution of 10 confirmed locations in Canada restricted to 5 general areas. The species grows in mainly mountainous areas on wet calcareous cliffs, presence of constant seepage and winter desiccation. Direct threats to populations include natural and human-caused events that destabilize the rock cliff habitat. There has been a recent a decline in habitat quality at the two most abundant locations and substantial loss of mature individual plants at one of these. Only one locality is protected. There is uncertainty about the status of northern Canadian populations.

Applicability of Criteria

Criterion A (Declining Total Population): Not applicable – does not meet decline not thresholds.

Criterion B (Small Distribution, and Decline or Fluctuation): Threatened under B2a and b (severely fragmented (fewer than 11 locations, continuing decline in area of occupancy, quality of habitat, and number of mature individuals).

Criterion C (Small Total Population Size and Decline): Endangered under 2a(i), continuing decline under potential threat of mine development in Alberta, fragmented population with no population estimated > 250 mature individuals.

Criterion D (Very Small Population or Restricted Distribution): Threatened under D2 (AO <20 km2); also verges on criteria for Threatened D1 (< 1000 individuals).

Criterion E (Quantitative Analysis): Not applicable

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René Belland and Jennifer Doubt both provided helpful advice during the preparation of this report. Malcolm Coupe provided field assistance for site visits in Alberta and British Columbia. Nathalie Djan-Chékar, Carson Wentzell and Leah Soper provided field assistance on the Great Northern Peninsula in Newfoundland. Nathalie Djan-Chékar and Malcolm Coupe both contributed photographs to this report. The comments of Linda Ley and two anonymous reviewers helped to clarify the report and make it more complete.

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BIOGRAPHICAL SUMMARY OF THE REPORT WRITER

Natalie Cleavitt earned her B.Sc. in the Department of Natural Resources at Cornell University in 1993. Her preoccupation with bryophytes began in 1991 when she became determined to identify the *Sphagnum* species in the peatlands where she was tracking seasonal greenhouse gas fluxes. She took her first bryophyte identification course at Trinity College in Dublin, Ireland in 1992 during a semester abroad. She has a special interest in the bryophyte flora of New Hampshire and in bryophyte ecology and has conducted several surveys and held many bryophyte identification contracts with the US Forest Service and N.H. Natural Heritage Program. She earned her Ph.D. from the University of Alberta in 2002 and is now a Postdoctoral Associate at Cornell University. Her Ph.D. work was a comparative study of the ecology of rare and common mosses in the Rocky Mountains of Alberta and *M. macrocarpa* was one of her study species.

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The late Howard A. Crum, University of Michigan Herbarium Ann Arbor.

COLLECTIONS EXAMINED

*indicates collection localities visited personally by the Natalie Cleavitt.

Alaska. Chisik Island: NE shores, waterfall and dripping cliffs. 24 June 1993. Schofield 99133. ALTA, UBC, DUKE.
Alaska. Kodiak Islands, Sitkalidak Island, on sandy loam knolls (?). 25 August 1931. Eyerdam 29. DUKE.
Alaska. Mt. Hultén: crevice of limestone cliff. 29 July 1982. Schofield 78130. UBC, DUKE.
Alaska. Southeast, East slope of Marble Mt., opposite Drake Island, Glacier Bay. Shore gravels, marble bedrock. 9 August 1968. Worley 11248. UBC.
Alaska. Valdez area: Between Delta Junction and Valdez along Hwy 4. Keystone Canyon. On mesic, quartzite-slatey outcrops bordering the highway adjacent to Bridal Veil Falls. 120m elevation. 21 June 1977. Vitt 18255, 18251, 18260, 18254, 18253. ALTA.
Alaska. Brooks Range, Atigun Gorge (Philip Smith Mountains; at waterfalls. On wet rock. 27 June 1977. Spatt 629. ALTA.
*Alberta. Cadomin: In small pits of (otherwise) smooth face of overhanging rock in creekbed. 5200 ft. elevation. (site referred to as Mmac Boulder by the contractor) 10 July 1966. Pegg 2386. PMAE.
*Alberta. Cadomin (Mountain Park area): on north facing slope of Whitehorse Creek. On mesic calcareous bluffs. (site called Mmac2 in this report) 14 May 1977. Vitt 18161. ALTA.
*Alberta. Kananaskis Area: vicinity of Trolls Falls. Limestone rock in spray of falls. 4200 feet elevation. 26 July 1982. Crichton s.n. ALTA.

*Alberta. Mountain Park area: 1700 m elevation beneath small permanent waterfall over Cadomin conglomerate. 19 August 1991. Vitt s.n. (site called Mmac 1 in this report). Earlier specimen from this same site: 16 June 1984. Vitt 31249. ALTA.

Colorado. San Juan Co.: Cascade Creek, trail to Engine Creek, NW slope of Engineer Mt., damp cliff near falls. 8 August 1990. Schofield 95902. UBC.

Colorado. San Juan Co.: 7 mi. NE of Silverton on Hwy 110, on rock in a narrow gulch adjacent to the (abondoned) Eureka Mine. 26 June 1990. Shaw 6145. DUKE.

Greenland. Disko: Godhavn, Kuanit. 21 August 1971. Holmen & Mogensen 71-463. ALTA. (Note: type specimen for M. porsildii collected here 1898).

Michigan. Alger Co.: Pictured Rocks National Lakeshore, South shore of Lake Superior at Miner's Castle, on sandstone. 3 November 1990. Shaw 6176. DUKE.

Montana. Park Co.: Silver gate on roof of limestone overhang at waterfall. 29 August 1948. Conard 48-988. Subsequent collections from this site: 1 mi. SE of Silver gate, Fall Creek, on Cambrian limestone. 25 August 1953. Whitehouse 27618. Silver gate and vicinity. 1992. Shaw 6014 and three other collections s.n. DUKE.

*Newfoundland. Northern Peninsula: Straitsview: north facing black shale sea cliffs on side of harbor in crevices of cliff just above tidal level. 18 August 1982. Hedderson 882 (Bryophyta Exsiccata Terrae-Novae et Labradoricae 139). ALTA. Subsequent collections: 1 August 1987. Schofield 89142. UBC.

Nunavut. N. Ellesmere Island. Head of Tanquary Fiord, 3 km south of base camp at 300 m elevation, under very wet overhanging limestone ledge. 17 July 1964. Brassard 1535. UBC, PMAE.

Excluded specimens (not *M. macrocarpa*):

Alberta. Kananaskis County. Troll Falls. Spray zone of calcareous waterfall. 1830 m elevation. 6 July 2000. Hastings. PMAE.

Colorado. Summit Co. Blue Lake Dam area, Monte Cristo Creek Valley between Mt. Quandary and N. Star Mt. 26 August 2000. Weber et al. B-111101. DUKE.

Colorado. Gunnison Co. Elk Mts., just south of Schofield Pass across from Emerald Lake. Noted as "probably the type locality" and "very abundant". (Note this would be the type locality of *Bryum nelsonii*). 15 August 2000. Weber et al. B-111098. DUKE.

COLLECTIONS PREVIOUSLY EXAMINED BY BRASSARD AND HEDDERSON (1983)

A number of specimens were not sent in response to the Natalie Cleavitt's loan requests, but have been previously examined by Brassard and Hedderson (1983) and should be regarded as reliable records of *M. macrocarpa* occurrence. Note that label information associated with the early Drummond collection is not precise enough to relocate the population and this collection is not counted in known population tallies in the report.

Alaska. Yukon River-Prudhoe Bay haul road, W. end of Atigun canyon, Brassard 13808 (NFLD).
Alaska. Aleutian Islands, Amchitka Island, near Cyril Cove, Shacklette 7181 (COLO).
Alaska. Alaska Range District, upper valley of Swift Fork of East Fork of Kuskokwim River, Viereck 5180 (COLO).
Alberta. Rocky Mountains. Drummond, Musci Americani 1828, No. 74 (NY)
Greenland. District W6. Quamarujuk Fjord, Akuliarusikavsak, Holmen 13359 (C).
Greenland. District E5. Rypefjord, SW coast, Holmen 18901 (C).
*Newfoundland. Great Northern Peninsula. Cape Onion-Western Head, Piercey 616 (NFLD)
Utah. Utah Co: Wasatch Mountains, Mount Timpanogos. Flowers 330. (COLO), Harris 464 (COLO), Kartchner 460 (COLO).

Appendix 1. Summary of location data for visited populations.

Province	Population	Sporophyte present? (largest colony)	No. of colonies (area occupied)	Date assessed
AB	Mmac1	Y	177 (10 m^2)	29 Jun 00
AB	Mmac 2	N	58 (2 m^2)	29 Aug 02
AB	Mmac 3	Y	260 (3 m^2)	29 Aug 02
AB	Mmac4	Y (10 x 15 cm)	35 (0.5 m^2)	29 Aug 02
AB	Mmac5	N	3 (too sparse)	July 99
AB	Mmac6	Y	30+ (0.5 m^2)	July 99
AB	Rapids	Y (35 X 50 cm)	40+ (9 m^2)	29 Aug 02
AB	Falls	N	15 (2 m^2)	July 99
AB	Boulder	Y	142 (2 m^2)	24 Apr 02
AB	Trolls Falls	Y	50+ (8 m^2)	3 Sept 99
BC	Mt. Socrates	N (4.5 x 6 cm)	15 (too sparse)	24 Aug 02
BC	Mt. Socrates	N (3 x 5 cm)	3 (too sparse)	25 Aug 02
NF	Straitsview	Y (0.5 x 1.0 cm)	9 (too sparse)	9 Aug 02
NF	Cape Onion	Y (<0.5 x 0.5 cm)	3 (too sparse)	10 Aug 02
NF	Cape Onion	N (0.5 x 36 cm)	3 (too sparse)	10 Aug 02
NF	Cape Onion	Y	6 (too sparse)	10 Aug 02
NF	Cape Onion	Y (10 x 10 cm)	27 (1.4 m^2) 17 (1.6 m^2)	10 Aug 02
NF	Cape Onion	Y	3 (too sparse)	10 Aug 02
NF	Cape Onion	Y	3 (too sparse)	10 Aug 02
NF	Cape Onion	Y	5+ (too sparse)	10 Aug 02
NF	L'Anse aux Sauvage	N	2 (too sparse)	10 Aug 02
NF	L'Anse aux Sauvage	Y	6+ (0.45 m^2)	10 Aug 02
NF	L'Anse aux Sauvage	Y	5+ (too sparse)	10 Aug 02
NF	Noddy Bay	Y (7 x 30 cm)	13+ (0.52 m^2)	11 Aug 02
NF	Cape Ardoise	N (0.5 x 4 cm)	3 (too sparse)	12 Aug 02
NF	White Cape	Y (6 x 13 cm)	13+ (2.2 m^2) 14+	12 Aug 02
NF	White Cape	Y (5 x 50 cm)	40+ (8.55 m^2) 16+ (3.4 m^2)	12 Aug 02
NF	White Cape	Y (15 x 20 cm)	3 (too sparse)	9 Aug 02