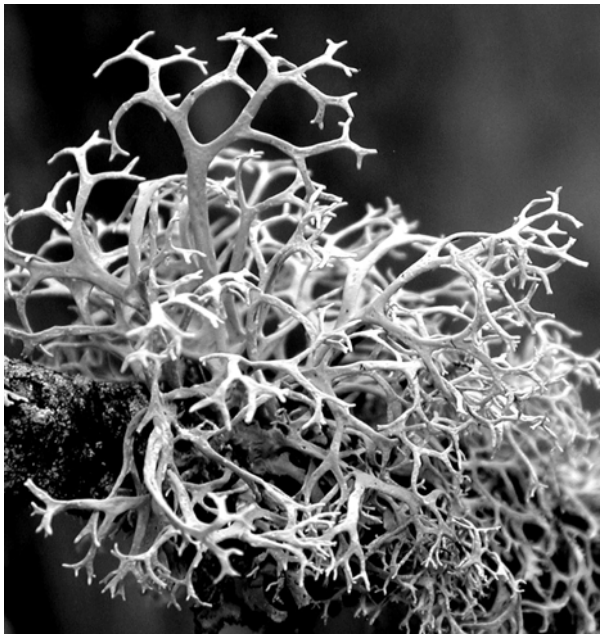
# COSEWIC
# Assessment and Status Report

on the

# Ghost Antler
## *Pseudevernia cladonia*

**in Canada**



**SPECIAL CONCERN**
**2006**

**COSEWIC**
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

**COSEPAC**
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Production note:

COSEWIC would like to acknowledge Stephen R. Clayden for writing the status report on the ghost antler *pseudevernia cladonia,* prepared under contract with Environment Canada, overseen and edited by René Belland, Co-chair (Mosses & Lichens), COSEWIC Plants and Lichens Species Specialist Subcommittee.

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# COSEWIC
# Assessment Summary

**Assessment Summary – April 2006**

**Common name**
Ghost antler

**Scientific name**
*Pseudevernia cladonia*

**Status**
Special Concern

**Reason for designation**
The species is a chalky white, finely branched macrolichen occurring on twigs of conifers in cool montane and coastal spruce-fir forests in eastern North America. It is very patchily distributed in New Brunswick and Nova Scotia, probably owing to dispersal limitations, and in southeastern Quebec, it is restricted to scattered mountaintops >800 m in elevation and to the height-of-land along the border with the United States. In its montane locations, the construction of communication towers, alpine ski development, and logging have caused some reductions in the area and quality of habitat. In the Maritimes, some population losses are attributable to logging and housing development. The severity of the threats is offset by the abundance of the species over a broad area and potential discovery of large populations on some mountain tops in Quebec.

**Occurrence**
Quebec, New Brunswick, Nova Scotia

**Status history**
Designated Special Concern in April 2006. Assessment based on a new status report.

# COSEWIC
# Executive Summary

## Ghost Antler
*Pseudevernia cladonia*

### Species information

*Pseudevernia cladonia* is a chalky white to pale grey tree-inhabiting macrolichen with evenly bifurcating, narrow lobes. Although the lobes are flattened in cross-section, and have a channeled, black-mottled, lower surface, the thallus overall has a fruticose habit superficially resembling that of a caribou lichen. It lacks soredia, isidia or other specialized vegetative propagules and forms apothecia only very rarely.

### Distribution

*Pseudevernia cladonia* occurs primarily in high-elevation spruce-fir forests in the Appalachian Mountains of eastern North America, from the Great Smokies (35°N) to Mount Katahdin (46°N). In the northeastern portion of its range, it is also present at low elevations along or near the Fundy and Atlantic coasts of Maine, New Brunswick, and Nova Scotia. A widely disjunct population in the high mountains of the Dominican Republic inhabits forests of the endemic Hispaniolan pine (*Pinus occidentalis*). Nine of the 17 localities known in the Maritime Provinces were first found after 1990. Before 2004, *P. cladonia* had been collected in Quebec only once, in 1959, on Mount Orford. However, recent field work has shown that it occurs rather widely in mature balsam fir forests at elevations above 800 m in the small area of southeastern Quebec adjoining the mountains of western Maine and northern New Hampshire.

### Habitat

In North America, *Pseudevernia cladonia* occurs in cool, humid, montane or coastal coniferous forests dominated by red spruce and (or) balsam fir (Fraser fir in the southern Appalachians). A key feature shared by these coastal and high elevation stands is their frequent and often prolonged immersion in fog or cloud. In Canada, *P. cladonia* has been found growing on balsam fir, red spruce and black spruce. It occurs mainly on twigs and branches, less frequently on the trunks of these tree species or on woody debris on the forest floor.

## Biology

Lacking specialized vegetative propagules, and only very rarely forming apothecia and ascospores, *P. cladonia* reproduces mainly by thallus fragmentation. However, its thallus is not particularly brittle, unlike those of many fruticose epiphytic lichens (e.g. *Bryoria* species). It thus appears to have a limited capacity for long-distance dispersal, or even for dispersal *within* stands when these are initially colonized by only one or a few fragments. Often, few other lichens are present on the twigs colonized by *P. cladonia*. This might indicate it is weak in competition and thereby excluded from branches with greater coverage of other species, or that it is tolerant of some characteristic(s) of the twig microhabitat inhospitable to other lichens.

## Population sizes and trends

Twenty locations for *P. cladonia* are known in Canada: 3 in Quebec, 10 in New Brunswick, and 7 in Nova Scotia. At most of the locations in the Maritime Provinces, fewer than 50 thalli have been found. A notable exception is a site in New Brunswick where more than 2,000 thalli are present. Three of 5 Maritime populations first found before 1990, and searched for in 2003-2004, were not relocated. Two of these have apparently been lost to housing development. In 2004, the known population in Quebec was increased from an unknown number of individuals at one small site, last documented in 1959, to more than 3,000,000 thalli present mainly in two locations with extensive elevations above 800 m. It is likely that other high-elevation occurrences will be found in a small area of montane southeastern Quebec adjoining the United States.

## Limiting factors and threats

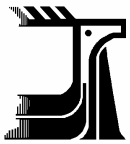
The southern coastal regions of New Brunswick and Nova Scotia are at the northeastern periphery of the range of *P. cladonia*. Its absence here at many sites that appear to provide suitable habitat is probably a consequence of its limited capacity for dispersal. Each of the known occurrences apparently represents an isolated instance of establishment through long-distance dispersal. Once it does become established in a forest stand, *P. cladonia* seems unable to spread quickly or widely, again because the thallus does not fragment readily or produce other propagules. Cutting of moist mature spruce-fir forests will likely eliminate the sites most likely to harbour populations. The occurrence comprising > 75% of the known population in the Maritime Provinces is in an old-growth stand currently threatened by cutting and housing development. A potential longer-term threat to the large population in montane southeastern Quebec is ongoing change in the mean elevation of the cloud base. Research indicates that this elevation has been increasing by c. 4 m per year over the past 30 years, possibly due to climate warming. If continued, these changes could result in a gradual but extensive reduction in the area of moist (cloud-influenced) montane fir forest suitable for *P. cladonia*. One of the “protected” mountain-top populations in a Quebec national park is threatened by an alpine skiing development, and may also have been reduced in size by the emplacement of several large telecommunications towers.

## Special significance of the species

*Pseudevernia cladonia* is one of a small number of lichens restricted to high-elevation and cool, coastal, coniferous forests in eastern North America. The coastal occurrences of the species are largely within Canada. At its montane locations, it may prove to be a useful indicator of climate change.

## Existing protection

Three of the 17 locations in the Maritime Provinces are in provincial parks, and one is in a national park. However, *P. cladonia* appears to have been extirpated by natural habitat change at the latter site. In Quebec, two of the locations documented to date are in Quebec national parks, though in one of these parks the population is threatened by mountain-top development; the third known location in Quebec has much more limited protection in a Zone d'exploitation contrôlée (ZEC).



## 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. Species designated at meetings of the full committee are added to the list. On June 5th 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 for 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 entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

## DEFINITIONS (2006)

| | |
|---|---|
| Wildlife Species | A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and it is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years. |
| Extinct (X) | A wildlife species that no longer exists. |
| Extirpated (XT) | A wildlife species no longer existing in the wild in Canada, but occurring elsewhere. |
| Endangered (E) | A wildlife species facing imminent extirpation or extinction. |
| Threatened (T) | A wildlife species likely to become endangered if limiting factors are not reversed. |
| Special Concern (SC)* | A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats. |
| Not at Risk (NAR)** | A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances. |
| Data Deficient (DD)*** | A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction. |

* 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. Definition of the (DD) category revised in 2006.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# COSEWIC Status Report

on the

# Ghost Antler

*Pseudevernia cladonia*

**in Canada**

2006

# TABLE OF CONTENTS



**List of figures**

**List of tables**

## SPECIES INFORMATION

### Name and classification

*Pseudevernia cladonia* (Tuck.) Hale & Culb.
*Bryologist* 69: 165 (1966)

**Basionym**: *Evernia furfuracea* var. *cladonia* Tuck., *Proceedings of the American Academy of Arts and Sciences* 1: 204 (1847); type: United States, "firs and other trees, on the mountains of northern New England", *Tuckerman* (FH – holotype).

**Additional synonyms:** *Parmelia furfuracea* var. *cladonia* (Tuck.) Howe, *Bryologist* 16: 35 (1913); *Parmelia cladonia* (Tuck.) Du Rietz, *Svensk Botanisk Tidskrift* 18: 390 (1924); *Evernia ceratea* var. *cladonia* (Tuck.) Fink*, The Lichen Flora of the United States*, 340 (1935)

**Classification:** Following convention, the lichen *Pseudevernia cladonia* bears the name of its fungal component (mycobiont). The genus *Pseudevernia* is a member of the family Parmeliaceae, in the order Lecanorales, division Ascomycota. The photosynthetic component (photobiont) is a coccoid green alga belonging to the morphological species *Trebouxia jamesii* (Kroken & Taylor 2000). Several as yet unnamed cryptic species, recognizable on the basis of DNA sequence variation, are included within *T. jamesii* (Kroken & Taylor 2000). It is possible that *P. cladonia* is lichenized with more than one of these phylogenetic species.

There are no currently recognized infraspecific taxa of *P. cladonia*. *Pseudevernia* is a small genus, comprising only four or five species worldwide. Hale (1968) recognized six species, two of which (*P. olivetorina* [Zopf] Zopf, *P. soralifera* [Bitt.] Zopf) are now generally included within *P. furfuracea* (L.) Zopf (e.g. Santesson *et al*. 2004). *Pseudevernia furfuracea* is widely distributed in temperate to boreal western Eurasia and northern Africa, with distant outliers in Mexico, Central and South America, and east Africa. *Pseudevernia cladonia*, *P. consocians* (Vainio) Hale & W. Culb., and *P. intensa* (Nyl.) Hale & W. Culb. are New World endemics differing from one another in morphology, geographic range, and ecology.

**Common name**: Ghost antler lichen (Brodo *et al*. 2001), here shortened to ghost antler. The name antler lichen appears to have been introduced by Nearing (1947). The modifier, "ghost", alludes to the pale, almost white colour of the thallus, which is sometimes accentuated in the shady understory of its coniferous forest habitat. No French or aboriginal names have been proposed. "Panache" or "Petits Bois" or "Petits Bois Blancs" are possibilities.

### Morphological and chemical description

*Pseudevernia cladonia* is a conspicuous tree-inhabiting macrolichen. Its chalky white to pale grey, matt-textured thallus is evenly and repeatedly bifurcate-branched

from the base (Figure 1). The internal branch-angles are mostly from 70° to 110°, each one curving slightly inward past the branching point in the form of a wishbone. The newly formed and younger branches are round to slightly flattened in cross-section, and about 0.2 mm in diameter. They gradually become more distinctly strap-shaped, with a channeled lower surface formed by down-turning and thickening of the lobe margins. Because the branching is in various planes, the thallus assumes a tufted (fruticose) growth-form. This character is alluded to in the species name, *cladonia*, a homonym of the genus name of the distantly related caribou lichens.

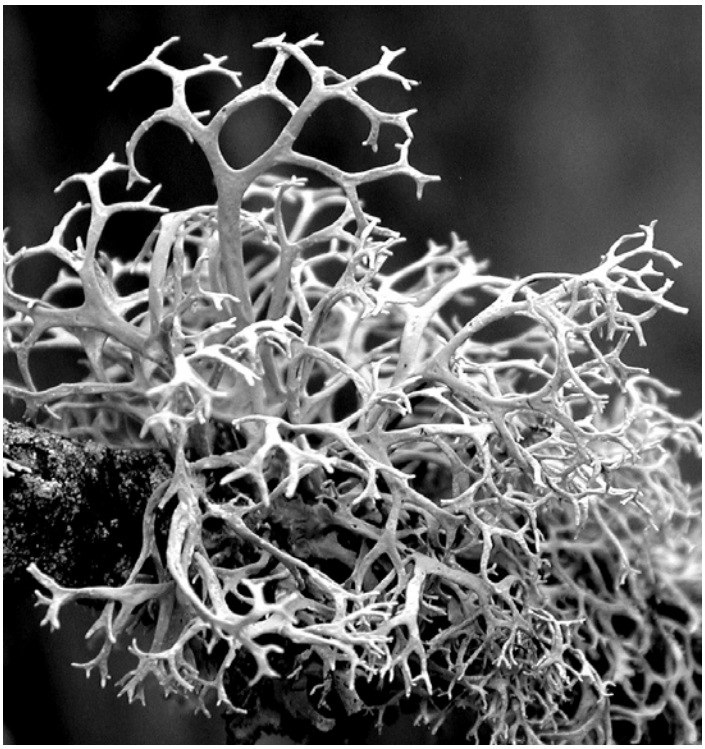

Figure 1. Thallus of *Pseudevernia cladonia*, on a twig of *Picea rubens*, at Wolsely Lake, New Brunswick (photo: S.R. Clayden).

Luxuriant thalli of *P. cladonia* can attain a diameter of 12 cm and a height (thickness) of 4 cm. In the older, basal parts of large thalli, the branches may be up to 2.5 mm in width. Their channeled lower surfaces become grey (or locally brown) to black-mottled to entirely black, though these dark-pigmented areas sometimes develop a thin, ash-white, fine-textured bloom ("pruina"). Over time, the changing orientation of some branches relative to the light induces partial, irregular switching in the development of upper-surface and lower-surface characteristics. These branches accordingly become more irregular (less flattened) in cross-section, and may have longitudinal ridges alternating with blackened grooves and pits.

Isidia, soredia, or other specialized vegetative propagules are lacking. Fine stress cracks orientated transversely to the branch axes are scattered to frequent, but these

extend downward (inward) only to the base of the cortex, and the dense cottony medulla is resistant to tearing. The thallus is, therefore, not particularly subject to fragmentation. Pycnidia are infrequent on the upper sides of younger branches; they are visible externally as black spots measuring 0.05 to 0.08 mm in diameter. Apothecia are extremely rare, and have been observed in only one thallus in the Canadian populations of *P. cladonia*.

The cortex and medulla contain the secondary chemical products atranorin and lecanoric acid, respectively.

There is an excellent colour photograph of this species in the book *Lichens of North America* (Brodo, Sharnoff, and Sharnoff 2001).

### Genetic description

No information is available on the population genetic structure of this species in Canada or elsewhere.

### Designatable units

None. Rationale: The montane populations of *P. cladonia* in southeastern Quebec and the low elevation coastal populations in the Maritime Provinces are separated by more than 300 km. Between these two regions, however, scattered populations are present in montane western and central Maine, and in Hancock and Washington Counties in coastal eastern Maine, adjoining New Brunswick. There is thus no major gap in the range of the species between Quebec, New Brunswick, and Nova Scotia. In spite of the obvious differences in the topographic situations of the montane and coastal populations, the climate and vegetation of these areas have many features in common. Both fall within the Atlantic Maritime Ecozone (Ecological Stratification Working Group 1995).

## DISTRIBUTION

### Global range

*Pseudevernia cladonia* occurs primarily in high-elevation coniferous forests in the Appalachian Mountains of eastern North America, from 35°N to 46°N (Figure 2). In the United States, it is known from the Great Smoky Mountains (Tennessee, North Carolina), the Alleghenies (Virginia, West Virginia), the Catskills and Adirondacks (New York), the Green and White Mountains (Vermont, New Hampshire), and the mountains of western and north-central Maine (Hale 1955, 1968; Hinds & Hinds 1998). A widely disjunct population occurs in Hispaniolan pine (*Pinus occidentalis*) forests in the high mountains of the Dominican Republic, at c. 19°N (Hale 1968). The northernmost, reliably documented occurrence is at Big Reed Pond (46°21'N), about 50 km NNW of Mount Katahdin in the state of Maine (Selva 1994). The montane

occurrences in northern Vermont, northern New Hampshire, and western Maine are contiguous, or nearly so, with other high elevation occurrences in a small portion of southeastern Quebec, Canada. In the northeastern portion of its range, *P. cladonia* is also present at low elevations along or near the eastern Gulf of Maine, Fundy and Atlantic coasts of Maine, New Brunswick, and Nova Scotia (Figure 3). A report of *P. cladonia* for the state of Oaxaca, Mexico (Yoshimura & Sharp 1968) probably stems from confusion with *P. intensa*. That species occurs in the southern Rocky Mountains of western North America and Mexico (Nash & Elix 2002).

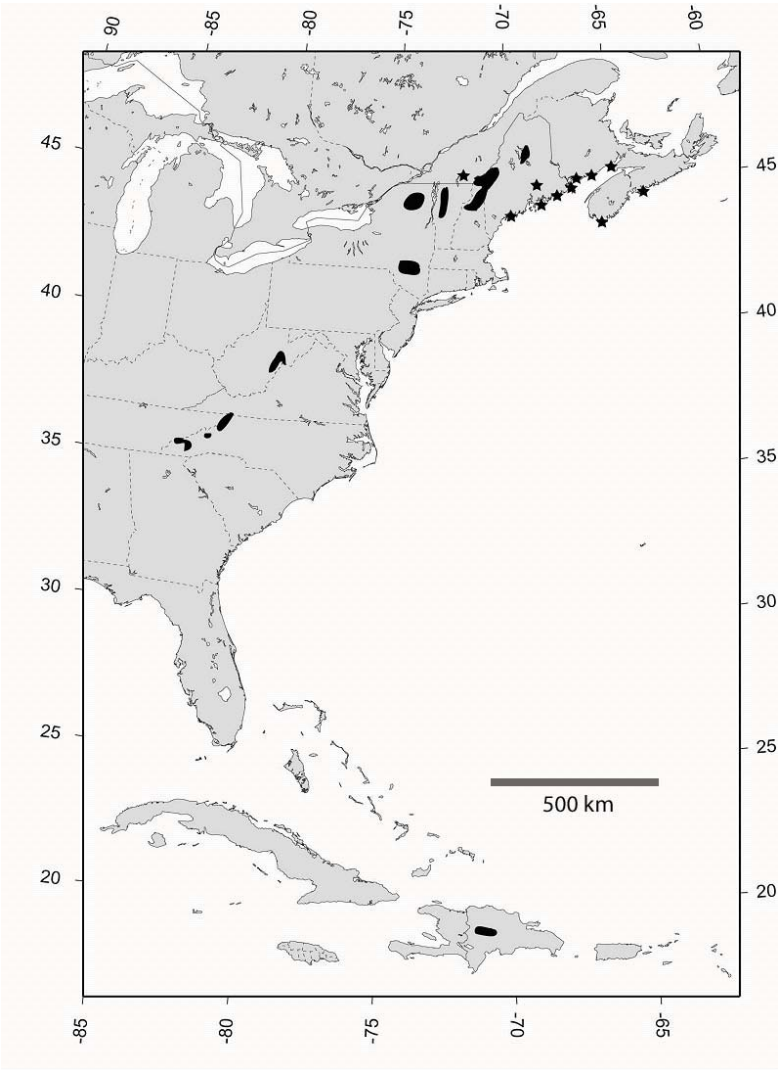


Figure 2. Global distribution of *Pseudevernia cladonia*. Stars indicate isolated occurrences, and in some cases represent two or more closely spaced localities.

From south to north in the Appalachians, the mean lower elevational limit of montane red spruce–fir forests decreases from about 1,500 m in the Great Smokies to about 760 m in the mountainous boundary region between New Hampshire/Maine and

southeastern Quebec (Marcotte & Grandtner 1974; Gauvin & Bouchard 1983; Cogbill & White 1991). At Mount Katahdin, the equivalent limit is at about 550 m (Cogbill & White 1991). The decrease between southeastern Quebec and Katahdin in the elevation of the deciduous-coniferous forest ecotone appears to reflect a gradient of increasing oceanicity (decreasing continentality) from west to east (see Cogbill & White 1991). The montane deciduous-coniferous ecotone is also correlated with a summer (July) mean temperature of 17°C (cf. Cogbill & White 1991; White & Cogbill 1992). Along the Bay of Fundy, the transition from coastal spruce-fir forest to inland mixed and deciduous forests is likewise correlated with this isotherm (Clayden 2000).

The montane and coastal distribution of *P. cladonia* is, in large part, reflective of these latitude-elevation, temperature, continentality, and forest vegetation gradients. In the Smokies, it is "common in the coniferous forest belt … on levels from 1540 m upwards" (Degelius 1941). On mountain slopes in southeastern Quebec, near the United States border, its lowest known occurrences are at 790 to 840 m (S.R. Clayden, pers. comm..; Table 1). The elevational range of *P. cladonia* on the slopes of Mount Katahdin is not known in detail; well-documented collections range only from c. 880 to 915 m (J.W. Hinds, personal communication). Between Katahdin and the Maine coast, however, scattered populations are present in old-growth forests at intermediate elevations. About 15 occurrences of *P. cladonia* are known in Maine (Degelius 1940; Sullivan 1996; Hinds & Hinds 1998; J. W. Hinds, personal communication; S.B. Selva, personal communication): Somerset Co. (Sandy Bay Mountain), Piscataquis Co. (Mount Katahdin; Big Squaw Mountain; Big Reed Pond), Penobscot Co. (Orono), Cumberland Co. (Prince Point), Hancock Co. (Lead Mountain; Black Mountain; Acadia National Park), and Washington Co. (Steuben).

**Table 1. Canadian localities and collections of *Pseudevernia cladonia*.**

| Code | Locality | Year of discovery | Most recent survey | Number of Individuals | Collection(s) | x* |
|---|---|---|---|---|---|---|
| QC1 | QUEBEC. Parc national du Mont Orford, summit of Mont Orford | 1959 | 2004 | >20,000 | F. LeBlanc 11589, 11622 [QFA]; S.R. Clayden 12717, 12734, 12736, 12746, 12747 [NBM] | |
| QC2 | QUEBEC. Parc national du Mont Mégantic, summits of Mont Mégantic and Mont Saint-Joseph | 2004 | 2004 | >1,000,000 | S.R. Clayden 12790, 12800, 12822 [NBM] | |
| QC3 | QUEBEC. ZEC Louise-Gosford, Mont Gosford and Quebec-Maine border region ENE of Mt Gosford | 2004 | 2004 | >2,000,000 | S.R. Clayden 12681, 12688, 12689, 12691, 12694 [NBM] | |

**Table 1. Canadian localities and collections of *Pseudevernia cladonia*.**

| Code | Locality | Year of discovery | Most recent survey | Number of Individuals | Collection(s) | x* |
|---|---|---|---|---|---|---|
| None assigned | QUEBEC: It is likely that populations are present at the following localities, not yet searched: (1) Mount Sutton, (2) Mont Sainte-Cécile, (3) Mount Sandy Stream, (4) 2 or 3 additional narrow segments of fir forest above 800 m along the QC-USA (New Hampshire, Maine) borders. | | | | | |
| NB1 | NEW BRUNSWICK. Charlotte Co.: Grand Manan | 2001 | 2003 | <10 | M. Maxfield 0193-G, 0194-G [NBM] | |
| NB2 | NEW BRUNSWICK. Charlotte Co.: Ross Island | 2002 | 2003 | <10 | M. Maxfield 0292-G [NBM] | |
| NB3 | NEW BRUNSWICK. Charlotte Co.: Deer Island | 1970s | 1980s | <10 | Not collected? [Maass] | |
| NB4 | NEW BRUNSWICK. Charlotte Co.: Beaver Harbour | 2003 | 2003 | 18 | S.R. Clayden, 16 June 2003 [NBM] | |
| NB5 | NEW BRUNSWICK. Charlotte Co.: New River Beach Provincial Park, Barnaby Head | 2004 | 2004 | 46 | S.R. Clayden 13146 | |
| NB6 | NEW BRUNSWICK. St. John Co.: Chance Harbour | 1991 | 2005 | >200 | S.R. Clayden 7166 [NBM] | |
| NB7 | NEW BRUNSWICK. Queens Co.: CFB Gagetown, Mount Douglas | 1996 | 2003 | 1 | S.R. Clayden 9159 [NBM] | x |
| NB8 | NEW BRUNSWICK. St. John Co.: Saint John, Wolsely Lake | 1996 | 2004 | >2,000 | S.R. Clayden 9158B [NBM] | |
| NB9 | NEW BRUNSWICK. St. John Co.: Cape Spencer | 1991 | 2003 | 5 | S.R. Clayden 7154 [NBM] | |
| NB10 | NEW BRUNSWICK. Albert Co.: Fundy National Park, Kinnie Brook | 1980 | 2003 | <10 | S.P. Gowan & I. Walker 2858 [CANL] | x |

**Table 1. Canadian localities and collections of *Pseudevernia cladonia*.**

| Code | Locality | Year of discovery | Most recent survey | Number of Individuals | Collection(s) | x* |
|---|---|---|---|---|---|---|
| NS1 | NOVA SCOTIA. Cape Chignecto Provincial Park, Mill Brook and Arch Brook | 1983 / 2nd and 3rd populations discovered in 2004 and 2005 by F. Anderson | 2005 | >300 [42 + >250] | W.S.G. Maass; S.R. Clayden 12661 [NBM]; F. Anderson C80 [NSPM] | |
| NS2 | NOVA SCOTIA. Halifax Co.: Halifax, Leiblin Park | c. 1974 | 2004 | 10 | W.S.G. Maass | |
| NS3 | NOVA SCOTIA. Halifax Co.: Halibut Cove | 1980s | 2004 | 1 | Not collected [W.S.G. Maass] | x |
| NS4 | NOVA SCOTIA. Halifax Co.: Portuguese Cove | 1980s | 2004 | <10 | W.S.G. Maass | x |
| NS5 | NOVA SCOTIA. Shelburne Co.: near Oak Park | 1980s | 1980s | <10 | W.S.G. Maass | |
| NS6 | NOVA SCOTIA. Lunenburg Co.: Blandford Game Sanctuary | 2005 | 2005 | 15 [13 + 2] | Not collected [F. Anderson, 13 April 2005] | |
| NS7 | NOVA SCOTIA: Yarmouth Co., precise locality unknown | 1980s | 1980s | <10 | Not collected? [W.S.G. Maass] | |

***x**: population not relocated in 2003-2004 surveys

The upper elevational limit of *P. cladonia* along the Appalachians can be inferred to coincide with that of closed spruce-fir forests. Like the lower limit of these stands, the elevation of the forest/tundra ecotone decreases with increasing latitude. However, the climatically determined treeline is exceeded only on scattered high summits, such as Mount Marcy, Mount Washington, and Mount Katahdin.

## Canadian range

In Canada, *P. cladonia* is known from a small area of the Appalachian mountains in southeastern Quebec, where it is restricted to elevations above 790 m, and from scattered coastal or near-coastal localities along the Bay of Fundy and Atlantic shores of New Brunswick and Nova Scotia (Figure 3, 4, 5; Table 1). Specific and reliable information on the occurrence of this species in Canada has been slow to emerge. Torrey (1935) reported it from the Chic-Choc Mountains, “at 2500–3000 ft,” in the Gaspé region of Quebec. However, there are no relevant voucher specimens at NY (R.C. Harris, personal communication), where R.H. Torrey’s collections are now housed. Nor are there subsequent reports of this species from the Chic-Chocs, though a number of experienced lichenologists have visited the region. Lepage (1947-1949) reported *P. cladonia* for Quebec on the basis of a specimen from Cap-aux-Corbeaux, Bic (*Lepage 1835* [QFA, NBM]). This material was examined by S.R. Clayden

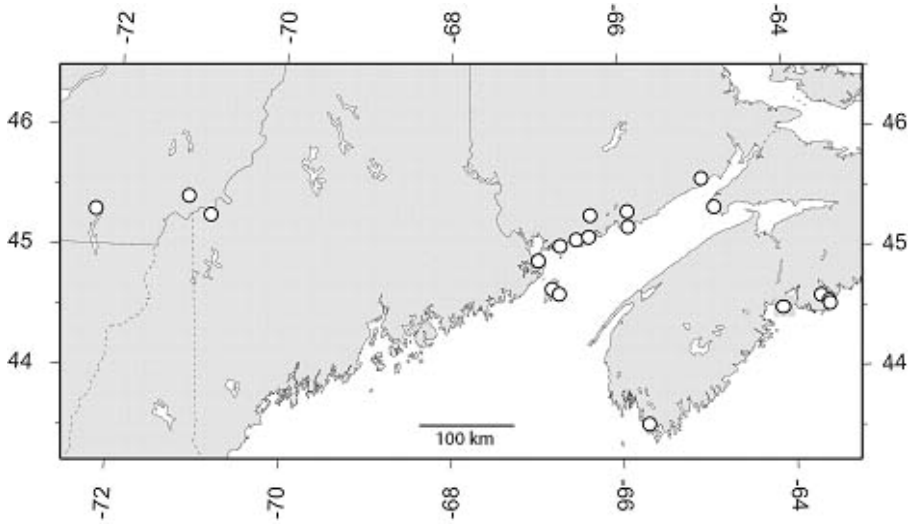


Figure 3. Distribution of *Pseudevernia cladonia* in Canada.

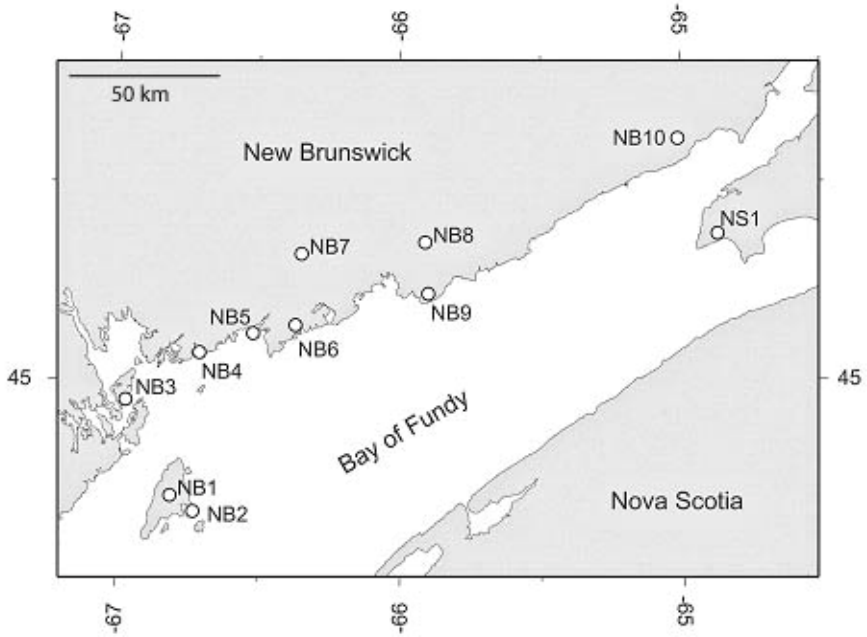


Figure 4. Coastal and near-coastal distribution of *Pseudevernia cladonia* around the Bay of Fundy. Numbers correspond to localities described in the text.

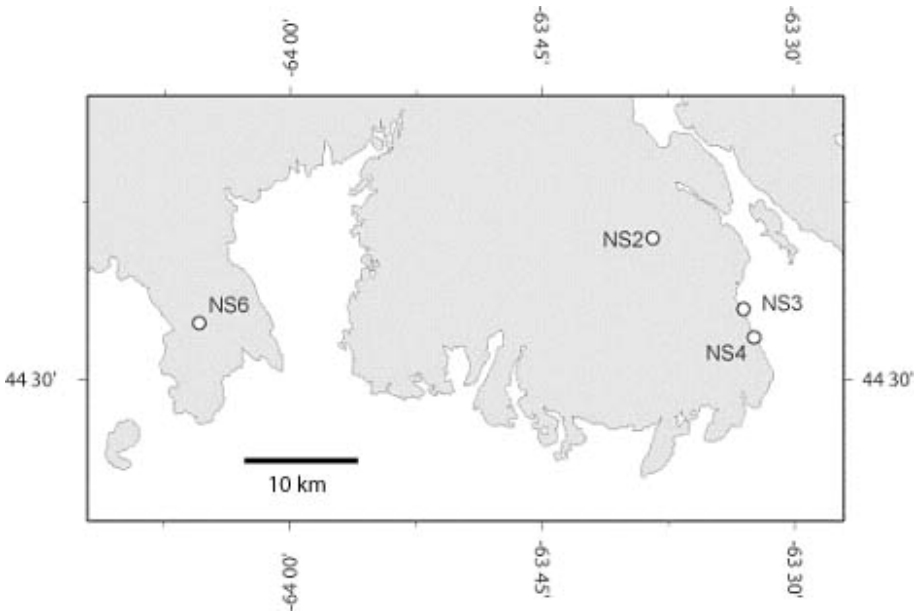


Figure 5. Occurrences of *Pseudevernia cladonia* in Halifax County and Lunenburg County, Atlantic coast of Nova Scotia. Numbers correspond to localities described in the text and in Table 1.

(pers. comm.) who revised it to *Anaptychia setifera* Räsänen. Lepage (1947-1949) also recorded *P. cladonia* for Nova Scotia, but did not provide locality or specimen data. No earlier reports or collections of the species from that province have been located. An erroneous report for Ontario (Yoshimura & Sharp 1968) resulted from misinterpretation of a specimen label.

Of the 20 Canadian localities verified or accepted in this status report, only one has been published: Gowan & Brodo (1988) reported *P. cladonia* for Fundy National Park, New Brunswick, as new to Canada. The earliest known Canadian collections were made by Fabius LeBlanc near the summit of Mount Orford, Quebec, in 1959 (*LeBlanc 11589*, *11622* [QFA]). LeBlanc (1960) noted this occurrence in his Ph.D. thesis on the phytosociology of epiphytic bryophytes and lichens in southern Quebec. His major paper on this subject recorded *P. cladonia* as a component of a rare species assemblage ("Union à *Parmelia furfuracea*") found "dans les montagnes où l'atmosphère est humide" (LeBlanc 1963, pp. 619, 626). However, no specific locality was mentioned, and no subsequent collections or observations of *P. cladonia* on Mount Orford or elsewhere in Quebec were made prior to the reconnaissance undertaken by S.R. Clayden in 2004 to document occurrences of this species.

In the 1970s and 1980s, while researching the distribution of *Erioderma* species and other rare epiphytic cyanolichens in Atlantic Canada, Wolfgang Maass discovered six small populations of *P. cladonia* in Nova Scotia and another in New Brunswick. Details of one of the Nova Scotia localities and a brief mention of the other sites were included in an unpublished report (Maass 1997). The New Brunswick locality was

inadvertently recorded by Maass (1997) in this report as Campobello Island, but was actually the neighbouring Deer Island (W.S.G. Maass, personal communication). Eight of the 10 localities presently known for *P. cladonia* in New Brunswick were discovered after 1990, four of them since 1991 (see Technical Summary and Table 1). Two of the Nova Scotia localities, as mapped in Figure 4 (NS1) and Figure 5 (NS6), comprise two separate populations, separated by < 1 km (see Table 1).

The **"extent of occurrence" of *P. cladonia* in Quebec** is inferred to be > 4,060 $km^2$, but as currently documented is < 1,150 $km^2$. The larger of these two estimates was obtained by assuming that as-yet-undocumented populations are likely to be found at Mount Sutton (972 m, c. 35 km SW of Mount Orford), at Mont Sainte-Cécile (885 m, c. 30 km NE of Mont Mégantic), and along the Quebec-Maine border at Mount Sandy Stream (950 m, c. 65 km NE of Mount Gosford). Within the polygon encompassing these summits and other known localities for *P. cladonia*, there are narrow, discontinuous segments of still-unexplored fir forest above 800 m along the New Hampshire and Maine borders; these segments probably total approximately 40 km in length.

The **"area of occupancy" in Quebec** is inferred to be c. 3.6 $km^2$. This is a very rough estimate based on the area of *mature* balsam fir-dominated forest occurring at elevations > 800 m, south of 46°N latitude, and east of the St. Lawrence River valley. Two additional areas of potential occurrence at latitudes < 47°N in southern Quebec were identified in a preliminary GIS analysis*: (i) Mont Tremblant (931 m) and vicinity, c. 100 km NW of Montréal; (ii) Mont du Midi (915 m) and vicinity, c. 60 km ESE of Quebec City. Little, if any, lichen inventory work has been undertaken in these areas. It is possible that *P. cladonia* will be found at Mont du Midi, but it seems unlikely it occurs at Mont Tremblant, that area being well outside the Appalachian range, and probably having a more continental climate than the montane areas east of the St. Lawrence.

The **"extent of occurrence" in New Brunswick and Nova Scotia** is c. 3,450 $km^2$. This estimate excludes large marine and other sizeable areas of unsuitable habitat. The **"area of occupancy" in these provinces** totals only c. 0.00114 $km^2$ (0.114 ha). To obtain the latter estimate, a minimum of 10 $m^2$ was arbitrarily assigned to any one site, even though some of the populations consisted of fewer than 10 individuals occurring on a single or a few very small trees (< 2 m in height, with a "canopy" projection of < 1.5 $m^2$).

*This analysis was carried out by geomatics staff at the Direction du patrimoine écologique et du développement durable, Ministère de l'Environnement, Québec, with kind cooperation and direction by Line Couillard (Chef d'équipe, Service de la biodiversité). The analysis yielded estimates of the area of land above 800 m elevation, and of the area of fir-dominated forests above this elevation, within a rectangle defined by the coordinates 45° to 47° N, and 70° to 75° W. The total area of fir forest above 800 m in the specified rectangle was estimated at 17.86 $km^2$ (1,786 ha), based on coverage data in the "SIFORT" system. However, this value seems to underestimate the actual area by a considerable amount. It is known that the precision of the SIFORT data is not as good as that of traditional ecoforestry maps (L. Couillard, personal communication). The area of montane fir stands in the Mont Mégantic and Mont Gosford areas alone probably exceeds 18 $km^2$. The estimates given here for the area of occupancy do not include the Mont Tremblant or Mont du Midi areas.

## HABITAT

### Habitat requirements

*Pseudevernia cladonia* occurs primarily in cool, humid, montane or coastal (and near-coastal) coniferous forests dominated by fir (*Abies balsamea, A. fraseri*) and (or) red spruce (*Picea rubens*). It is absent from more northerly boreal spruce-fir forests in which red spruce is replaced by black spruce (*P. mariana*) and/or white spruce (*P. glauca*). However, black spruce is present in some of the poorly drained coastal localities in New Brunswick and Nova Scotia. In most of these stands, there are also scattered mountain paper birch (*Betula cordifolia*) and mountain-ash (*Sorbus americana, S. decora*) trees. Balsam fir is replaced in the southern Appalachians by the closely related Fraser fir (*A. fraseri*). In the Dominican Republic, *P. cladonia* occurs in high elevation forests of Hispaniolan pine (*Pinus occidentalis*).

Key features of both the coastal and high elevation habitats of *P. cladonia* are their cool temperatures and their frequent and often prolonged immersion in fog or cloud. The mean cloud base along the Appalachians in eastern North America is c. 800 m. Above this elevation, slopes and summits in the northern Appalachians are in cloud for 30% to 50% of all hours (Mohnen 1992). Along the Gulf of Maine and Bay of Fundy, marine advection fog, formed by cooling of moist air masses passing over the cold ocean surface, blankets the coastal region for 12% to upwards of 27% of the time from April to October (Cox *et al*. 1989). Fog frequency increases from west to east from the mid-Maine coast into the Bay of Fundy (Jagels *et al*. 1989), reaching its highest levels near Saint John (Cox *et al*. 1996), and declining toward the head of the bay. Localized areas of higher fog incidence, including Cape Chignecto (*P. cladonia* site NS1), may indicate the presence of colder surface waters near shore, in turn reflecting tidal currents and mixing patterns. The south shore of the Bay of Fundy, from North Mountain to Digby Neck, probably has less frequent fogs than the north shore (see Cox *et al*. 1996), and this may account for the apparent absence there of *P. cladonia* (Figures 3, 4). Fog frequency and duration along portions of the Atlantic shore of Nova Scotia are comparable to or higher than those in the Bay of Fundy, but detailed mapping of fog occurrence in the Maritimes is not available.

Where it occurs near the coast, *P. cladonia* is a species of humid, forest interiors, not wind-exposed headlands. The structure and topographic setting of its habitats in New Brunswick and Nova Scotia are otherwise quite variable. Some are mature to old growth red spruce dominated forests with a high canopy and many trees probably > 100 years old. Although these stands may be on poorly drained sites, and as a consequence have extensive peaty hollows (e.g. NB9, NS1), others (NB4, NB7, NB8, NB10) are on well-drained, west- or northwest-facing, cool slopes and adjoining low ridges. Site NB8, which has by far the largest documented population of *P. cladonia* in the Maritime Provinces (c. 85% of all known individuals), is an exceptional tiny remnant of old growth red spruce, with some trees probably > 200 years old. It is likely that, with increasing distance from the coast, *P. cladonia* is increasingly confined to old growth stands, in which a high relative humidity offsets the lower frequency of fog. It is

significant in this regard that the rather isolated occurrence of *P. cladonia* at Big Reed Pond in northern Maine is in the largest tract of old growth red spruce forest remaining in the state, and that this site harbours many other rare epiphytic lichens (Selva 1994).

Although *P. cladonia* is a frequent epiphyte in montane fir forests in the Adirondacks (Schmull *et al*. 2002), the White Mountains (Lang *et al*. 1980), and nearby southern Quebec, at least in Quebec its presence/absence and relative abundance are clearly a function of stand age, continuity, and humidity (S.R. Clayden, pers. comm.). An age of c. 80 years is commonly considered to be the average interval at which such fir stands are recycled by epidemics of spruce budworm, senescence, and windthrow (e.g. Lang *et al*. 1980). Such recycling (or harvesting for pulpwood) takes place at widely varying scales, giving rise to both extensive areas of even-aged stands, and to mosaics of much smaller forest patches, the ages uniform within but variable between adjacent patches. Within this dynamic context, *P. cladonia* in Quebec is largely restricted to mature to over-mature stands, ranging from small patches < 0.1 ha in size to ± continuous areas perhaps approaching 50 ha. It is also more frequent on north-facing than other slope aspects, and, on level ground, more frequent in sites with impeded than good drainage. At the lowermost site (790 m) found in Quebec, it occurs on the north (but not south) facing slope of a small, steep-sided, forested ravine, still with extensive ice in its mossy, boulder-filled base when the area was examined in mid-June 2004.

At some of the New Brunswick and Nova Scotia coastal sites for *P. cladonia*, the forests are quite low in stature (maximum tree height 10-12 m). These stands may be rather open in structure as a result of windthrow of dead or dying trees (e.g. NB5). However, the relative humidity in these stands remains high owing to poor drainage and the presence of extensive, though thin, mats of *Sphagnum*. The suite of *Sphagnum* species occurring in these sites characteristically includes *S. russowii, S. girgensohnii* and *S. magellanicum*. There is considerable overlap in the understory vegetation of the coastal and montane spruce-fir habitats of *P. cladonia*. Common species include the bryophytes *Pleurozium schreberi, Bazzania trilobata*, and several *Dicranum* species (the coastal but not montane sites sometimes with *D. majus*), and the vascular plants *Dryopteris campyloptera, Oxalis montana, Coptis groenlandica, Clintonia borealis, Cornus canadensis, Maianthemum canadense* and *Gaultheria hispidula*. Coverage of low to tall shrubs, including *Nemopanthus mucronata* and *Vaccinium myrtilloides*, is generally very low.

*Pseudevernia cladonia* is a twig and branch specialist. It is much less common on tree trunks or on coarse woody debris on the forest floor. All of the epiphytic thalli observed in Canada have been on *Abies balsamea*, *Picea rubens*, or *P. mariana*. LeBlanc (1960) recorded it on *Betula alleghaniensis* on Mount Orford, but there is no voucher specimen for this substrate record. In the southern Appalachians, *P. cladonia* occurs mainly on *Abies fraseri* and *Picea rubens*, but infrequently also on hardwood trees, on the ericaceous shrub *Menziesia pilosa* and, rarely, on rock (Degelius 1941; Dey 1978).

At most of the *P. cladonia* sites in New Brunswick and Nova Scotia, the thalli are mainly on fine, dead, often decorticate, twigs of small, spindly, shade-suppressed firs, and less commonly spruces. These saplings are generally only 1 to 3 m tall, and located beneath a canopy of trees 10 to 20 m in height. The one noteworthy variant on this pattern at the Maritime sites is the old-growth stand (NB8) with > 2,000 thalli. Here, *P. cladonia* is present not only on small firs and woody debris, but also on the boles of large red spruces and on dead, spreading lower branches, c. 6 to 10 m above the ground, of some of these large trees. At every stand examined, an effort was made to inspect the canopy of larger trees, in part with binoculars, but also by searching for recently windthrown trees, and, where feasible, by climbing. In its montane fir forest habitat in southern Quebec, *P. cladonia* regularly occurs from the lowest spreading fir branches upward nearly to the tops of the trees. It is probably most abundant from about 1.5 to 4 m above the ground, and again, is most common on dead branches and needle-free portions of live branches. However, it can also spread to a limited degree over live needles.

There are generally few other lichens present with *P. cladonia* on the branches and twigs it inhabits – often only thin thalli of the crustose species *Fuscidea arboricola* and *Scoliciosporum chlorococcum*, and scattered small *Hypogymnia* thalli. The coverage and diversity of other lichens is, nonetheless, often greater on neighbouring branches or trees, and includes an assemblage of common species typical of moist northeastern spruce-fir forests. Among those more frequent in mature versus early successional (*P. cladonia* vs. non-*P. cladonia*) coastal stands in the Maritimes are *Alectoria sarmentosa, Everniastrum catawbiense, Hypogymnia krogiae* and *Usnea subscabrosa*. *Everniastrum catawbiense* is present at most of the *P. cladonia* sites along the Bay of Fundy. This likewise Appalachian- and subtropical-montane species is rarer overall than *P. cladonia*, but is not infrequent in the foggy Fundy coastal region. Significantly, a widely disjunct occurrence of *E. catawbiense* was found, along with *P. cladonia*, in the Mont-Mégantic area, the first record of this species for Quebec and for any montane site in the northern Appalachians.

It is unclear whether *P. cladonia* tends to be excluded or not by interspecific competition on branches with more abundant foliose and fruticose lichen cover. However, the common epiphytic macrolichens occurring with it at the stand level are perhaps less able to colonize or thrive, as it does, on fine dead twigs. It is also possible that *P. cladonia* thalli require good ventilation (promoting rapid drying?), in spite of the humidity of the spruce-fir understory. If so, this requirement might be best met in its branch/twig microhabitat. The within-stand distribution of *P. cladonia* thalli at the sites in New Brunswick and Nova Scotia is highly clumped. This pattern is discussed more fully in the section Population Sizes and Trends.

**Habitat trends**

The overall area of habitat for *P. cladonia* in Canada appears to be stable. Succession and maturation of montane fir forests in previously logged, but now protected, areas of southeastern Quebec may result in gradual population increases

within these areas. However, such gains could be offset by losses potentially resulting from logging of montane forests, and from further development of communication towers or alpine skiing at mountaintop sites. The potentially adverse impact of an ongoing rise in the mean cloud base, and thus in the moisture budgets, of high elevation forests in the northern Appalachians, is not yet clear.

In the Maritime Provinces, logging of moist, mature, coastal or near-coastal spruce-fir forests over the past 150 years may have reduced the availability of suitable habitat. This cannot be known with certainty, as thorough inventories of the epiphytic lichens of such forests were initiated only in the 1970s and 1980s. It may be significant, as previously noted, that the largest population of *P. cladonia* known in this region is in a stand of old-growth red spruce, and that its northernmost occurrence in Maine is likewise in an exceptional remnant of old spruce forest. Documented local losses or alteration of habitats which formerly supported populations of *P. cladonia* in the Maritimes resulted either from natural disturbances and forest succession, or from human activity, including housing development.

**Habitat protection/ownership**

Two of the 17 known occurrences of *P. cladonia* in the Maritime Provinces are in provincial parks: New River Beach Provincial Park, New Brunswick (NB5), and Cape Chignecto Provincial Park, Nova Scotia (NS1). One of the occurrences is in Fundy National Park, New Brunswick (NB10), but the species appears to have been extirpated by natural habitat change at this locality. The occurrence at Mount Douglas, New Brunswick (NB7) is within Canadian Forces Base Gagetown, a large military training base owned by the federal Department of National Defence. One of the Nova Scotia occurrences (NS6) is in a provincial game sanctuary. This designation does not afford protection to vegetation. All other occurrences of *P. cladonia* in the Maritimes are apparently on privately owned land.

In Quebec, two of the known locations are in Quebec “national” parks: Parc national du Mont-Mégantic and Parc national du Mont-Orford. In the latter park, protection has been minimal, as the population is restricted to the small summit-plateau of Mount Orford. Here, alpine ski development and the construction of telecommunications towers have probably had significant adverse impacts on the areal extent of the population and on the number of individuals present. The third known location in Quebec has limited protection in a “Zone d’exploitation contrôlée” (ZEC Louise-Gosford). It is likely that *P. cladonia* will be found in montane fir forests on Mount Sutton, an outlier of the Green Mountains of Vermont, situated about 35 km southwest of Mount Orford. A large portion (c. 6,000 hectares) of the Sutton massif has recently been acquired by the Nature Conservancy of Canada for protection as part of the “Appalachian Corridor Appalachien” straddling the Canada–US border.

## BIOLOGY

### Life cycle and reproduction

Apothecia and ascospores are formed only rarely by *P. cladonia*. Only one fertile thallus, bearing a single apothecium, has been found in Canada – at a high elevation location in southeastern Quebec (QC3). Sexual reproduction of the mycobiont is thus likely to be insignificant in the reproduction of the *P. cladonia*-*Trebouxia* symbiosis. Conidia-bearing structures (pycnidia) are likewise rare, as would be expected if their function was primarily to produce sexual gametes. In *Pseudevernia intensa*, an endemic of the southern Rocky Mountains, both pycnidia and apothecia are frequent.

Soredia, isidia, or other specialized vegetative propagules are also lacking in *P. cladonia*. The lichen must therefore reproduce mainly through fragmentation of the thallus. The thallus is not particularly brittle, however. The cortex may have frequent cracks running transversely to the branch axes, but the adjoining portions of the thallus are, for the most part, held closely together by the well-developed, cottony medulla.

### Herbivory

Herbivory or parasitism of *P. cladonia* thalli has not been detected.

### Physiology

Little is known about the physiology of *P. cladonia* on the basis of experimental or quantitative studies. Its requirements and tolerances can be inferred to some extent from its overall geographic range and community-level occurrence. Its restriction to foggy coastal and montane forests suggests a requirement for cool, humid climates. With increasing distance from cool coastal areas, it is progressively more restricted, at non-montane elevations, to humid old-growth stands. Its conifer twig, branch, and trunk substrates are probably moderately to quite strongly acidic. However, it is much less affected by acidifying pollutants, particularly sulphur dioxide, than are epiphytic cyanolichens. This is consistent with its persistence within the limits of Halifax and Saint John. In Saint John, its occurrence at Wolsely Lake is about 10 km donwind from a pulp and paper mill and a major oil refinery in the direction of the prevailing (southwesterly) spring-to-fall winds.

### Dispersal/migration

Wind and animals, particularly birds, are the main potential vectors for the dispersal of *P. cladonia* between stands or over longer distances. Its dispersal is probably limited, however, by a very modest reproductive effort. It lacks specialized vegetative propagules, does not fragment readily, and only very rarely produces apothecia and ascospores. In these respects, *P. cladonia* somewhat resembles the boreal forest-inhabiting fruticose lichen *Alectoria sarmentosa*. It may also share some aspects of the population dynamics of that species. Dettki (1998) and Dettki *et al*.

(2000) have shown that, in Scandinavia, *A. sarmentosa* has a very limited capacity to disperse from old-growth spruce forests, its optimal habitat, to adjoining clear-cuts and regenerating stands. This might partly reflect a requirement for the humid microclimatic conditions of old stands, but is also a function of the very limited production of propagules (thallus fragments). In contrast, some *Bryoria* species fragment readily, and are therefore efficient dispersers and colonizers of young forests. Although *P. cladonia* is locally frequent within a small remnant stand of old red spruce trees at one of its localities in New Brunswick, it is absent from the neighbouring younger forests. Overall, the very sporadic distribution of its occurrences in maritime eastern Canada is suggestive of rare, chance instances of successful long-distance dispersal to mature spruce-fir stands.

### Interspecific interactions

Often, few other lichens are present on the twigs colonized by *P. cladonia*. This might indicate it is weak in competition and thereby excluded from branches with greater coverage of other species, or that it is tolerant of some chemical or other characteristic(s) of the twig microhabitat inhospitable to other lichens.

### Adaptability

In areas where its populations are highly fragmented, *P. cladonia* is poorly adapted to recover from major stand-level disturbances, including forest harvesting, owing to its limited capacity for long-distance dispersal, As previously noted, the species has shown no sign during nine years of observation in an old-growth red spruce stand in New Brunswick (NB8) of dispersing into immediately adjacent younger stands. On the other hand, it remains frequent where it is already established.

## POPULATION SIZES AND TRENDS

### Search effort

Because *P. cladonia* is a conspicuous, easily identified species, it is very unlikely it has been overlooked by specialist and even general lichen collectors. Thus, its rarity in the Maritime Provinces is real. In contrast, its apparent rarity in southeastern Quebec prior to this study was evidently an artefact of the relative lack of previous lichenological exploration of montane fir forests in that region. The three Quebec populations documented in this report were located and surveyed during three days of intensive searching. However, as noted above elsewhere, there are several montane sites not yet intensively searched where there is a good probability that *P. cladonia* will be found.

Areas of potential occurrence along the Fundy coasts of New Brunswick and Nova Scotia, as well as the Nova Scotian Atlantic coast, have been explored over many years by S. Clayden, S. Gowan, W. Maass, F. Anderson, and others. The overall lichen collections base for these areas is at least 7,000 specimens, and there are no large

segments of the coastal region in which no lichen surveys have been undertaken. In 2004, a workshop involving >20 expert lichenologists from North America and Europe spent four days collecting intensively in four large protected areas along the Fundy coast in Nova Scotia, between Cape Chignecto Provincial Park and the Portapique River. A number of humid spruce-fir forests, from early successional to old-growth stands were examined, but no populations of *P. cladonia* were found. The subsequent rediscovery of a population in Cape Chignecto Park first documented by W. Maass in 1983, and the discovery by F. Anderson of another nearby population in October 2004 (mapped together as NS1 in Fig. 4), emphasize the difficulty of carrying out targeted searches for *P. cladonia*. Within its broad areas of potential occurrence, as determined by climatic and vegetation conditions, its actual locations apparently reflect chance colonization events.

It is possible, but very unlikely, that more extensive populations of *P. cladonia* are present in the upper canopy of coastal spruce-fir forests than current records would suggest, and that these populations have been missed by ground-based searching. In most stands, occasional, recently windthrown trees can be found, and the canopy epiphytes of such trees were always carefully examined. Also, if well-established canopy populations of *P. cladonia* were present in a stand, some thalli should show up in litterfall. This is indeed the case, for example, at locality NB8. The absence of *P. cladonia* thalli in litterfall in many carefully searched spruce-fir stands can therefore be taken as evidence for the lack of canopy populations in those stands.

**Abundance**

Twenty locations for *P. cladonia* are known in Canada: 3 in Quebec, 10 in New Brunswick, and 7 in Nova Scotia (Table 1). The number of individuals in Quebec is inferred to be >10,000,000, and in the Maritime Provinces >2,600. At most of the locations in the Maritimes, fewer than 50 thalli have been found. A notable exception is a site in New Brunswick (NB8: Fig. 4, Table 1) where more than 2,000 thalli are present. More detailed estimates of population sizes at individual locations are provided in Table 1.

At the stand level, especially in the Maritime Provinces, the occurrence of *P. cladonia* is often highly clumped. A single or a few small trees may bear most (sometimes dozens or hundreds) of the thalli, with similar neighbouring trees having few or none. This pattern apparently results from the initial colonization of a tree near its apex, followed by downward dissemination and establishment of fragments, with little lateral dispersal from tree to tree.

**Fluctuations and trends**

The total Canadian population of *P. cladonia* is probably stable. In 2004, a 3 day reconnaissance of high-elevation areas in southeasternmost Quebec increased the known population from an indeterminate number of individuals at one small site, last documented in 1959, to more than 3,000,000 thalli occurring mainly in two areas with

extensive elevations above 800 m. It is very likely that other high-elevation occurrences will be found in the small part of southeastern Quebec adjoining the United States. Three of five Maritime populations first found in 1980 or earlier, and searched for in 2003-2004, were not relocated, and 2 of these (NS3, NS4) have apparently been lost to housing development. Another population (NB10) has apparently been eliminated since its discovery in 1980 by natural habitat change – dense regeneration of spruce in an otherwise old stand opened up by a spruce budworm epidemic.

### Rescue effect

The populations of *P. cladonia* in southeasternmost Quebec are, in part, continuous with populations in the montane coniferous forests of eastern Maine and northern New Hampshire. Immigration of individuals into Canada is possible and likely in this area. Populations in the Adirondack Mountains of New York and the Green Mountains of Vermont may also provide a source of propagules dispersing to outliers of montane fir forest in southeastern Quebec, such as those on the summits of Mount Orford and (likely) Mount Sutton. Immigration into the coastal regions of New Brunswick and Nova Scotia from adjoining Maine is possible, but probably rare. The closest coastal populations in Maine, like those in the Maritimes, are small and highly fragmented.

## LIMITING FACTORS AND THREATS

The southern coastal regions of New Brunswick and Nova Scotia are at the northeastern edge of the range of *P. cladonia*. Its absence here at many sites that appear to provide suitable habitat is probably a consequence of its limited capacity for dispersal. Each of the known occurrences apparently represents an isolated instance of establishment through long-distance dispersal. Once it does become established in a forest stand, *P. cladonia* seems unable to spread quickly or widely, again because the thallus does not fragment readily or produce other propagules. Cutting of moist mature spruce-fir forests will likely eliminate the sites most likely to harbour populations. The occurrence comprising > 75% of the known population in the Maritime Provinces is in an old-growth stand currently threatened by cutting and housing development. The natural disturbance dynamics of spruce-fir forests, including periodic epidemics of spruce budworm, will cause populations of *P. cladonia* to fluctuate on a local scale. Novel forest pathogens, such as the introduced spruce longhorn beetle (*Tetropium fuscum*), could pose a greater threat.

A potential long-term threat to the large population in montane southeastern Quebec is ongoing change in the mean elevation of the cloud base. Research indicates that this elevation has been increasing by c. 4 m per year over the past 30 years, possibly due to climate warming (Richardson *et al*. 2003). If continued, these changes could result in a gradual but extensive reduction in the area of moist (cloud-influenced) montane fir forest suitable for *P. cladonia*. One of the “protected” mountain-top populations in a Quebec national park is threatened by an alpine skiing development,

and may also have been reduced in size by the emplacement of several large telecommunications towers.

## SPECIAL SIGNIFICANCE OF THE SPECIES

*Pseudevernia cladonia* is one of a small number of lichens restricted to high-elevation and cool, coastal, coniferous forests in eastern North America. The coastal occurrences of the species are largely within Canada. Changes in its elevational distribution, or in the frequency of coastal populations, might be useful indicators of climate change.

## EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Three of the 17 locations in the Maritime Provinces are in provincial parks, and one is in a national park. However, *P. cladonia* appears to have been extirpated by natural habitat change at the latter site. In Quebec, two of the locations documented to date are in Quebec national parks, though in one of these parks the population is threatened by mountain-top development; the third known location in Quebec has much more limited protection in a ZEC (Zone d'exploitation contrôlée).

# TECHNICAL SUMMARY

***Pseudevernia cladonia***
ghost antler Panache
Range of Occurrence in Canada: Quebec, New Brunswick, Nova Scotia

| **Extent and Area Information** | |
|---|---|
| • *Extent of occurrence (EO)(km²)*<br>Sum of separate estimates for NB (2,890 $km^2$), NS (560 $km^2$), and QC (known: < 1150 $km^2$; inferred: > 4,060 $km^2$). The occurrences in QC are separated from those in NB and NS by the state of Maine. The NB and NS occurrences are separated by large areas of unsuitable habitat. Large marine areas falling within EO polygons in NB and NS were excluded from EO estimates. | < 4,600 km² (known)<br>> 7,510 km² (inferred) |
| • *Specify trend in EO* | Probably stable |
| • *Are there extreme fluctuations in EO?* | Probably not |
| • *Area of occupancy (AO) (km²)*<br>Estimated AO for QC is 20% of the approximate area (18 $km^2$) of *Abies*-dominated forest occurring above 800 m elevation in southeastern QC (east of the St. Lawrence valley, south of 46° N) – based in part on site visits and in part on GIS analysis by Ministère de l'Environnement (Direction du patrimoine écologique et du développement durable) and Ministère des Ressources naturelles, de la Faune et des Parcs, Québec; estimate of AO for NB and NS based on site visits, with minimum of 10 $m^2$ assigned to any one site. | QC: 3.6 km² (includes potential habitat*)<br>NB, NS: 0.00114 km² |
| • *Specify trend in AO* | QC: unknown, but possibly increasing with increasing age of high-elevation fir forests in protected areas.<br>NB, NS: some evidence of decline. |
| • *Are there extreme fluctuations in AO?* | Unknown |
| • *Number of known or inferred <u>current</u> locations* | Overall: 21 or 22 known or inferred (not including 4 locations at which the species is apparently extirpated).<br>QC: 3 known; at least 3 other isolated mountaintop locations and 2 or 3 other areas of continuous occurrence at high elevation along QC-Maine border inferred. NB, NS: 13 locations known. |
| • *Specify trend in #* | Overall: probably stable.<br>QC: probably stable; still present at site where first recorded in 1959.<br>NB, NS: uncertain; 4 of 17 locations no longer extant, but intensive searching continues to detect small populations at scattered, previously unknown locations (5 since 2000). |
| • *Are there extreme fluctuations in number of locations?* | No |

| | |
|---|---|
| • *Specify trend in area, extent or quality of habitat* | Overall: probably stable.<br>QC: area and quality of habitat possibly increasing in protected areas due to maturation of formerly harvested fir forests; however, declines probably occurring at other high elevation sites due to logging or development of communication towers and alpine skiing. Potential impacts of increasing elevation of cloud base are as yet unknown.<br>NB, NS: some ongoing local losses or alteration of habitat, both natural and human-caused; extent of potential habitats probably stable, but habitat availability offset by low dispersal capacity of this species. |
| **Population Information** | |
| • *Generation time (average age of parents in the population)* | Uncertain, but probably < 10 years |
| • *Number of mature individuals*<br>No objective measure of "maturity" in this species. Thalli of any size more than a few mm are equally subject to fragmentation, which is probably the only means of reproduction except for extremely rare instances of relichenization following production and dispersal of ascospores. Estimates are of number of individuals ≥ 1 cm in diameter. | QC: > 10,000,000<br>NB, NS: > 2,600 (of which >2,000 are at one site in NB) |
| • *Total population trend:* | Probably stable |
| • *% decline over the last/next 10 years or 3 generations.* | — |
| • *Are there extreme fluctuations in number of mature individuals?* | No |
| • *Is the total population severely fragmented?* | QC: Yes, mtn tops are isolated islands<br>NS/NB: No, although species occurs sporadically, suitable habitat is more/or less continuous. |
| • *Specify trend in number of populations* | Overall: probably stable.<br>QC: probably stable.<br>NB, NS: uncertain; 4 of 17 documented populations no longer extant, but intensive searching continues to detect small, scattered, previously unknown populations (5 since 2000). |
| • *Are there extreme fluctuations in number of populations?* | No |
| **Threats (actual or imminent threats to populations or habitats)** | |
| Housing development, mountain-top development (communication towers, alpine ski trails and infrastructure), logging, climate change? (specifically, the increasing elevation of the average cloud-base in eastern North America) | |

| **Rescue Effect (immigration from an outside source)** | |
|---|---|
| • *Status of outside population(s)?*<br>USA: no status assigned nationally or in any US states | |
| • *Is immigration known or possible?* | Immigration into QC localities possible and likely because of continuity with those in adjoining US; immigration into NB and NS possible, but probably rare |
| • *Would immigrants be adapted to survive in Canada?* | Yes |
| • *Is there sufficient habitat for immigrants in Canada?* | Yes |
| • *Is rescue from outside populations likely?* | NB, NS: no<br>QC: yes |
| **Quantitative Analysis** | |
| **Current Status**<br>COSEWIC: Special Concern<br>April 2006. | |

*NOTE: This AO of 3.6 $km^2$ is really "potential" AO since it includes habitat that was not surveyed by the author.

**Status and Reasons for Designation**

| **Status**: Special Concern | **Alpha-numeric code**: Not applicable |
|---|---|

**Reasons for Designation**:
The species is a chalky white, finely branched macrolichen occurring on twigs of conifers in cool montane and coastal spruce-fir forests in eastern North America. It is very patchily distributed in New Brunswick and Nova Scotia, probably owing to dispersal limitations, and in southeastern Quebec, it is restricted to scattered mountaintops >800 m in elevation and to the height-of-land along the border with the USA. In its montane locations, the construction of communication towers, alpine ski development, and logging have caused some reductions in the area and quality of habitat. In the Maritimes, some population losses are attributable to logging and housing development. The severity of the threats is offset by the abundance of the species over a broad area and potential discovery of large populations on some mountain tops in Quebec.

**Applicability of Criteria**

**Criterion A**: (Declining Total Population): Criterion does not apply.

**Criterion B**: (Small Distribution, and Decline or Fluctuation): Full suite of criteria not met. Meets criteria for AO EN/TH, and criteria b(ii,iii) as continuing declines in area of occupancy and extent and quality of habitat are observed or inferred in NS and NB, and are inferred in Quebec. However, there is no extreme fluctuation (criterion c) and the species is known from >10 locations (criterion a). The criterion for extreme fragmentation is not applicable since species is considered fragmented in only QC portion of its range.

**Criterion C**: (Small Total Population Size and Decline): Criterion is not met. The number of thalli in the Canadian population exceeds 10,000.

**Criterion D**: (Very Small Population or Restricted Distribution): Criterion is not met. Although area of occupancy is estimated at 3.6 $km^2$, criterion D2 Threatened is not fully met as the threats will not lead to endangerment in a short time period. Occurrences in NB and NS are mainly very small and localized; these could be subject to extirpations resulting from human activities or from natural changes involving disturbance or forest succession. The larger sites in Quebec are potentially threatened by logging in montane fir forests (i.e. where these are not protected in parks). Effects of climate change on cloud level are documented and may result in extirpation in an unspecified time period. If mean cloud-elevation continues to increase on recent trends, declines of *P. cladonia* are also possible at these sites.

**Criterion E**: (Quantitative Analysis): Criterion does not apply.

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Patrick Graillon, Responsable de la conservation, Parc national du Mont-Mégantic
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## BIOGRAPHICAL SUMMARY OF REPORT WRITER

Stephen Clayden is Curator of Botany at the New Brunswick Museum. He is a lifelong naturalist, and became interested in lichens during his undergraduate studies at Mount Allison University. He investigated the dynamics of lichen-rich communities on rock outcrops in the Abitibi region of Quebec for his M.Sc. at the Université de Montréal, and earned his Ph.D. at King's College London for studies of the life histories and systematics of yellow *Rhizocarpon* species (the "map lichens"). He has collected and researched lichens widely in Atlantic Canada and Quebec, and co-authored *The Rare Lichens of Canada: a Review and Provisional Listing* (COSEWIC, 1998), with Trevor Goward and Irwin Brodo.

## COLLECTIONS EXAMINED

All specimens collected and (or) examined during the preparation of this report are listed in Table 1.