COSEWIC
Assessment and Status Report

on the

Pale-bellied Frost Lichen
Physconia subpallida

in Canada

ENDANGERED
2009

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 2009

Common name
Pale-bellied Frost Lichen

Scientific name
Physconia subpallida

Status
Endangered

Reason for designation
This lichen is an eastern North American endemic that, in Canada, is restricted to 2 known locations in southern Ontario. The lichen grows as an epiphyte on hardwoods and requires bark with high pH and high moisture holding capacity. Only 45 individuals are known, growing on 16 trees. The lichen appears to have suffered a dramatic population decline throughout its range since the early 1900s; in Canada 4 historical sites have been lost. The major threat to the lichen is air pollution and timber harvest.

Occurrence
Ontario

Status history
Designated Endangered in November 2009.

COSEWIC
Executive Summary

Pale-bellied Frost Lichen
Physconia subpallida

Wildlife species description and significance

Physconia subpallida is a rosette forming foliose lichen that can be strikingly white in the field. There are several distinctive characters that separate it from other eastern North American *Physconia* lichens including: 1) absence of common means of asexual production in lichens (isidia and soredia), 2) presence of fruiting bodies (apothecia) and/or lobules, and 3) a pale undersurface with spreading attachment structures (rhizines) in distinct clusters.

Physconia subpallida is an eastern North American endemic. It is the only eastern North American member of the genus that is commonly fertile, has lobules, and has a pale undersurface. These unique characters increase the importance of this species to understanding the genus as a whole. Two distinct forms of this lichen are known. One form is commonly fertile with flattened appressed lobules and the other form is generally sterile with cylindrical erect lobules. This presents a opportunity to investigate the development of apothecia and study the expression of the same morphological structures in a single fungal genome.

As a lichen that appears to be extremely sensitive to air pollution, *Physconia subpallida* may be a valuable indicator of forest health and air quality in southern Ontario.

Distribution

Physconia subpallida is an eastern North American endemic occurring only in the United States and Canada. It is known, at least historically, from Massachusetts and New Hampshire west to southern Ontario, Michigan, and eastern Iowa south to central Illinois, Ohio, and Virginia. It is also disjunct in the Ozarks region of eastern Oklahoma and northwestern Arkansas. In Canada, *P. subpallida* is restricted to southern Ontario where it is at the northern edge of its range. There are only two known locations.

Habitat

This lichen mainly grows as an epiphyte on hardwood trees, but has also been collected from fence rails and rocks, including limestone. The host trees *P. subpallida* is known to occur on include: *Fraxinus* sp. (Ash), *Juglans nigra* (Black Walnut), *Ostrya virginiana* (Hop-hornbeam), and *Ulmus* sp. (Elm; including *Ulmus americana*). At the two known extant sites in Canada the lichen is restricted to *Ostrya virginiana*. The lichen seems to require a substratum with relatively high pH and moisture holding capacity.

Biology

Physconia subpallida can reproduce via sexually and asexually produced spores. It may also be able to reproduce asexually via dispersal of lobules. However, the lichen lacks common means of asexual production in lichens (isidia and soredia), and it is possible that the larger lobules are not as easily dispersed as these more common, smaller propagules.

Population sizes and trends

The vast majority of collections from throughout the range of the lichen were made before 1973 with four recent collections from Canada and two from the USA. In Canada, there are a total of two extant and approximately four historical (last documented over 100 years ago) populations, and the lichen appears to have suffered a dramatic decline in populations since the early 1900s. None of the historical populations documented in southern Ontario is thought to occur today. One of the extant populations (Billa Lake in Lanark County) appears to have remained stable since its discovery in 2004 although more time and additional survey work are needed to determine the stability of this population. A comparison of recent collections with older herbarium collections indicates that both the frequency of apothecia and the size of thalli have decreased over time.

Threats and limiting factors

Habitat availability for this lichen in southern Ontario has been negatively affected, over the past century, primarily by air pollution as well as by changes in land use and forest composition. The two extant Canadian populations are both currently unprotected on provincial lands that are open to logging operations. Improvements in air quality have significantly decreased sulfate deposition and so this rare lichen may be able to expand its populations in the long-term.

Protection, status, and ranks

There is currently no legal protection for *Physconia subpallida*. The lichen has previously been assigned a provincial conservation status rank of S1 (critically imperiled) in Ontario and a global conservation status rank of G3 (uncommon worldwide).

TECHNICAL SUMMARY

Physconia subpallida
Pale-bellied Frost Lichen — Physconie pâle
Range of occurrence in Canada (province/territory/ocean): ON

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used)	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Decline (historical)
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	30 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value; other values may also be listed if they are clearly indicated (e.g., 1x1 grid, biological AO)).	16 km²
Is the total population severely fragmented?	No
Number of "locations∗"	2
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Decline (historical)
Is there an [observed, inferred, or projected] continuing decline in number of locations?	Unknown Lost 4 (historical)
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Inferred - Decline in air quality causes direct and indirect toxic effects and observed increase in forest fragmentation affecting site continuity and humidity.
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations∗?	No
Are there extreme fluctuations in extent of occurrence?	No

∗ See definition of location.

Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
1: Arcol Road (2007): 26 individuals, 5 with apothecia on 8 trees total	26
2: Billa Lake (2007): 19 individuals, 1 with apothecia on 8 trees total	19
Total	45

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	N/A

Threats (actual or imminent, to populations or habitats)

Populations are on Crown land with no official protection. Forests may be logged (Arcol Road has been selectively logged). Continued concern over effects of sulfate deposition levels in southern Ontario.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? USA: The overall ranking of this lichen in the USA was not found, but the lichen has also suffered an historical decline in this country. There are currently only 2 known extant (documented since 1986) populations in the USA. New England: RH (no specimens known since 1950 in the New England states)	
Is immigration known or possible?	Unlikely
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Unknown
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (2009)
Ontario: S1
Global conservation status rank: G3

Final Status and Reasons for Designation

Final Status: Endangered	**Alpha-numeric code:** B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v); C2a(i); D1

Reasons for designation:
This lichen is an eastern North American endemic that, in Canada, is restricted to 2 known locations in southern Ontario. The lichen grows as an epiphyte on hardwoods and requires bark with high pH and high moisture holding capacity. Only 45 individuals are known, growing on 16 trees. The lichen appears to have suffered a dramatic population decline throughout its range since the early 1900's; in Canada 4 historical sites have been lost. The major threat to the lichen is air pollution and timber harvest.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets criterion B1 for Endangered, with EO < 5000 km², and B2 for Endangered, with IAO < 500 km²; meets subcriterion (a) known from less than 5 locations; meets subcriterion (b) for continuing decline inferred for (i) extent of occurrence, (ii) index of area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or populations, (v) number of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Meets criterion C2 for Endangered, with < 2500 individuals, and a(i), no populations observed to contain > 250 mature individuals
Criterion D (Very Small or Restricted Total Population): Meets criterion D1 for Endangered (< 250 mature individuals).
Criterion E (Quantitative Analysis): Data not available.

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 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 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
(2009)

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 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.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

Scientific name:	*Physconia subpallida* Esslinger
English common name:	Pale-bellied Frost Lichen
French common name:	Physconie pâle
Synonyms:	none
Past determinations (none are true synonyms):	*Heterodermia hypoleuca* (Ach.) Trevisan (as *Physcia hypoleuca*), *Physcia stellaris* (L.) Nyl., *Physconia distorta* (With.) J. R. Laundon, *Physconia muscigena* (Ach.) Poelt, *Physconia pulverulacea* Moberg, *Physconia pulverulenta* (Schreber) Poelt (sometimes as *Physcia pulverulenta*; including various forms), and *Physconia venusta* (Ach.) Poelt (as *Physcia venusta*).
Bibliographic citation:	Mycotaxon 51: 91-99 (1994)
Type specimen:	U.S.A. Vermont. Chittenden Co.: Lake Champlain, Malletts Bay, on elm, 21 Mar 1910, *D.B. Griffin 77* (holotype: FH!).

This foliose lichen belongs to the genus *Physconia* Poelt (1965), which is a small genus with about 25 species worldwide, 12 of which occur in North America (Cubero *et al.* 2004; Hinds and Hinds 2007). *Physconia* belongs to the family Physciaceae (Order Lecanorales: Phylum Ascomycota: Kingdom Fungi). Species of *Physconia* are closely related to those in the genera *Anaptychia* and *Phaeophyscia* (Cubero *et al.* 2004). The specific epithet, *subpallida*, refers to the pale tan to white lower surface of the thallus. All other North American members of the genus have brown to black under surfaces at least towards the centre.

This lichen was described relatively recently in 1994 (Esslinger 1994) and there are no primary synonyms. Before this lichen was described it often was determined as *P. distorta* or the synonyms of *P. distorta, P. pulverulacea* and *P. pulverulenta*. *Physconia distorta* as currently understood does not occur in North America (Esslinger 1994). *Physconia subpallida* has also been misidentified as other non-sorediate lichens in the genus *Physconia* including *P. venusta* (a Eurasian lichen [Esslinger 1994]) and *P. muscigena* (an arctic-alpine lichen with a black lower cortex [Hinds and Hinds 2007]). Examination of specimen packets of *P. subpallida* revealed that it has also been misidentified as a few other more distantly related lichens (see past determinations above). In addition, it appears that Mason Hale confused *P. subpallida* with *Anaptychia palmulata* (Hale 1979; Esslinger 1994).

Morphological description

Physconia subpallida is a rosette forming foliose lichen that can be strikingly white in the field due to a heavily pruinose upper surface (Figure 1). Thalli range in size from 0.1 to 44 cm^2 with an average of 7.6 ± 7.9 cm^2 (based on measurements from specimens and field work; see Appendix 1). This lichen lacks isidia and soredia. Apothecia are sometimes present although from the 45 thalli at two distinct populations that Cleavitt & Werier observed only 6 of them had apothecia. Marginal and laminal lobules are often present especially in the centre of the thallus and sometimes these become extremely dense. The lobules are at times flattened and appressed to the rest of the thallus but sometimes are more cylindrical and erect (Figure 1). Cleavitt and Werier during report preparation in 2007 noticed and Esslinger (1994) mentions two apparent forms of *P. subpallida*. One form has apothecia present with flattened appressed lobules and the other form has apothecia absent with dense cylindrical erect lobules (Figure 1). Pycnidia are often present on the upper surface of the thallus or lobules. The lower surface is corticate, white or pale tan, and has squarrose branched rhizines. The lichen lacks lichen substances and chemical tests are not generally useful for distinguishing between this lichen and morphologically similar lichens. Members of *Physconia* have the green alga *Trebouxia* sp. as the photobiont (Esslinger 1994; Hinds and Hinds 2007). Detailed descriptions are available in Esslinger (1994) and Hinds and Hinds (2007).

Figure 1. Two forms of *Physconia subpallida*: apotheciate form with flattened lobules (left) and densely lobulate form with erect cylindrical lobules and no apothecia (right). Both specimens are growing on *Ostrya virginiana* at the newly documented Arcol Road population, Ontario.

There are several distinctive characters of this lichen that separate it from all other eastern North American *Physconia* species including: 1) absence of isidia and soredia, 2) presence of apothecia and/or lobules with pycnidia, and 3) a pale undersurface with squarrose rhizines in distinct clusters. A total of five species in the genus *Physconia* occur in southern Ontario. All but *P. subpallida* regularly have soredia. See Table 1 for distinguishing features of these five species.

Table 1. Summary of the morphological characters of the five species of *Physconia* that occur in southern Ontario (from Esslinger 1994, 2002; Brodo *et al.* 2001; Hinds and Hinds 2007; and T. Esslinger personal communication).

	***Physconia* spp.**				
	detersa	***enteroxantha***	***leucoleiptes***	***perisidiosa***	***subpallida***
Soralia	marginal, continuous, not labriform, white to brown	marginal, continuous, not labriform, sometimes yellowish	marginal and terminal, discrete, labriform, white to brown	marginal, discrete, labriform on short lateral lobes, white to brown	absent
Lobes and lobe tips	flat to sometimes weakly reflexed, not lobulate, (0.6-)1-2(-3) mm wide	flat, not lobulate, 0.6-2(-3) mm wide	becoming reflexed, not lobulate, mostly 1-2 mm wide	ascending, sometimes lobulate on margins, 0.5-1.5 mm wide	flat or convex, lobulate, 1-2.5(-3) mm wide
Apothecia and apothecial margins	infrequent, non-lobulate (usually) sorediate margins	infrequent, margins entire and sorediate	infrequent, lobulate margins with labriform soralia	rare, margins entire or sometimes becoming lobulate, lobules sometimes with labriform soralia	common, lobulate margins without soredia
Medulla	white	pale-yellow to off-white	white	white	white
Lower surface	corticate, black toward centre	corticate, black toward centre	corticate, black toward centre	ecorticate (with black striations) at lobe tips, white margins and black centre	corticate, white to pale tan

Hale (1979) mistakenly confused specimens of *P. subpallida* for what he called “white pruinose sun-forms of [*Anaptychia palmulata*]”. According to Esslinger (1994), Hale (1979) confused *P. subpallida* with *A. palmulata* because both lichens have a pale lower surface. While *A. palmulata* can have white pruinose lobe tips (Hinds and Hinds 2007) it lacks the dense white pruinose upper thallus surface of *P. subpallida*. The pruina on some old herbarium specimens of *P. subpallida* are sometimes difficult to detect. However, live specimens of these species are different in colour with *A. palmulata* being blue-green and *P. subpallida* a tan or light brown colour obscured by dense, white pruina. Characters that separate specimens of *P. subpallida* from *A. palmulata* include presence of pruina (usually very dense) on the thallus lobes (typical of the genus *Physconia*), pruinose apothecial disks, and margins of the apothecial disks with more flattened lobes that bend down toward the lichen thallus. In contrast, *A. palmulata* lacks pruina or is pruinose only on the lobe tips, has epruinose apothecial disks, and has lobules on the apothecial disk margins lacking or inwardly pointed. In addition, a less consistent distinction is that *P. subpallida* tends to have squarrose rhizines whereas *A. palmulata* often has simple to bunched rhizines although specimens from more northern locales can also have squarrose rhizines (Esslinger 1994; T. Esslinger personal communication).

Hinds and Hinds (2007) noted that the lichen may also be confused with the arctic-alpine species *P. muscigena*, which is known from the Gaspé Peninsula because it also lacks soredia and isidia. Two specimens of *P. subpallida* seen by Cleavitt and Werier had at one point been labelled *P. muscigena*. *Physconia muscigena* differs from *P. subpallida* by its dark lower surface (at least towards the centre), lobes distinctly concave (especially near the tips), partly to almost completely pruinose upper surface, habit of growing on mosses on rock or soil, and its artic-alpine distribution (Brodo *et al.* 2001; Esslinger 2002; Hinds and Hinds 2007). In contrast, *P. subpallida* has a pale tan to white lower surface, lobes flat to convex, completely pruinose upper surface, primarily the habit of growing on bark, and a temperate eastern North American distribution (Esslinger 1994).

The western lichen *P. americana* was described by Esslinger (1994) in the same publication as *P. subpallida* and the two were apparently previously combined under the name *P. distorta* (including the synonyms *P. pulverulenta* and *P. pulverulacea*). In *P. americana,* the lower surface towards the centre is dark brown to black, lobules are usually restricted to the apothecial margins but occasionally occur on the central part of the thallus, pruina are sometimes patchy rather than densely covering the thallus surface as in *P. subpallida*, and it is restricted to western North America (Esslinger 1994; Brodo *et al.* 2001).

In the field, small, densely pruinose, almost esorediate specimens of the normally densely sorediate *P. perisidiosa can be mistaken* for *P. subpallida.* At a site in Algonquin Provincial Park, such specimens were found in an old maple forest where the thalli were growing almost exclusively on *Ostrya virginiana* with a few on *Fagus grandifolia*. Furthermore, several thalli at the Algonquin Park site were fertile with densely pruinose apothecia, a rare occurrence for *P. perisidiosa*, but common for *P. subpallida* (I. Brodo personal communication). In the field, if individuals of *P. perisidiosa* are small and lack or only have very sparse soredia, they can be difficult to distinguish from *P. subpallida* because both can be white with dense pruina and produce lobules. In addition to the presence of soredia, *P. perisidiosa* has the undersides of the lobe tips ecorticate and the lower surfaces becoming dark in the centre (Brodo *et al.* 2001; Hinds and Hinds 2007). In the non-sorediate *P. subpallida*, the undersides are smooth, corticate, and pale throughout (Esslinger 2004; see Table 1).

Designatable units

One designatable unit for *Physconia subpallida* is recognized because the lichen is known only from a single ecozone in Canada.

Special significance

Physconia subpallida is a North American endemic. It is the only eastern North American member of the genus that is commonly fertile, lacks soredia, has lobules, and has a pale undersurface. Within the series *Pulverulentae* (the largest clade within the genus), *P. subpallida* is the only lichen with the pleisiomorphic (ancestral) character of a pale undersurface (Cubero *et al.* 2004). These unique characters increase the importance of this lichen to understanding the genus as a whole. Two distinct forms of this lichen are known (one with flattened appressed lobules that often have apothecia and one with cylindrical erect lobules that often lack apothecia) presenting a unique opportunity to investigate the development of apothecia in a lichen as well as the significance of different expressions of the same morphological structures.

As the interest in the preservation of biodiversity has increased it becomes vital that all species, even if they do not have a currently known value, are preserved. This lichen is apparently sensitive to SO_2 concentrations and so has value as an air quality indicator.

DISTRIBUTION

Global range

Physconia subpallida is currently understood to be an eastern North American endemic. The range of the lichen closely overlaps with the extent of the eastern temperate deciduous forest as described by Braun (1950). It is known, at least historically, from Massachusetts and New Hampshire west to southern Ontario, Michigan, and eastern Iowa south to central Illinois, Ohio, and Virginia (Figure 2). It is also disjunct in the Ozarks region of eastern Oklahoma and northwestern Arkansas. Throughout its range it is quite local with large disjunctions between populations (Figure 2). It is unclear why this is the situation given that this lichen does not appear to inhabit rare habitats. The vast majority of collections are from before 1973 with only four collections documented recently.

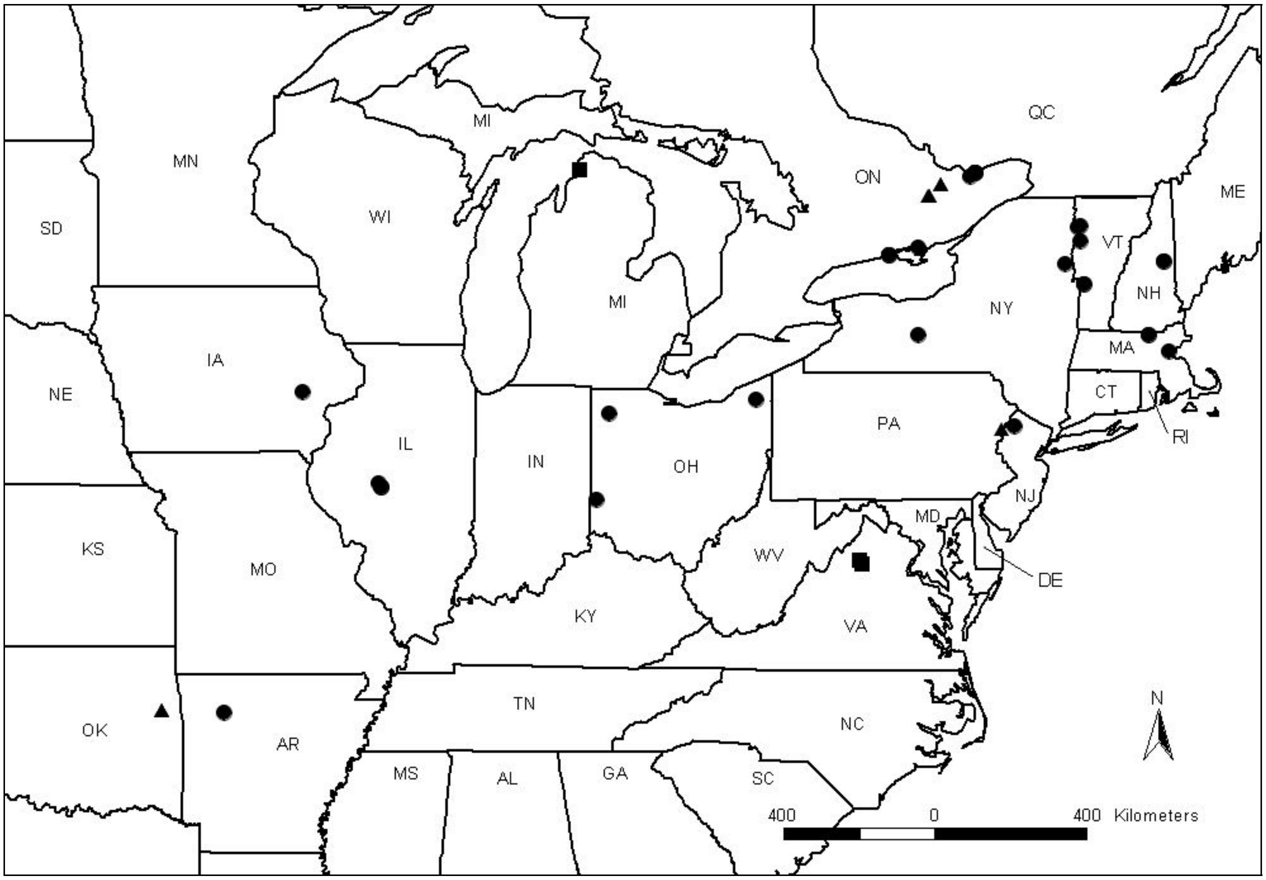

Figure 2. North American distribution of *Physconia subpallida*. Symbols refer to the year of collection. ● = pre-1955 (includes five specimens without year but assumed to be pre-1955 collections); ■ = 1967-1972; ▲ = 1986 to present.

Canadian range

The known Canadian range of *Physconia subpallida* is restricted to southern Ontario (Figure 2). The lichen was known historically from Brighton, Belleville, and Ottawa (including Britannia [a community within Ottawa]) (Table 2). Extant populations are known only from two locations: Billa Lake and Arcol Road (Table 2; Figure 2). Given *P. subpallida*'s known historical range in North America, southern Quebec may also include suitable habitat for this lichen. Extent of occurrence (EO) is 30 km^2 and index of area of occupancy (IAO) is 16 km^2.

Table 2. All known Canadian populations (historical and extant) of *Physconia subpallida*. All sites are within the province of Ontario.

Site Name	County / City	When first found	When last observed	Population size			Substratum
				area in hectares	# of trees on	cm^2 of thalli	
Brighton	Northumberland County	1893	1893	unknown	unknown	unknown	rails, unspecified tree trunks
Belleville	Hastings County	1868	1868	unknown	unknown	unknown	unspecified trees
Arcol Road	Frontenac County	2007	2007	7.0 in 2007	8 in 2007	191 in 2007	*Ostrya virginiana* (Hop-hornbeam)
Billa Lake	Lanark County	2004	2007	3.8 in 2007	8 in 2007	164 in 2007	*Ostrya virginiana* (Hop-hornbeam)
Ottawa*	City of Ottawa	1891	1900	unknown	unknown	unknown	unspecified tree trunks, rocks
Britannia**	City of Ottawa	1902	1902	unknown	unknown	unknown	*Fraxinus* sp. (Ash)

* This population may represent as many as four separate populations or may be the same population as Britannia
** This population may not be distinct from the Ottawa population

The exact number of locations (historical and extant) known from Canada is unclear due to the lack of precise location information on some of the historical specimens. Five specimens collected on different dates all by John Macoun in the late 1800s and early 1900s come from the Ottawa region. Four of these specimens simply have Ottawa written for location while one has Britannia (a community within Ottawa). If Cleavitt & Werier assume these five specimens represent two distinct locations, then in total, there are four historical and two extant locations known from Canada (Table 2).

Search effort

Other lichenologists familiar with this lichen (Rob Lee, Irwin Brodo, Steve Selva, Chris Lewis, and others) have searched many sites in southern Ontario (searching specifically for *Physconia subpallida*) without finding any individuals other than at the Billa Lake site (open squares Figure 3) (I. Brodo personal communication; R. Lee personal communication; C. Lewis personal communication). In addition, the Ottawa region, where historical collections of *P. subpallida* are known, has been thoroughly searched over the past 40 years without success (I. Brodo personal communication).

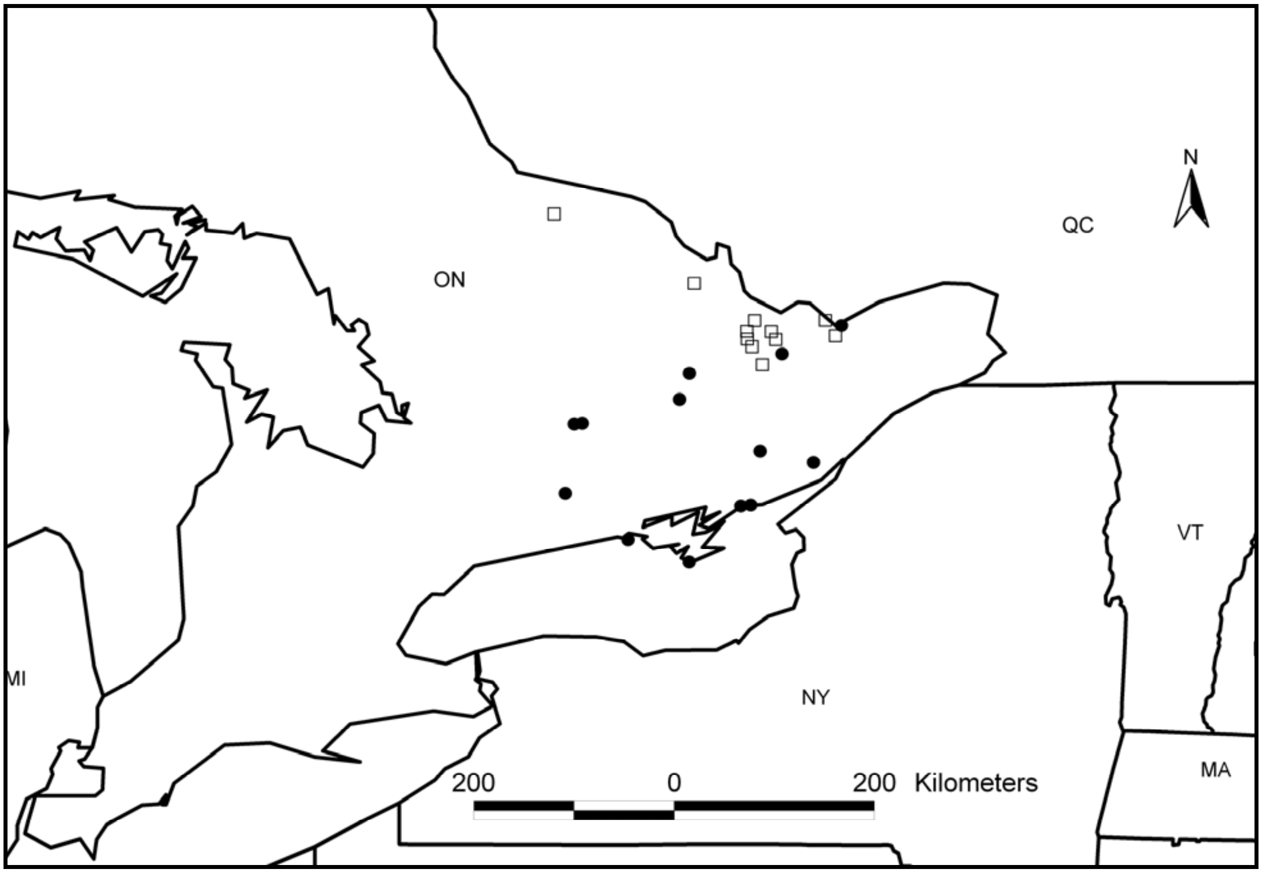

Figure 3. Search efforts for *Physconia subpallida* in southern Ontario. ● = unsuccessful targeted searches for *P. subpallida* by Cleavitt and Werier in 2007, ☐ = unsuccessful targeted searches for *P. subpallida* by other lichenologists.

Although perhaps not as intensively searched as the Ottawa region, southern Ontario contains many sites where lichens have been collected. *Physconia subpallida* is known from only six sites in the province but has not been seen at four of the sites for over 106 years. To help demonstrate the frequency of collections in southern Ontario, the site locations of all specimens of the superficially similar *Anaptychia palmulata* and all *Physconia* spp. housed at Canadian Museum of Nature (CANL) were mapped. In addition, the collecting locales of Pak Yau Wong (lichenologist, CANL) were mapped. The latter locales are sites where P. Wong has attempted to collect all the species of lichens present (I. Brodo personal communication; Figure 5). This information helps demonstrate that lichens have been searched for and collected at many sites in southern Ontario. If more species and collectors were included in this mapping as well as additional herbaria examined the number of locations would be greater.

Physconia subpallida also appears to be currently rare throughout most of its range, although historical collection over a wide geographical area from roadside habitats suggests greater prevalence pre-1900. Richard Harris, New York Botanical Garden (NYBG), has been collecting lichens for over 40 years throughout eastern North America and has seen this lichen only once in the field (R. Harris personal communication). Jim and Patricia Hinds have been collecting lichens in New England for over 35 years and have never encountered this lichen in that region. In addition, there are no known recent collections of *P. subpallida* from New England (Hinds and Hinds 2007). Another active lichenologist in eastern North America, James Lendemer, NYBG, has also never encountered this lichen in the field (J. Lendemer personal communication). The herbaria CUP-L, CANL, COLO, F, FH, HERB ESSL, MICH, MIN, NY, WIS, and US (in part) were searched by Cleavitt and Werier or knowledgeable lichenologists for *P. subpallida* (see collections examined for more details). These herbaria include the major repositories for lichen specimens in eastern North America, and yet only about 27 collecting locations (44 specimens many of them duplicates) of *P. subpallida* were verified. Therefore, although this lichen has quite a wide geographical distribution it currently appears to be very rare throughout this range.

HABITAT

Habitat requirements

This lichen mainly grows as an epiphyte on hardwood trees, but has also been collected from fence rails and rock including limestone (Table 3). The tree species *Physconia subpallida* is known to occur on include: *Fraxinus* sp. (Ash; probably *F. americana* [White Ash]), *Juglans nigra* (Black Walnut), *Ostrya virginiana* (Hop-hornbeam), and *Ulmus* sp. (elm; including *Ulmus americana* [American Elm]). In Canada, this lichen is limited to rock, fence rails, *Fraxinus* sp. (probably *F. americana*), and *Ostrya virginiana*. At the two known extant sites in Canada the lichen is restricted to *Ostrya virginiana* (Figure 4). This information comes from historical specimen labels and field survey work for this report. A few historical specimens indicate more than one substratum for *P. subpallida* at a particular population while some lack substratum information altogether (Table 3).

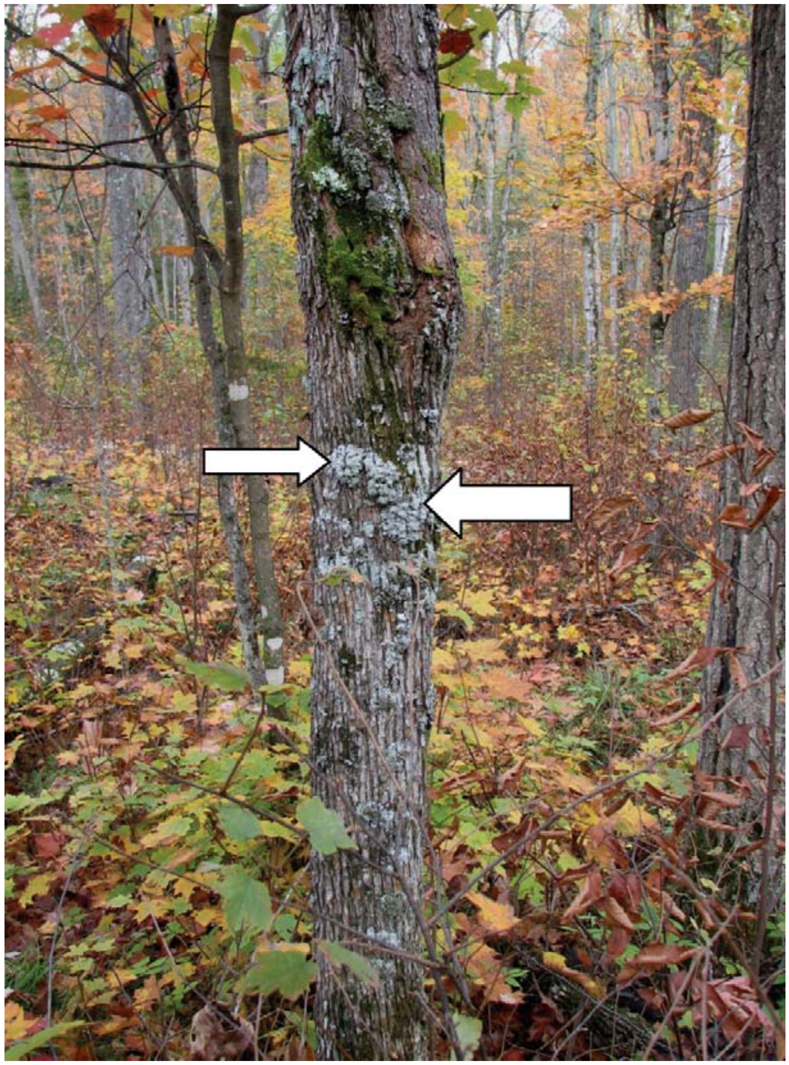

Figure 4. Habitat of *Physconia subpallida*. White arrows point to colonies of *P. subpallida* in the photograph.

Table 3. Substrata where *Physconia subpallida* has been documented based on specimen labels and field observations.

Substratum	Number of populations (historical and extant)
Fraxinus sp. (Ash)	2
Juglans nigra (Black Walnut)	1
Ostrya virginiana (Hop-hornbeam)	3 total
Ulmus sp. (Elm)	4 total (1 “dead elm” and 1 *Ulmus americana* [American Elm])
unspecified tree	7 total (1 from “old trees” and 1 from “hard bark”)
wooden fence rail	1
limestone	1
other rock	2 (1 from “shaded boulders”)
none specified	8

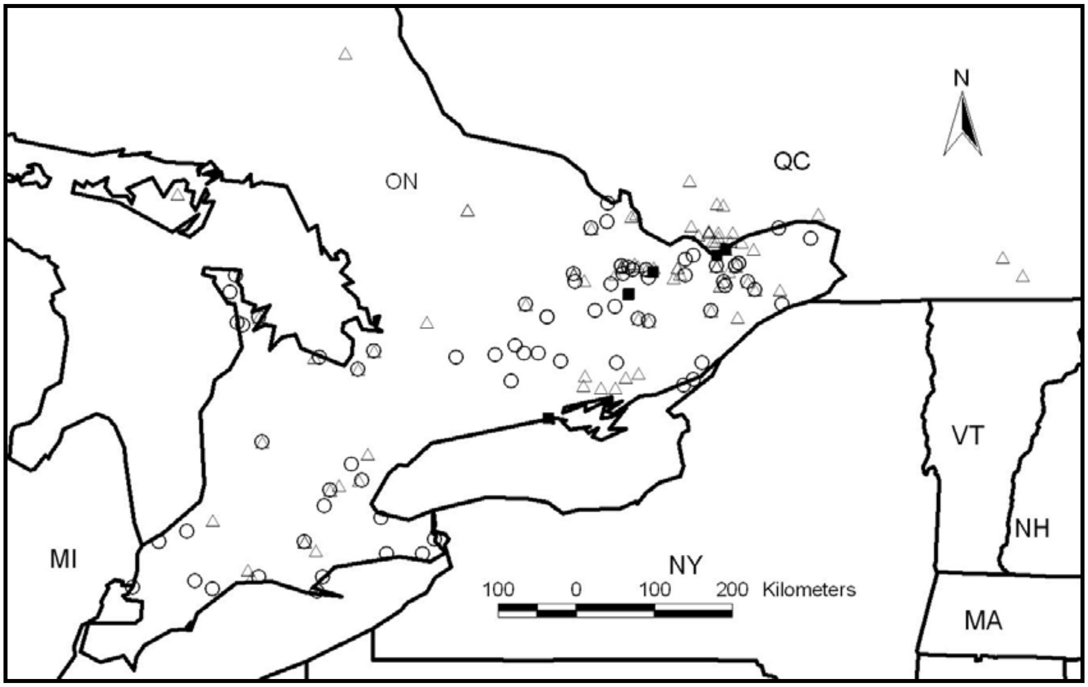

Figure 5. Search efforts for non-targeted lichens and known population of *Physconia subpallida* (historical and extant) in southern Ontario and southern Quebec. △ = site locations of specimens of the non-targeted lichens *Physconia* spp. and *Anaptychia palmulata* housed at CANL, O = collecting locales of the lichenologist P. Wong, ■ = extant and historical collections of *P. subpallida*.

One of the known extant sites in Canada (Billa Lake) is considered to be an old-growth forest (White 1996). For this reason, it has been suspected that *Physconia subpallida* may be an old-growth dependent lichen (I. Brodo personal communication; R. Lee personal communication). The bryophyte associates of *P. subpallida* also suggest older forest stands as eight bryophytes that have been found to be growing close to individuals of *P. subpallida* (Table 4) have been previously cited as indicators of older forests by Keddy and Drummond (1996) and Cooper-Ellis (1998). The only other evidence Cleavitt & Werier could find to support this claim is that an 1878 collection of *P. subpallida* from Menard County, Illinois, USA, was made from an “old tree” (see collections examined). The other known extant site in Canada (Arcol Road) was selectively logged relatively recently (within 5 to 10 or so years prior to our survey in 2007). It is unclear if this site had old-growth characteristics prior to logging but no evidence of old-growth characteristics were seen during the 2007 survey by Cleavitt and Werier (see description of this site below). In addition, although this site is currently not an old-growth forest, the *P. subpallida* individuals that were observed appeared healthy (i.e. they did not show necrotic patches or significant signs of decay). Other than the Billa Lake site, Cleavitt and Werier searched at least two old growth forests in southern Ontario without finding any *P. subpallida*. One of these sites (Jobe’s Woods in Presqu’ile Provincial Park) is very close to Brighton, a historical site for *P. subpallida*. The question of the significance of old-growth forests to *P. subpallida* needs further investigation.

Table 4. The moisture holding capacity and vapour capacity of tree species in southern Ontario. Percentage values are a percentage based on the weight of water absorbed per dry weight of the bark sample. Trees where *Physconia subpallida* is known to occur are marked with an asterisk. Data are summarized from various sources cited in Young (1937); Billings and Drew 1938; Hale 1955; Barkman (1958); Brodo (1968); Snell and Keller (2003) and Everhart *et al.* (2008).

Tree species	Moisture holding capacity (%)	Vapour capacity (%)	Bark pH
*Ostrya virginiana**	No data	22	5.8
*Ulmus americana**	120	18.2	5.1-6.9
Ulmus rubra		19	4.8-7.0
*Fraxinus americana**	51-123	18.8-21	5.1-7.0
Acer rubrum	83-132	15.0	3.5-5.6
Tilia americana	80		4.5-6.1
Fagus grandifolia	58-64	17-18.8	4.6-5.9
Quercus rubra	32	16.7	2.8-5.6
Acer saccharum	5-29	19	4.8-6.7

Other habitat characteristics suspected to be of importance to *Physconia subpallida* include site humidity and bark traits including moisture holding capacity, pH and Ca content. Moisture holding capacity (mhc) of tree bark can be measured in different ways and measurements can be variable depending on what is compared (e.g. mass of water absorbed compared to the mas, volume, or surface area of bark) and how it is measured (reviewed in Barkman 1958 and Brodo 1968); therefore comparisons between studies are sometimes difficult. A list of moisture holding capacity and vapour capacity values are presented in Table 4 for some of the tree species which *P. subpallida* is known to grow on (*Ulmus* sp. [including *U. americana*] and *Fraxinus* sp. [probably *F. americana*]) and for comparison some of the other common hardwood trees found in southern Ontario (when information is available).

Although there are some discrepancies between the ordering of trees by vapour capacity versus moisture holding capacity, species of trees on which *Physconia subpallida* has been collected generally have a relatively high moisture holding capacity compared with other hardwood trees known from southern Ontario (Table 4). In addition, the water content of bark has been documented to be higher under moss cover (Barkman 1958). Many of the trees which *P. subpallida* was found to grow on at the two extant sites in southern Ontario had significant bryophyte cover. Individuals of *P. subpallida* were also found (from field and herbarium specimen observation) to grow over bryophytes.

Like moisture holding capacity measurements of tree bark, pH also can be quite variable depending on the methods used (e.g. how thick of bark is used and whether the undersurface is coated with wax), where the sample came from (e.g. roadside vs. forest interior), or the purity of the sample (e.g. if it is impregnated with dust or is clean) (Barkman 1958; Schmidt *et al.* 2001) making comparisons between different measurements and studies difficult. In general, the bark of tree species that *Physconia subpallida* occurs on have a relatively high pH (Table 4). No information related to data presented in Table 4 could be found for *Juglans nigra* (the one other tree species from which *P. subpallida* has been collected).

The two extant sites in Canada share in common a high density of *Ostrya virginiana* stems and high humidity as evidenced by fogs during site visits by Cleavitt and Werier, and by the luxuriant growth of bryophytes known to require humid sites, especially *Leucodon andrewsianus* and *Porella platyphylla*. Detailed information about the habitat is provided below.

The Arcol Road population occurs exclusively on live bark, or in one case recently dead bark, of *Ostrya virginiana* with a diameter at breast height (dbh) ranging from 12.5-17.0 (mean 15.1 ±1.6) cm. Specimens occur from 0.5 to 2 metres above the ground and on all aspects of the trunks. The overall site is a 0-45 degree northwest to north-northwest facing forested slope and ridge. There are some more or less flat terraces along the slope. The forest had been selectively logged about 5 to 10 years before our site visit in 2007 based on condition of stumps within the site. The logged trees appear to have been mature although not huge when they were cut. The larger stumps measured about 42 cm diameter at 0.3 m high. The forest has some openings as a result of the logging. The soils are predominantly mesic although along some of the ridges they are slightly drier. The dominant trees in the canopy are *Acer saccharum* (Sugar Maple) and *Quercus rubra* (Red Oak). Other trees present in the canopy include *Betula papyrifera* (White Birch), *Fraxinus americana* (White Ash), *Populus tremuloides* (Quaking Aspen), *Picea glauca* (White Spruce), *Pinus strobus* (White Pine), *Thuja occidentalis* (Northern White Cedar), and *Tsuga canadensis* (Eastern Hemlock). The understory is dominated by *Ostrya virginiana* and saplings of the tree species found in the canopy. Other understory trees present include *Abies balsamea* (Balsam Fir), *Fagus grandifolia* (American Beech), and *Ulmus thomasii* (Rock Elm). The shrub layer is dominated by *Dirca palustris* (Leatherwood). Other shrubs present include *Symphoricarpos albus* var. *albus* (Snowberry) and *Viburnum acerifolium* (Maple-leaved Viburnum). The herb layer is moderate in density with *Carex pensylvanica* (Pennsylvania Sedge) and *Oryzopsis asperifolia* (White-grained Mountain-ricegrass) dominant. Some other herbs present include: *Aquilegia canadensis* (Wild Columbine), *Piptatherum racemosum* (Black-fruited Mountain-ricegrass), and *Elymus trachycaulus* (Slender Wheatgrass). Many macrolichens and bryophytes grow on the same trees as *Physconia subpallida* (Table 5) Other macrolichens seen at this site in general include *Flavoparmelia caperata* (Common Greenshield Lichen), *Lobaria quercizans* (Smooth Lungwort), *Melanelia subaurifera* (Abraided Brown-shield Lichen), *Myelochroa galbina* (Smooth Axil-bristle Lichen), *Phaeophyscia pusilloides* (Pompom-tipped Shadow Lichen), and *Physcia adscendens* (Hooded Rosette Lichen).

Table 5. Epiphytic bryophytes and macrolichens found growing adjacent to individuals of *Physconia subpallida* throughout its range. For sites visited in the field (Billa Lake and Arcol Road), adjacent individuals include all species found on the same trees. For herbarium specimens adjacent individuals include all species found in the same specimen packets. See collections examined for the total list of specimens of *P. subpallida* observed during preparation of this report. Species found growing with *P. subpallida* from two or more populations are in bold.

Associated epiphyte species	Specimen source		
	Billa Lake	**Arcol Road**	**Herbarium**
Mosses			
Anomodon attenuatus		X	
Haplohymenium triste			X
Leskea polycarpa	X		
Leskeella nervosa		X	
Leucodon andrewsianus	X	X	X
Lindbergia brachyptera			X
Neckera pennata		X	
Orthotrichum obtusifolium		X	X
Orthotrichum speciosum			X
Orthotrichum spp.			X
Plagiomnium sp.			X
Platygyrium repens	X		X
***Pylaisia* spp.**	X	X	X
Liverworts			
Frullania eboracensis	X	X	X
Porella platyphylla	X	X	
Radula complanata	X	X	
Macrolichens			
Candelaria concolor	X	X	X
Leptogium sp.			X
Lobaria quercizans			X
Parmelia sulcata			X
Physciella chloantha			X
Physconia detersa		X	
Physconia enteroxantha		X	
Physconia leucoleiptes	X	X	X
Physconia perisidiosa		X	
Phaeophyscia hirsuta	X	X	
Phaeophyscia hispidula		X	
Phaeophyscia rubropulchra	X	X	X
Physcia aipolia	X	X	X
Punctelia rudecta	X	X	X

The Billa Lake population occurs exclusively on live bark of *Ostrya virginiana* with diameters (dbh) ranging from 11.5-17.3 (mean 15.3 ±1.9) cm. Specimens occur from 0.5 to 2 m from the ground on various aspects of the trunks. The overall site is a flat to moderate northwest to southwest facing forested slope. There is a small rocky ridge present as well. Parts of the forest appear to be old growth. The dominant tree in the canopy is *Acer saccharum*. Other trees present in the canopy include *Abies balsamea*, *Fagus grandifolia*, *Pinus strobus*, *Quercus rubra*, *Tilia americana* and *Tsuga canadensis.* The understory is composed of the species that occur in the canopy as well as *Ostrya virginiana* with no clear dominants. The shrub and herb layer are relatively sparse. One herb noted is *Oryzopsis asperifolia*. One other macrolichen seen at this site was *Myelochroa galbina* (smooth axil-bristle lichen).

Habitat trends

All known populations (historical and extant) of *Physconia subpallida* in Ontario occur in or within 125 km of the Eastern Ontario Model Forest (EOMF). The EOMF consists of the eastern part of Ontario east of and including Lanark County and the United Counties of Leeds and Grenville. Forested areas within this region drastically decreased with European settlement in the 1800s. By 1880 forest cover had been reduced to less than 30% in at least half of the townships in this region with some townships having less than 10% forest cover (Keddy 1994). All known historical collections of *P. subpallida* were made around this time period (from 1868 to 1902; Table 2). Since this time forest cover has increased slightly with forested areas (including forested wetlands) covering approximately 34% of the land in the late 1900s (Keddy 1994; Rowsell 2005). The current distribution of forest cover within the EOMF is not uniform and occurs primarily in the west-central part (where the two extant Ontario *P. subpallida* locations [Billa Lake and Arcol Road] occur; Rowsell 2005). The Ottawa region (where two historical populations are known) is currently a large metropolitan area with the population of the city of Ottawa growing from about 101,000 in 1901 to 704,000 in 2001 (City of Ottawa 2009). Belleville and Brighton (the other known historical locales) are currently small cities with populations in 2006 of about 49,000 and 10,000 respectively (Statistics Canada 2008). Therefore, while overall forest cover in southern Ontario has remained stable or increased slightly since the early 1900’s the urban areas where all four historical populations are known have increased in size resulting in a loss of forest cover in these areas.

Prior to the 1970s southern Ontario was exposed to particularly high levels of atmospheric pollution including acidifying rain as a result of high levels of sulphur dioxide and nitrates. Southern Ontario and Quebec have been particularly exposed to high sulfate and nitrate deposition (Whelpdale and Barrie 1982). High levels of SO_2 appear to be toxic to *Physconia subpallida* (see limiting factors and threats section). In addition, because this lichen appears to require tree bark with a relatively high pH it is particularly susceptible to habitat destruction by acidifying air pollution. Although trees with a naturally high pH bark could initially buffer some of the acidifying effects of acid rain, over time, acid rain leaches cations from surface bark, resulting in bark acidification (Farmer *et al.* 1991). This lower buffering capacity of tree bark relative to rock and soil substrates explains the long-term emphasis on epiphytes as pollution indicators (e.g., Hawksworth and Rose 1970). In addition, higher bark pH would not necessarily negate direct toxic effects of SO_2 (Van Herk 2001). Long-term acidification of bark leads to an effective shift in the pH gradient available with bark of trees becoming more acidic overall resulting in a decrease in suitable habitat for epiphytes requiring higher pH bark. Therefore, even though the amount of forest cover in southern Ontario appears to have at least remained stable during the early part of the 20th century it appears that overall suitable habitat declined during this time period as a result of atmospheric pollutants. Within southern Ontario, the Ottawa region has had long-term deposition levels that are about half of the values of more westerly sites such as Windsor, Mississauga, Toronto, and Hamilton (Ontario Ministry of the Environment 2007) and therefore the existence of extant *P. subpallida* populations in this area may be more likely for this reason.

Since the early 1970s these pollutants have been reduced dramatically in southern Ontario but still are high relative to other parts of Canada. Therefore, suitable habitat for *Physconia subpallida* may be increasing. Still, the legacy of high levels of these pollutants may still be reducing habitat as a result of acidified tree bark.

BIOLOGY

Genetic description

There has been no genetic work done specifically with *Physconia subpallida*. Recent work on mating systems of other lichen fungi suggests that both self-fertile and obligate out breeding taxa exist with the latter being far more common (Honegger and Zippler 2007). Although in many lichens the formation of apothecia is closely linked to thallus size (Honegger and Zippler 2007), Cleavitt & Werier also found large thalli of *P. subpallida* without apothecia (e.g., Figure 1, right). The importance of the two different growth forms (apotheciate with appressed flattened lobules vs. non-apotheciate with dense erect cylindrical lobules) of this lichen deserves further investigation in terms of their reproductive and ecological significance.

Life cycle and reproduction

Physconia subpallida can reproduce in various ways. When individuals have apothecia, sexually reproduced fungal ascospores are present. Individuals with pycnidia can form asexually produced fungal spores called conidia. The conidian, when they play a role in the sexual reproduction of the fungus, are sometimes termed spermatia (Brodo *et al.* 2001; Hinds and Hinds 2007). Thallus formation by ejected ascospores requires, in all but a few genera, that the spores germinate and make contact with a compatible photobiont (algal partner). Little is known about this process in nature, although the process has recently been observed by transplanting axenically grown mycobionts into natural environments (Etges and Ott 2001).

Physconia subpallida lacks soredia and isidia but often has lobules which may function as a means of asexual reproduction, via their dispersal. The role of lobules in asexual reproduction by *P. subpallida* needs further investigation. The lobules are larger and heavier than isidia or soredia and might therefore only be effective for maintaining the lichen within a site rather than contributing to colonization of new sites. If the lobules are not functional propagules, then this lichen may be limited to reproducing via spores and to re-establishing the mycobiont-photobiont relationship for every colonization event. However, the relative effectiveness of various means of reproduction remain unknown in this lichen by either spores or lobules.

At the Billa Lake population one out of 19 thalli had apothecia and at the Arcol Road population five out of 26 thalli had apothecia. All specimens had either flattened or erect cylindrical lobules and some had pycnidia. Significantly more of the historical herbarium specimens had apothecia than the field measured specimens ($X^2 = 62.8$, $p < 0.001$). This may represent collector bias indicating that thalli with apothecia were preferentially chosen for specimens. Thallus size was not a good predictor of apothecia presence for this lichen ($p > 0.50$).

Physiology and adaptability

Given recent studies of regenerative structures in lichens it seems possible that the lobules on the thallus surface of *P. subpallida* may serve a function in increasing the surface area and boundary layer for gas exchange and water relations (Ott *et al.* 1993; Tretiach *et al.* 2005). The pruina of *P. subpallida*, as in other lichens, are made up of calcium oxalate crystals (Giordani *et al.* 2003). Presence of calcium oxalate crystals increases the wettability of the thallus (Hauck *et al.* 2008), and may also function as a means of water storage (Clark *et al.* 2001). In several *Physconia* spp. the pruina were found to be bi-pyramidal crystals of di-hydrated weddelite in which the water molecules can leave the crystals over time as they are dried (Giordani *et al.* 2003). The deposition of pruina is dependent on availability of calcium from the substratum or exposure to oxidative stress and is at least partially controlled by the mycobiont. In lichens, calcium oxalate is derived from oxalic acid which is a by-product of the mycobiont (Giordani *et al.* 2003). Pruina may also function in increasing the reflectivity of the thallus. Dense pruina are characteristic of *P. subpallida* and the importance of calcium ion availability for calcium oxalate crystal formation probably reflects the restriction of this lichen to substrata, the bark of which contains sufficient calcium and a high pH.

Dispersal and migration

Dispersal of this lichen is achieved by spores and possibly also lobules, although the role of either form of reproduction of the lichen is not established. Because of their size, lobules may mainly contribute to within site persistence (short-range dispersal). Therefore, establishment of new populations may be limited to spore dispersal and re-lichenization. Re-lichenization of mycobionts has recently been shown to be sensitive to environmental conditions even for common lichens (Hilmo and Ott 2002). In addition, with increased forest fragmentation, near some historical sites such as Belleville, Brighton, and Ottawa, *Physconia subpallida* may be faced with longer dispersal distances between suitable habitats than in the past.

Interspecific interactions

Nothing is known about competitive interactions of *P. subpallida*. The lichen was found growing with at least 30 different epiphyte species (Table 5). Thirteen of these epiphytes (four mosses, three liverworts, and six macrolichens) were found growing with *P. subpallida* at more than one population (Table 5). Cleavitt and Werier often found the lichen growing over bryophytes, both on the tree boles and in herbarium specimens, although it also occurs on bare bark of hardwood trees. The role of interspecific interactions is unknown, but comparison of associated lichen from historical herbarium specimens and present day populations suggests that the lichen has always grown in close association with other epiphytes.

POPULATION SIZES AND TRENDS

Sampling effort and methods

In October of 2007, Cleavitt and Werier spent six days and examined 14 sites while searching for this lichen in southern Ontario (solid circles Figure 3, and Table 6). At or near historical locations as much forested habitat as possible was visited. In between historical locations focus was placed on older, mature, mesic forests as well as forests with an abundance of *Ostrya virginiana* trees. While suitable habitat (mature mesic forested habitat with at least some *Ostrya virginiana*) was available at all of these sites including some old growth mesic forests (Billa Lake site, Mark S. Burnham Provincial Park, Presqu'ile Provincial Park) *Physconia subpallida was found* at only two sites. One site, Billa Lake, was already known to be extant. The other *P. subpallida* site, Arcol Road, was a "new" population but is only 30 km in straight-line distance from the Billa Lake site.

Table 6. Summary of presence of five *Physconia* spp. at visited field sites and in CANL collections.

Site name	*Physconia* spp.				
	detersa	***enteroxantha***	***leucoleiptes***	***perisidiosa***	***subpallida***
Mud Lake Natural Area	X				
Clayton Lake			X		
Billa Lake*	X		X		X
Frontenac Prov. Park	X	X	X	X	
Lemoine Point Cons. Area		X			
Parrots Bay Cons. Area	X				
Point Petre Prov. Wildlife Area	(no *Physconia* spp. recorded for this site.)				
Presqu'ile Prov. Park	X				
Mark S. Burnham Prov. Park	X	X	X	X	
Kawartha Highlands Prov. Park (two adjacent sites)	X		X		
Bon Echo Prov. Park	X		X	X	
Buck Shot Lake Road*	X	X	X	X	
Arcol Road	X	X	X	X	X
Charleston Lake Prov. Park*	X		X		
Herbarium collections for southern Ontario at CANL	41	11	30	29	7

* Note: Determinations returned by Ted Esslinger also indicate the presence of *Physconia grumosa* Kashiw. & Poelt, which has not been formerly published as present in North America, but is known by Ted Esslinger (personal communication) from other sites in eastern North America.

Abundance

Of the six (see notes under "Canadian range" section) known Canadian populations, only two (Billa Lake and Arcol Road) are currently known to be extant (Table 2). In 2007, the Billa Lake population covered an area approximately 3.8 ha in size. Within this area *P. subpallida* was found on only eight trees with a total of 164 cm^2 of thallus area. Rob Lee, who was present in both 2004 and 2007, indicated that a few thalli that had been photographed in 2004 were not found during the 2007 site visit. The Arcol Road population was found to cover an area of approximately 7.0 ha in size. Within this area *P. subpallida* were harboured on only eight trees with a total thallus area of 191 $cm^{2.}$.

Physconia subpallida thalli appear to occur with low frequency and cover even at localities where populations are known to be present. At and close to both the Billa Lake and Arcol Road sites hundreds of *Ostrya virginiana* trees were searched but only a total of 16 trees harboured *P. subpallida*.

The four other *Physconia* lichens Cleavitt and Werier found in southern Ontario (*P. detersa, P. enteroxantha, P. leucoleiptes,* and *P. perisidiosa*) were all more common than *P. subpallida* based on our collections and specimens of *Physconia* for southern Ontario at CANL (Table 5) but *P. subpallida* is at the northern edge of its range in southern Ontario.

Fluctuations and trends

This lichen appears to have undergone a decline throughout its North American range. Even with numerous lichenologists active in eastern North America over the past several decades (see search effort section), only four of the 27 known populations (some collected as early as 1862) have been seen in the past 35 years and only seven populations have been seen in the past 50 years. In 2000, an annual foray including many northeastern lichenologists was held in northwestern Vermont (an area with three historical occurrences of *P. subpallida*) and no observations of *P. subpallida* were made even though the visited sites included an old-growth forest stand (Hinds *et al.* 2002).

In Canada, the lichen appears to have undergone a decline. Out of the six known Canadian populations (Table 2; Figure 2) only two are currently believed to be extant. The two populations known from the Ottawa region have not been found after extensive lichen field work in the Ottawa region over the past 40 years (I. Brodo personal communication). The Brighton and Belleville populations were not relocated and are believed to be extirpated. The Belleville area was also searched by I. Brodo while looking for the lichen *Xanthoria parietina* without finding *P. subpallida* (Brodo *et al.* 2007). These areas have undergone large scale habitat destruction in the past century due to urbanization and atmospheric pollution and therefore these historical populations have likely become extirpated as well.

The Arcol Road population was first found in 2007 and it remains unclear whether this population is stable. However, individuals of *P. subpallida* at this site appeared healthy (i.e. they did not show necrotic patches or significant signs of decay). The Billa Lake population appears to have remained stable between its discovery by Rob Lee in 2004 and the field survey in 2007 (R. Lee personal communication; comparison of three thalli using photos from 2004). Three years is a short time to assess population stability and further survey work is needed to more accurately assess this site.

Trends in thallus size were examined by Cleavitt and Werier for the 2007 report. The size of 76 thalli from herbarium specimens representing 22 populations as well as the living specimens observed in the field was measured (see Appendix 1, where the herbarium specimens that were measured are marked by an asterisk). An estimate of the area of thalli from herbaria was determined by multiplying the length times the width of each thallus. This calculation was used because many specimens were close to rectangular. Given that most of the specimens were not perfect rectangles, these measurements are approximations. Most of the thalli measured appeared to be fragments from larger thalli. Some of these fragments were probably broken during herbarium mounting and do not represent the original thallus size. Overall, herbarium specimen thalli range from 0.8-26.4 cm^2 with a mean of 7.4 ± 5.1 cm^2. Specimens that had information regarding their year of collection were graphed based on the year they were collected (a total of 67 thalli from 18 locations). Based on these measurements thallus size appears to have significantly decreased over time (Figure 6). However, the thallus size estimates of herbarium specimens may not be comparable with thallus size determinations of living individuals *in the field*. Two main reasons for this are: 1) most of the thalli from herbarium specimens appeared broken or incomplete and 2) herbarium collecting may be biased toward choosing larger thalli. The first source of bias would suggest that the decrease in thallus size may be greater than expressed by values in Figure 6, because these are largely measurements on thallus fragments. The second source of bias would likely hold true over time and should not affect the pattern shown in Figure 6. Decreases in both thallus size and fertility of lichens in response to pollution have been well documented in Europe (e.g. early review by Hawksworth *et al.* 1973).

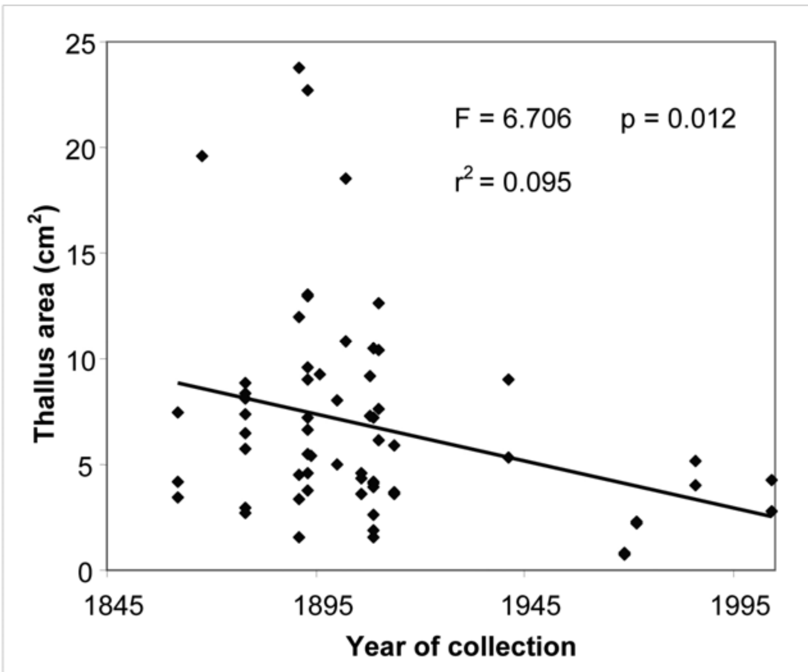

Figure 6. Decline in the size of thalli based on measurements from herbarium specimens of *Physconia subpallida* (specimens that were plotted are marked by an asterisk in the collections examined section [excluding specimens that lack year information]).

Rescue effect

Rescue effect from more southern populations does not seem probable because the nearest of the two recent collections from the U.S. are approximately 500 km from the border. There are numerous other historical U.S. populations that are relatively close to the border but these populations have not been seen in at least 40 years. It is possible that some populations in the U.S. close to the border of Canada are still extant but given that this area has had active lichenologists working there for the past several decades (see search effort section) it is likely that *P. subpallida* is no longer extant in this region or is extremely rare, making dispersal opportunities limited. Maintenance of the lichen within Canada will rely heavily on the preservation of the two known populations.

THREATS AND LIMITING FACTORS

Since the 1970s, sulfur dioxide (SO_2) has been having toxic effects on epiphytic lichens through suppression of photosynthesis and respiration (e.g., Beekley and Hoffman 1981). Beekley and Hoffman (1981) found that of four foliose lichens examined, "*Physconia grisea*" collected from bark of *Populus deltoides* had the greatest suppression of photosynthesis following an SO_2 fumigation treatment. Beekley and Hoffman's "*P. grisea*" was likely one or more of the North American sorediate *Physconia* spp. During the early 1970s in Europe, lichens that had fidelity to particular limits of SO_2 pollution were chosen as indicator lichens (Hawksworth and Rose 1970; Johnsen and Søchting 1973; Turian and Desbaumes 1975). Two European *Physconia* lichens, *P. grisea* and *P. distorta* (as *P. pulverulenta*), were chosen as indicator species for semi-sensitive and extremely sensitive species, respectively. Of the two lichens, *P. distorta* is most closely related to *P. subpallida* based on morphology and both are listed in the series (clade) *Pulverulentae*, although *P. subpallida* was not included in the molecular data (Cubero *et al.* 2004). Indeed, prior to description of *P. subpallida* as a distinct North American lichen by Esslinger (1994), both were referred to as *P. distorta.*

Physconia distorta has been shown in several studies to completely disappear from areas with winter mean annual SO_2 concentrations above 40 ųg m^{-3} (Hawksworth and Rose 1970; Johnsen and Søchting 1973). In addition at lower SO_2 concentrations, Søchting and Ramkaer (1982) noted that *P. distorta* "tends to form many small adventitious lobes in the central part of the thallus" in areas where it is still present, but in decline. *Physconia distorta* also shows decrease in presence of apothecia, which is also interpreted as a response to SO_2 toxicity (Søchting and Ramkaer 1982).

Prior to 1971 *Clean Air* regulations, the mean annual average SO_2 levels in Ontario were well above the provincial critical level of 55 ųg m^{-3} (approx. 20 ppb) (Ontario Ministry of the Environment 2007, 2008), which is also above the 40 ųg m^{-3} concentration at which sensitive *Physconia* lichens have been shown to disappear in Europe (Hawksworth and Rose 1970; Johnsen and Søchting 1973). In response to increased emission regulation during the 1970s, the SO_2 emissions in Ontario and throughout eastern North America decreased dramatically, and in Ontario there has been an 88% reduction in mean annual SO_2 emissions between 1971 and 2006 (Ontario Ministry of the Environment 2007). Although air quality has much improved in the province, Ontario continues to have the highest SO_2 concentrations in Canada and 80% of this SO_2 is emitted by point sources (e.g. smelters and electricity generating plants; Ontario Ministry of the Environment 2007). In addition, episodes of elevated SO_2 levels in the air may still occur when weather systems from more polluted mid-western states in the U.S. stall over southern Ontario (Ontario Ministry of the Environment 2007).

Even with lower present day SO_2 concentrations, the legacy of leaching of base cations from tree bark surfaces (especially calcium, Ca) and acidification of the bark surfaces will most probably hinder re-colonization by sensitive lichens (Bates *et al.* 1990; Batty *et al.* 2003) producing a lag in recovery such as that documented for larger scale forest recovery in southern Ontario (Watmough and Dillon 2003; Watmough *et al.* 2005). In addition, bark Ca content is closely related to soil Ca availability, and loss of Ca from soils in southern Ontario forests could have long-term implications for epiphytes with high requirements for Ca such as *P. subpallida*, (Bates 1992). The germination of ascospores of the closely related European lichen, *Physconia distorta*, is inhibited by elevated SO_2 (Belandria *et al.* 1989).

In addition to the known SO_2 pollution sensitivity of the closely related *P. distorta* in Europe, *P. subpallida* has several morphological traits that suggest sensitivity to SO_2. Hauck *et al.* (2008) outlined several traits that lead to increased SO_2 sensitivity in lichens based on the demonstrated correlation between wettability of the thallus surface and sensitivity to SO_2 toxicity. Lichens that absorb water droplets more readily (hydrophilic) tend to be more sensitive to SO_2 concentrations. One *Physconia* lichen, *P. grisea* is very hydrophilic, and although this lichen may withstand higher SO_2 levels on calcareous soil and rock, it has disappeared from trees in many high SO_2 areas (Hauck *et al.* 2008). All three lichen traits that increase the hydrophilic nature of the thallus are present in *P. subpallida*, namely presence of pruina, corticated thallus surface lacking soredia, and lack of secondary lichen substances (Hauck *et al.* 2008).

Patterns of SO_2 deposition within a forest stand are heterogeneous with taller trees and trees closer to the forest edge (especially on the windward side) receiving higher deposition than subcanopy and interior trees (Erisman and Draaijers 2003). This may partially explain why the two known populations of *P. subpallida* occur only on subcanopy *Ostrya* in a largely forested portion of the province. Apart from the single lane dirt road near the Arcol road population, both populations were surrounded by continuously forested landscape.

In addition to the SO_2 sensitivity of *P. subpallida*, this lichen is also limited by its requirement for a humid, but not saturated environment (Hauck *et al.* 2008). Relative humidity in a forest stand is a significant predictor of occurrence for two highly pruinose western species of *Physconia*, *P. americana* and *P. perisidiosa* (Jovan 2003). These two lichens peak in their occurrence in forest stands with average humidity levels between 45%-65%. Therefore, forest practices that reduce relative humidity (perhaps below an average of 50%) may have negative impacts on *P. subpallida*.

Other changes in southern Ontario forests that may have led to the apparent decline of *P. subpallida* in this region and throughout its range include forestry practices, land clearing and forest fragmentation, and decline of the American elm (*Ulmus americana*). Historically, large long-lived individuals of lichen of importance to *P. subpallida* were more common in southern Ontario such as *Ulmus* spp. and *Ostrya virginiana* (Leadbitter *et al.* 2002). Elm species are regarded as critical habitat for *Physconia* lichens at their northern ranges limits in Norway and Sweden (Fritz 2008; Tønsberg et al 1996). Available studies including epiphytes of American elm in Ontario and nearby US locations are limited and include mention only of “*Physconia grisea*”, a lichen now understood not to occur in North America (Mahoney 1973; Barclay-Estrup and Sims 1979). However, it seems possible that severe decline of elm in southern

Ontario and elsewhere in the range of *P. subpallida*, which began in the 1930s (1960s in southern Ontario) as the result of Dutch Elm Disease, may have partly contributed to a decrease in suitable habitat for this lichen because it was historically known from this tree species (Table 3).

Currently *Physconia subpallida* is known from only 16 individual trees in two small distinct populations in Canada. A single stochastic disturbance event (i.e. fire, ice storm) of even a small size could potentially kill a large portion of the trees where individuals occur thereby having a large impact on the lichen's presence and possibly its viability in Canada. The four populations of *P. subpallida* known only from historical collections (Ottawa, Britannia, Brighton, and Belleville) occur in areas that have undergone habitat destruction and development in the past century. Therefore, much of the necessary habitat for the lichen in these areas is presently absent.

Neither of the two extant locations in Canada (Arcol Road and Billa Lake) is currently protected as they occur on unprotected Crown land. Therefore this lichen's location in Canada is currently open to extirpation by logging and land development.

Although the factors limiting this lichen in Canada or throughout its range are not definitive it is clear that this lichen is quite rare both in Canada and throughout its range with a total of only 27 populations known globally with only four of these (two from the United States and two from Canada) having been documented in the past 35 years. The status of the two US populations is unknown but the Canadian populations represent specimens from only 16 trees total. Southern Ontario is at the north edge of the range of the lichen.

PROTECTION, STATUS, AND RANKS

Legal protection and status

There is currently no legal protection for *Physconia subpallida* populations in Canada.

Non-legal status and ranks

The lichen has been assigned a provincial conservation status rank (S-rank) of S1 (critically imperiled) in Ontario (M. Oldham personal communication). In the New England states, this lichen has been given the regional conservation status rank (R-rank) of SH (no specimens known since 1950 in New England; Hinds and Hinds 2007). The lichen has yet to be ranked by NatureServe but has been given the global conservation status rank (G-rank) of G3 (uncommon worldwide [21-100 sites] or threatened because some factor makes it vulnerable to decline, such as sensitivity to air pollution or dependence on old-growth forests) by Hinds and Hinds (2007).

Habitat protection and ownership

Both extant populations in southern Ontario occur on unprotected Crown land. There are no known populations in Canada on protected lands.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

Robert Lee and Jennifer Doubt aided with visiting the Billa Lake population. Jennifer Doubt also hosted us while we were in the Ottawa area and helped with the loan from CANL (including scans of many label packets for location information in Figure 5) and visitation of the "Britannia" area in Ottawa. Irwin Brodo was helpful in discussions of field characters, with searches for the lichen in Algonquin Provincial Park, and in providing information on collecting locales of Pak Yau Wong. Suzanne Mills provided a night of housing in Kingston, ON. Chris Lewis conducted further searches for the lichen in Algonquin Provincial Park (note that his previous report of *P. subpallida* from Algonquin Provincial Park was later revised to *P. perisidiosa*). Ted Esslinger was helpful throughout report preparation including many email communications and verification of *Physconia* collections made during the Ontario fieldwork. Richard Harris examined the lichen collections at NY. Douglas Ladd examined one specimen of *P. subpallida* from US. The Bailey Hortorium (BH) provided workspace with dissecting microscopes and Robert Dirig of CUP-L assisted with loan requests. The curators of COLO, F, FH, MICH, MIN, and WIS graciously sent specimen loans. Irwin Brodo, Bill Crins, Linda Ley, Janet Marsh, Mike Oldham, and Michele Piercey-Normore reviewed drafts of this paper and provided valuable comments.

Authorities consulted

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Robert E. Lee, discoverer of the Billa Lake population, Independent naturalist, White Lake, ON, Canada.

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Natalie Cleavitt is a Research Associate in the Department of Natural Resources at Cornell University. Her Ph. D. thesis was focused on an ecological comparison of rare and common moss species and she has a long-term interest in bryophyte and lichen conservation. She is the current U.S. representative to the IUCN bryophyte conservation committee and has served on the COSEWIC bryophyte and lichen subcommittee since 2003. She has been increasingly interested in macrolichen ecology beginning with a project looking at the effects of acidic fogs on epiphytic macrolichens and bryophytes in Acadia National Park, Maine.

David Werier is a Botanical and Ecological Consultant with an undergraduate degree in Biology from SUNY, Buffalo. He primarily focuses on conservation and taxonomy of tracheophytes. He has also studied macrolichen identification and ecology for the past 15 years and has made some important contributions to our understanding of macrolichen distributions in eastern North America. He currently serves on the board of the New York Flora Association, attends the annual New York rare plant status meetings, and is a co-author of the online New York Flora Atlas.

COLLECTIONS EXAMINED

Specimens of *Physconia subpallida* were sought by the authors from CUP-L, CANL, COLO, F, FH, MICH, MIN, and WIS. At herbaria where Theodore Esslinger had not previously annotated specimens to *P. subpallida* Cleavitt & Werier examined all specimens labelled as *P. subpallida* as well as names that have been misapplied to this taxon. In addition, Richard Harris (personal communication) examined specimens of *P. subpallida* from NY and Douglas Ladd (personal communication) examined one specimen of *P. subpallida* from US. Below is a list of all specimens of *P. subpallida* known to the authors. Specimens examined by the authors are indicated with "!", by Richard Harris with "Harris!", and by Douglas Ladd with "Ladd!"

Canada: ONTARIO: Frontenac Co.: Arcol Road, 1.6 miles N from intersection with Shore Estates lane, N of Canonto Conservation Area, on *Ostrya virginiana*, 6 October 2007, *Nat Cleavitt & David Werier 55* (HERB. ESSL.!), *Nat Cleavitt & David Werier 56* (CANL!); Arcol Road, 1.0 miles N from intersection with Shore Estates Lane, N of Canonto Conservation Area, on *Ostrya virginiana,* 7 October 2007, *Nat Cleavitt & David Werier 59* (CANL!); **Hastings Co.:** Belleville, on trees, 17 September 1868, *John Macoun s.n.* (CANL*!); **Lanark Co.:** ["Billa Lake" site] ca. 17 km S of White lake, 25 km

WNW of Carleton Place, old growth sugar maple forest on *Ostrya virginiana* at 3 m, 24 October 2004, *Irwin M. Brodo 31689* (CANL*!); [“Billa Lake” site] south shore of Darling Long Lake, ca. 26.7 km W of Almonte, on *Ostrya virginiana*, 2 October 2007, *Nat Cleavitt & David Werier 8* (CANL!, HERB. ESSL.!); **City of Ottawa:** Britannia, woods south of Britannia, on ash trees, 6 May 1902, *John Macoun s.n.* (CANL*!); Ottawa, on trees, 20 April 1891, *John Macoun 90* (CANL*!); Ottawa, on trees in woods, 16 April 1891, *John Macoun 355* (CANL*!); Ottawa, on trunks and rocks, 16 October 1893, *John Macoun s.n.* (CANL*!); Ottawa, on trunks and rocks, 10 May 1900, *John Macoun s.n.* (COLO*!); **Northumberland Co.:** Brighton, on old rails and trees, 16 October 1893, *John Macoun 194* (CANL*!); Brighton, on trunks, 16 October 1893, *John Macoun 77* (CANL*!); Brighton, on trunks and rails, 16 October 1893, *John Macoun 179* (CANL*!); **USA: ARKANSAS: Newton Co.:** Fallsville, on *Juglans nigra*, July 1954, *M. E. Hale Jr. 3523* (US Ladd!); **ILLINOIS: Menard Co.:** old trees, 1878, *E. Hall s.n*. (F*!); Athens, January 1862, *E. Hall s.n*. (F*!); Athens, 1878, *E. Hall s.n*. (F*!); Athens, [no date], *E. Hall s.n.* (WIS!). **IOWA: Johnson Co.:** 22 March 1896, *T.J. Fitzpatrick s.n*. (F*!); **MASSACHUSETTS: Middlesex Co.:** Cambridge also Ipswich, on hard bark, [no date], *E. Tuckerman 20* (FH*!); Pepperell, elm trunk, 14 August 1909, *L.W. Riddle 551* (FH*!); Pepperell, elm bark, August 1909, *L.W. Riddle 553a* (FH*!); **MICHIGAN: Emmet Co.:** Five Mile Creek area, SW 1/4, Sec. 32, T 36 N, R 6 W, on *Ostrya* 6 ft. from ground level, 15 July 1969, *D.H. Pfister 51* (FH*!); **NEW HAMPSHIRE: Carroll Co.:** Mt. Washington, S of Conway, in valley on Rt. 16, on bark, April 1941, *[P.F.] Scholander & [G.A.] Llano s.n.* (MIN*!, WIS!); **NEW JERSEY: Sussex Co.:** Newton, on limestone, [no date], *G.G. Nearing s.n.* (F*!); **NEW YORK: Essex Co.:** Chilson Lake, July 1899, *Carolyn W. Harris 26* (CUP-L!); **Yates Co.:** Penn Yan, [no date], *S.B. Buckley s.n.* (FH*!); **OHIO: Ashtabula Co.:** Orwell, on *Ulmus americana* bark, 19 January [no year], *E.E. Bogue 728* (FH*!); **Defiance Co.:** Defiance, 1894, *E.L. Fullmer s.n.* (FH*!); **Preble Co.:** Eaton, on dead elm tree 5 ft. from base, 10 April 1914, *Bruce Fink 234* (COLO*!); **OKLAHOMA: Cherokee Co.:** Cookson Wildlife Management Area, along Bolin Hollow Rd. at Jeff Baggett Field, 1.8 mi NE of entrance at headquarters, on *Fraxinus* at edge of seepy limestone glade, 14 April 2004, *R. Harris 48983, 48993, 48996* (NY Harris!); **PENNSYLVANIA: Monroe Co.:** Delaware Water Gap Nat. Rec. Area, six miles SW of Bushkill, high peak NW of Tocks Island, on peak with limestone in forest of oaks, hickory, ash, and basswood, elevation 860 ft., 5 August 1986, *Clifford M. Wetmore 56259* (MIN*!); **VERMONT: Rutland Co.:** Mountains N of Middletown Spa, 18 June 1909, *S.H. Burnham s.n.* (CUP-L!, FH*!); **Chittenden Co.:** Bernard, on trees, July 1906, *H. Clapp s.n.* (FH*!); Charlotte, Mt. Philo, on shaded boulders, August 1908, *L.W. Riddle 347* (FH*!); Malletts Bay, Lake Champlain, on elm, 21 March 1910, *D.B. Griffin 77* (FH*!); **VIRGINIA: Madison Co.:** Shenandoah National Park, S slope of Hawksbill Mt. from upper Hawksbill overlook to summit, mixed oak deciduous habitat, 29 March 1972, *Robert S. Egan 4235* (MIN*!); Stony Man, hardwood (mostly white oak) forest, 3700-4011 ft., 19 September 1967, *H.A. Imshaug 38562* (NY Harris!).

Appendix 1. Thallus size of herbarium and field measured specimens

The size of 45 (19 from Billa Lake and 26 from Arcol Road) thalli from two populations observed in the field and 76 thalli from 22 populations from herbarium specimens were measured. Herbarium specimens that were measured are marked by an asterisk in the collections examined section. The approximate size of thalli was calculated by multiplying the length times the width of each thallus. This calculation was used because many specimens were close in shape to a rectangle. Still, because most of the specimens were not perfect rectangles, these measurements should be seen as approximations. Most of the thalli measured appeared to be fragments. At least some of these fragments were probably broken during processing and do not accurately represent the original thallus size. Overall, thalli range from 0.1-44 cm^2 with a mean of 7.6 ± 7.9 cm^2. Field measured thalli range from 0.1-44 cm^2 with a mean of 7.9 ± 11.3 cm^2. Herbarium specimen thalli range from 0.8-26.4 cm^2 with a mean of 7.4 ± 5.1 cm^2.

Province/state	Site	Herbarium specimen or field observed	Thallus replicate	Year of collection or field observation	Size (cm^2)
IO	Johnson County	specimen	1	1896	9.24
MA	Cambridge	specimen	1	unknown	13.68
MA	Cambridge	specimen	2	unknown	11.47
MA	Cambridge	specimen	3	unknown	11.73
MA	Cambridge	specimen	4	unknown	3.75
MA	Pepperell	specimen	1	1909	10.5
MA	Pepperell	specimen	2	1909	3.9
MA	Pepperell	specimen	3	1909	4.08
MA	Pepperell	specimen	4	1909	4.14
MA	Pepperell	specimen	5	1909	7.2
MA	Pepperell	specimen	6	1909	1.9
MI	Five Mile Creek	specimen	1	1969	0.8
MI	Five Mile Creek	specimen	2	1969	0.77
NH	S of Conway	specimen	1	1941	9
NH	S of Conway	specimen	2	1941	5.32
NJ	Newton	specimen	1	unknown	7.68
NJ	Newton	specimen	2	unknown	7.98
NJ	Newton	specimen	3	unknown	7.44
NY	Penn Yann	specimen	1	unknown	9.92
OH	Athens	specimen	1	1862	4.16
OH	Athens	specimen	2	1862	3.45
OH	Athens	specimen	3	1862	7.44
OH	Athens	specimen	4	1878	8.84
OH	Athens	specimen	5	1878	6.48
OH	Athens	specimen	6	1878	8.1
OH	Athens	specimen	7	1878	8.4
OH	Athens	specimen	8	1878	5.76
OH	Athens	specimen	9	1878	7.36
OH	Athens	specimen	10	1878	6.44
OH	Athens	specimen	11	1878	7.4
OH	Athens	specimen	12	1878	2.7
OH	Athens	specimen	13	1878	2.97
OH	Defiance	specimen	1	1894	5.4
OH	Eaton	specimen	1	1914	5.92
OH	Eaton	specimen	2	1914	3.6
OH	Eaton	specimen	3	1914	3.68
OH	Orwell	specimen	1	unknown	26.4
OH	Orwell	specimen	2	unknown	7.68
ON	Arcol Road	field	1	2007	4.14

Province/state	Site	Herbarium specimen or field observed	Thallus replicate	Year of collection or field observation	Size (cm^2)
ON	Arcol Road	field	2	2007	1.8
ON	Arcol Road	field	3	2007	5.04
ON	Arcol Road	field	4	2007	2.94
ON	Arcol Road	field	5	2007	1.44
ON	Arcol Road	field	6	2007	0.36
ON	Arcol Road	field	7	2007	0.09
ON	Arcol Road	field	8	2007	6.25
ON	Arcol Road	field	9	2007	1.44
ON	Arcol Road	field	10	2007	0.88
ON	Arcol Road	field	11	2007	0.78
ON	Arcol Road	field	12	2007	2.4
ON	Arcol Road	field	13	2007	6.2
ON	Arcol Road	field	14	2007	2.1
ON	Arcol Road	field	15	2007	34
ON	Arcol Road	field	16	2007	38.5
ON	Arcol Road	field	17	2007	17.5
ON	Arcol Road	field	18	2007	1.54
ON	Arcol Road	field	19	2007	3.3
ON	Arcol Road	field	20	2007	4.35
ON	Arcol Road	field	21	2007	11.05
ON	Arcol Road	field	22	2007	0.36
ON	Arcol Road	field	23	2007	7.5
ON	Arcol Road	field	24	2007	4.29
ON	Arcol Road	field	25	2007	2.3
ON	Arcol Road	field	26	2007	30
ON	Belleville	specimen	1	1868	19.61
ON	Billa Lake	field	1	2007	5.04
ON	Billa Lake	field	2	2007	5.6
ON	Billa Lake	field	3	2007	8
ON	Billa Lake	field	4	2007	4.5
ON	Billa Lake	field	5	2007	4.5
ON	Billa Lake	field	6	2007	2.04
ON	Billa Lake	field	7	2007	1
ON	Billa Lake	field	8	2007	0.35
ON	Billa Lake	field	9	2007	4.5
ON	Billa Lake	field	10	2007	2.5
ON	Billa Lake	field	11	2007	1.17
ON	Billa Lake	field	12	2007	0.72
ON	Billa Lake	field	13	2007	36
ON	Billa Lake	field	14	2007	4
ON	Billa Lake	field	15	2007	44
ON	Billa Lake	field	16	2007	6
ON	Billa Lake	field	17	2007	25
ON	Billa Lake	field	18	2007	8.05
ON	Billa Lake	field	19	2007	1.32
ON	Billa Lake	specimen	20	2004	2.76
ON	Billa Lake	specimen	21	2004	4.25
ON	Brighton	specimen	1	1893	13
ON	Brighton	specimen	2	1893	7.2
ON	Brighton	specimen	3	1893	5.51
ON	Brighton	specimen	4	1893	6.6
ON	Brighton	specimen	5	1893	3.8
ON	Brighton	specimen	6	1893	4.56
ON	Brighton	specimen	7	1893	22.68
ON	Brighton	specimen	8	1893	12.92
ON	Britannia	specimen	1	1902	18.49
ON	Britannia	specimen	2	1902	10.8
ON	Ottawa	specimen	1	1900	8
ON	Ottawa	specimen	2	1900	5

Province/state	Site	Herbarium specimen or field observed	Thallus replicate	Year of collection or field observation	Size (cm^2)
ON	Ottawa	specimen	3	1893	4.6
ON	Ottawa	specimen	4	1893	9.02
ON	Ottawa	specimen	5	1893	9.62
ON	Ottawa	specimen	6	1891	23.76
ON	Ottawa	specimen	7	1891	12
ON	Ottawa	specimen	8	1891	4.5
ON	Ottawa	specimen	9	1891	3.4
ON	Ottawa	specimen	10	1891	1.54
PA	Delaware Water Gap	specimen	1	1986	3.99
PA	Delaware Water Gap	specimen	2	1986	5.13
VA	Hawksbill Mt.	specimen	1	1972	2.21
VA	Hawksbill Mt.	specimen	2	1972	2.28
VT	Bernard	specimen	1	1906	3.6
VT	Bernard	specimen	2	1906	4.6
VT	Bernard	specimen	3	1906	4.37
VT	Charlotte	specimen	1	1908	9.2
VT	Charlotte	specimen	2	1908	7.26
VT	Malletts Bay	specimen	1	1910	10.4
VT	Malletts Bay	specimen	2	1910	6.15
VT	Malletts Bay	specimen	3	1910	12.65
VT	Malletts Bay	specimen	4	1910	7.6
VT	Middletown Spa	specimen	1	1909	1.53
VT	Middletown Spa	specimen	2	1909	2.6

Appendix 2. Table of field work completed for this report

Date	Place	Purpose	***P. Subpallida*?**
2 Oct	Mud Lake, Ottawa	Field searching for historical Britannia and Ottawa populations	No
2 Oct	Billa Lake	Field survey of known extant population with Robert Lee and Jennifer Doubt	Yes; 19 thalli on 8 *Ostrya virginiana* trees only 1 with apothecia
3 Oct	Frontenac Provincial Park, Canoe Lake Rd. Access	Field searching for new populations	No
4 Oct	LeMoine Point Conservation Area	Field searching for historical Belleville population	No
4 Oct	Parrots Bay Conservation Area	Field searching for historical Belleville population	No
4 Oct	Point Petre Provincial Wildlife Area	Field searching for historical Belleville population	No
4 Oct	Presqu'ile Provincial Park, Jobe's Woods	Field searching for historical Brighton population	No
5 Oct	Presqu'ile Provincial Park	Field searching for historical Brighton population	No
5 Oct	Mark S. Burnham Provincial Park	Field searching for new populations	No
5 Oct	Kawartha Highlands Provincial Park, Anstruther Lk Rd	Field searching for new populations	No
6 Oct	Bon Echo Provincial Park	Field searching for new populations	No
6 Oct	Rte 30 (Buckshot Lake Rd) just south of Little Finch Lake Rd.	Field searching for new populations	No
6 Oct	Arcol Road, north of Canonto Conservation Area	Field searching for new populations	Yes; 16 thalli on 5 *Ostrya virginiana* trees only 4 with apothecia
7 Oct	Arcol Road, north of Canonto Conservation Area	Field searching for new populations	Yes; 10 thalli on 3 *Ostrya virginiana* trees only 1 with apothecia and 1 quite large; this expands population area above
7 Oct	Charleston Lake Provincial Park	Field searching for new populations	No