COSEWIC
Assessment and Status Report

on the

Crumpled Tarpaper Lichen
Collema coniophilum

in Canada

THREATENED
2010

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:

COSEWIC. 2010. COSEWIC assessment and status report on the Crumpled Tarpaper Lichen *Collema coniophilum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 24 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Production note:
COSEWIC acknowledges Trevor Goward for writing the provisional status report on the Crumpled Tarpaper Lichen, *Collema coniophilum*, prepared under contract with Environment Canada. The contractor's involvement with the writing of the status report ended with the acceptance of the provisional report. Any modifications to the status report during the subsequent preparation of the 6-month and 2-month interim status reports were overseen by René J. Belland, COSEWIC Mosses and Lichens Specialist Subcommittee Co-chair.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la collème bâche (*Collema coniophilum*) au Canada.

Cover illustration/photo:
Crumpled Tarpaper Lichen — Photo: Tim Wheeler

Catalogue No. CW69-14/606-2011E-PDF
ISBN 978-1-100-16005-4

Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – November 2010

Common name
Crumpled Tarpaper Lichen

Scientific name
Collema coniophilum

Status
Threatened

Reason for designation
This foliose, tree-inhabiting cyanolichen is endemic to Canada where it occupies a narrow range restricted to trees in old-growth forests on calcareous soils in humid, inland British Columbia. The lichen is poorly adapted for dispersal since it has never been found with sexual reproductive structures and its vegetative propagules are not easily dispersed. The lichen has an apparently declining distribution, resulting from ongoing loss of old-growth forest through clear-cut logging. The factors underlying its rarity and narrow endemism are not well understood.

Occurrence
British Columbia

Status history
Designated Threatened in November 2010.

COSEWIC
Executive Summary

Crumpled Tarpaper Lichen
Collema coniophilum

Wildlife species description and significance

Crumpled Tarpaper Lichen, *Collema coniophilum*, is a distinctive, moderately sized leafy lichen with several broad, mostly rounded lobes, at most 2-4 (-5) mm wide. The smooth upper surface is dark olive green to blackish brown that becomes weakly and sparsely covered in low “blisters” that eventually expand upwards into low broad ridges. Small, blackish, finger-like protrusions are present on the upper surface, and contrast with the upper surface. The lower surface varies from dark olive green to pale olive beige, and sometimes has tufts of tiny white hairs.

Distribution

Crumpled Tarpaper Lichen is currently known to be endemic to Canada. Its core range occupies a small, humid portion of the Rocky Mountain trench, approximately 65 km east of Prince George, though additionally it is known from the Upper Adams River, in the Columbia Mountains, 20 km southeast of Blue River. Biogeoclimatically these regions are located within the wettest, coolest subzones of the Interior Cedar-Hemlock and Sub-boreal Spruce Zone.

Habitat

Throughout its range, Crumpled Tarpaper Lichen appears to be restricted to base-rich or base-enriched trees, including Subalpine Fir, Western Hemlock, Engelmann Spruce and to a much lesser extent Black Cottonwood, Trembling Aspen, and Western Red-Cedar. Its establishment at a given locality is greatly enhanced by, and indeed certainly depends on, nutrient enrichment from any of several sources. This species has been documented only from humid old forests older than about 100 years.

Biology

Crumpled Tarpaper Lichen is a colonist of young twigs. It appears to be an asexual species, reproducing exclusively via coarse granular outgrowths of the upper surface known as isidia. Isidia are too large to be effectively dispersed by wind; and because they have no special mechanism of adhesion, successful long-distance dispersal on the feet of birds is also expected to occur rather rarely. In the event, however, that an isidium does reach a new locality, successful establishment is likely to occur only on nutrient-rich or nutrient-enriched twigs and young branches. Throughout the wettest portions of its geographic range, nutrient-rich twigs and branches are presumably infrequently encountered owing to the leaching effects of heavy precipitation. This greatly reduces this species' frequency of occurrence.

Population sizes and trends

To date, Crumpled Tarpaper Lichen has been documented at only eight localities worldwide, with a total of 170 thalli. Recent attempts to relocate this species at three of these localities have been unsuccessful, notwithstanding that two of them now enjoy legislated protection through the establishment of provincial parks. The third locality has been lost as a result of recent clearcut logging.

At one of the remaining four localities, Crumpled Tarpaper Lichen occurs in rather large numbers, with about 140 thalli observed in 2006. Even here, however, there is evidence of population decline, presumably owing to recent reductions in road traffic, and hence diminished incidences of road dust (see section below).

Threats and limiting factors

To date Crumpled Tarpaper Lichen has been recorded only from old growth forests; it is not known to inhabit younger forest types. This being the case, there can be little doubt that the loss of old growth forests as a result of clearcut logging is causing a corresponding decline in this species, at least under natural conditions. There is evidence, however, that logging activities may actually be promoting Crumpled Tarpaper Lichen at some sites through the artificial creation of nodes of nutrient enrichment in connection with calcareous road dust. Thus the very act of hauling logs to mill seems to favour the establishment of sizable populations of this species. It is doubtful that Crumpled Tarpaper Lichen could accumulate to such numbers – 140 thalli at one locality – under natural conditions. So long as this dust effect persists, and so long as the old growth stands that support Crumpled Tarpaper Lichen at such stands remain intact, the future of this species would seem secure. Unfortunately, there is no easy way to ensure that old forests will be allowed to intersect indefinitely with calcareous gravel roads. What is more, any land use practice that tends, through the loss of old forests, to confine Crumpled Tarpaper Lichen to a small number of artificially enhanced roadside stands clearly jeopardizes this species, e.g., through increased vulnerability to stand-replacing disturbance such as wildfire, disease, insect outbreak, and blow down.

Protection, status and ranks

To date, Crumpled Tarpaper Lichen has received legislated protection at only two of the eight localities at which it has been documented. Unfortunately, it is no longer known to occur at either of these localities. Elsewhere throughout its range it is vulnerable to habitat loss through logging.

TECHNICAL SUMMARY

Collema coniophilum

Crumpled Tarpaper Lichen — Collème bâche

Range of occurrence in Canada (province/territory/ocean): BC

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)	At most 10 yrs, based on presumed age of host twigs.
Is there an [observed, **inferred**, or projected] continuing decline in number of mature individuals?	Yes
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	3218 km²
Index of area of occupancy (IAO)	28 km² (calculated using 2x2 km grid)
Is the total population severely fragmented?	Possibly, but more study required
Number of “locations”	Only 7 extant locations in Canada (where it is globally endemic) of which the presence of the lichen at 2 is unknown
Is there an [observed, **inferred**, or projected] continuing decline in extent of occurrence?	Probably declining, owing mostly to progressive loss of old growth forests
Is there an [**observed**, **inferred**, or projected] continuing decline in index of area of occupancy?	Natural populations probably decreasing. Road dust populations probably stable or decreasing. One site lost to logging.
Is there an [**observed**, **inferred**, or projected] continuing decline in number of populations?	Natural populations probably decreasing. Road dust populations probably stable or decreasing. One site lost to logging.

Is there an [**observed**, inferred, or projected] continuing decline in number of locations?	Declining: Lost 1 site from logging; presence of lichen at 2 others was not confirmed (may be extirpated)
Is there an [**observed**, **inferred**, or projected] continuing decline in [area, extent and/or quality] of habitat?	Certainly declining for natural populations, probably stable for road dust populations. One site lost to logging.
Are there extreme fluctuations in number of populations?	Unknown
Are there extreme fluctuations in number of locations?	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Are there extreme fluctuations in index of area of occupancy?	Unknown

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
See Table 1	
Total	170 mature thalli

Quantitative Analysis

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

Threats (actual or imminent, to populations or habitats)

Natural Populations:

1) Loss of old growth forest as a result of logging.

Road Dust Populations:

1) Reductions in road dust, whether as a result of seal-coating, paving or decreased traffic.
2) Loss of roadside (calcareous) old growth stands as a result of wildfire, insect outbreak, or blowdown.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	N/A
Is immigration known or possible?	N/A
Would immigrants be adapted to survive in Canada?	N/A
Is there sufficient habitat for immigrants in Canada?	N/A
Is rescue from outside populations likely?	N/A

Current Status

COSEWIC: Designated Threatened in November 2010.

Additional Sources of Information:

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** D1
Reasons for designation: This foliose, tree-inhabiting cyanolichen is endemic to Canada where it occupies a narrow range restricted to trees in old-growth forests on calcareous soils in humid, inland British Columbia. The lichen is poorly adapted for dispersal since it has never been found with sexual reproductive structures and its vegetative propagules are not easily dispersed. The lichen has an apparently declining distribution, resulting from ongoing loss of old-growth forest through clear-cut logging. The factors underlying its rarity and narrow endemism are not well understood.	

Applicability of Criteria

Criterion A: Not applicable. Inferred decline suspected, but rate unknown.
Criterion B: Not applicable. Shows neither Severe Fragmentation (a), nor Extreme Fluctuations (c).
Criterion C: May meet criterion for EN C2a(i) but there are uncertainties in continuing decline because of the lack of documented survey effort in some portions of the species range.
Criterion D: Meets criterion TH D1 (total populations < 1000 individuals)
Criterion E: Data not available for PVA.

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
(2010)

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

Collema coniophilum Goward 2010
Division: Ascomycota
Class: Lecanoromycetes
Order: Peltigerales
Family: Collemataceae

Crumpled Tarpaper Lichen, *Collema coniophilum*, was recently described by Spribille *et al.* (2009) from the Bowron Lake area in the Fraser River drainage. The epithet derives from Greek *konis*, dust, and *philos*, loving: a reference to this species' affinity for trees heavily impregnated with (calcareous) road dust. The common name is descriptive.

Sexual fruiting structures (apothecia) are lacking in *Collema coniophilum*, making this species difficult to place with respect to other members of its genus. Based on morphological characters, however, it appears to belong in the *C. cristatum* group: an assemblage of otherwise rock-dwelling (saxicolous) species restricted to the northern hemisphere (Degelius 1954). If this placement is eventually upheld, e.g., through the application of molecular methods, *C. coniophilum* would be the only tree-dwelling member of this group.

Morphological description

Collema coniophilum (Figure 1) is a gel lichen, that is, its photosynthesizing partner, here *Nostoc*, is embedded in a gelatinous matrix distributed throughout the thallus. Thallus leafy, 1.5-2.5 (-3) cm across, loosely appressed to often in part ascending along the margins, bearing several rather broad, mostly rounded lobes, the largest ones 2-4 (-5) mm wide, usually rather thickened toward the tips, and here forming a rim 250-350 µm thick (moist), elsewhere mostly 200-300 µm thick, except thinner in appressed central portions, which often have a distinctly "stretched," membranous appearance; upper surface dark olive green to blackish brown (creamy olivaceous in "stretched" portions), smooth to becoming weakly and sparsely covered in low "blisters" (pustules), these eventually expanding upwards into low broad ridges, and finally into a complex network of narrow folds or "crimps"; isidia present over upper surface, blackish, or at any rate usually distinctly darker than upper surface, coarsely granular, 0.05 to 0.2 mm across, scattered to crowded, extending outwards in patches toward the tips of even young, actively growing lobes, also present over lobe margins; lobe margins plane or more often wavy; lower surface dark olive green to becoming pale olive beige (central portions), lacking rhizines, but occasionally forming tufts of tiny white hairs. Apothecia unknown. Pycnidia occasionally present over upper surface, pale yellowish, 0.15-0.2 mm wide. Conidiospores rod-shaped, 4.5-5 µm x 1.5 µm.

Figure 1. *Collema coniophilum*: Habit. Photo: Tim Wheeler.

Collema coniophilum is a highly variable species in which rapid growth occurs not only in the vicinity of the lobe tips, as in most other lichens, but periodically throughout the thallus. Lateral growth appears to correlate with degree of attachment, with closely appressed portions soon expanding outwards in all directions as a thin pale membrane, thereby causing the "blistered" portions of the upper surface to raft apart. The blisters also continue to grow through the life of the thallus, initially buckling upwards as low ridges, later developing into broad, raised, tarpaulin-like folds. In more loosely attached thalli, on the other hand, the membranous portions are more or less lacking, and the folds, at least at maturity, are more continuous.

Generic description

Collema is a genus of small to medium-sized foliose (rarely crustose) lichens with a non-stratified thallus that usually becomes swollen and gelatinous when moist. The upper surface is dark olive green to brownish black, and appears rather dull, owing to a lack of cortical cells. The lower surface also lacks a cortex, is similar in colour to the upper surface, and often bears either sparse blunt outgrowths (hapters) or tufts of tiny white hairs; these attach the lichen to the supporting surface. Isidia are present in many species, but soredia are lacking. The photobiont consists of a cyanobacterium (*Nostoc*) in the form of pale olive-grey cells 5-7 µm long, these scattered throughout the thallus, and often in part forming loose chains. Apothecia, if present, have a pale brown, reddish brown or blackish brown disc, and are rimmed with a thalline margin. The asci normally contain 8 spores, but this number can vary from only 2 spores to 16 spores, depending on species. The spores themselves also vary greatly, and range from 2-celled to many-celled (muriform). Lichen acids are lacking. Most species colonize base-rich substrates, including soil, rocks and trees in dry to rather moist sites.

Leptogium is similar, but has a shinier, more "compact" upper surface, owing to the presence of a cortex one cell thick. Many *Leptogium* species have a bluish cast, though surface colour can vary from reddish brown to blackish depending on species.

As presently circumscribed, *Collema* is a heterogeneous genus comprised of 22 morphological groupings (Degelius 1974). *Collema coniophilum* appears to belong in the *C. cristatum* group, which itself comprises 7 species, in western North America including *C. cristatum* (L.) F.H. Wigg., *C. fuscovirens* (With.) J.R. Laundon and *C. undulatum* Laurer. All of these species are restricted to the northern hemisphere, and all are common in the west (Goward *et al*. 1994; Brodo *et al.* 2001).

Similar species

Notwithstanding a high degree of variability, *Collema coniophilum* is a rather distinctive species, characterized by its dark olivaceous thallus, its gelatinous interior, its rather broad, thickish lobes often somewhat rimmed at the tips, and its partly "blistered," partly ridged upper surface that usually bears coarse, granular isidia outward to the tips of even rapidly growing lobes. Its closest relative appears to be *C. fuscovirens* (With.) Laundon, in which, however, the lobes are paper-thin throughout and the isidia are restricted to the inner portions of the thallus, being absent from the rapidly expanding lobe tips. That species, moreover, grows directly on rock, whereas *C. coniophilum* is known only from the branches of trees. Also similar are *C. furfuraceum* (Arnold) Du Rietz and *C. subflaccidum* Degel. both of which, however, are easily distinguished by their flatter, more appressed habit, their uniformly thin lobe tips, their lack of any "crimping" over the upper surface, and (again) the absence of isidia at the tips of rapidly growing lobes.

Confusion with *Collema auriforme* derives from the production in both species of granular isidia, as well as from a tendency of the central portions of the thallus to become "stretched" and membranous. *Collema coniophilum* further resembles *C. auriforme* in having strongly swollen lobe tips. In the latter species, however, the upper surface lacks "blisters," and the isidia are confined to ridges over the older portions of the thallus; they rarely occur on appressed portions, and apparently never extend outwards to rapidly growing lobe tips. Unlike *C. coniophilum*, moreover, *C. auriforme* appears to grow exclusively on the ground (Degelius 1954, under *C. auriculatum*).

Designatable units

Only one designatable unit is recognized for the purpose of assessment; the lichen is found in a single ecozone.

Special significance

The status of *C. coniophilum* as endemic to western Canada is exceptional among macrolichens, in which most species have broad, often intercontinental distributions (Ahti 1977). More surprising still, this species' global range appears to lie entirely within a small region of humid old growth forests in inland British Columbia. From these observations it follows that ensuring the long-term well-being of *C. coniophilum* is a uniquely Canadian responsibility.

DISTRIBUTION

Global range

Collema coniophilum appears to be Canadian endemic restricted to humid inland British Columbia (Figure 2). Owing in part to a pronounced physiological requirement for high levels of calcium enrichment (see below), this species is unlikely to occur in coastal areas, where canopy nutrients are constantly leached as a result of heavy winter precipitation (Farmer *et al*. 1991). This could explain, for example, its absence in the forests of the U.S. Pacific Northwest, notwithstanding a sustained search effort on the part of lichenologists dating from the mid-1970s. A similar observation can be made regarding southeast Alaska, in which the epiphytic lichen flora is also comparatively well known (Geiser *et al*. 1998).

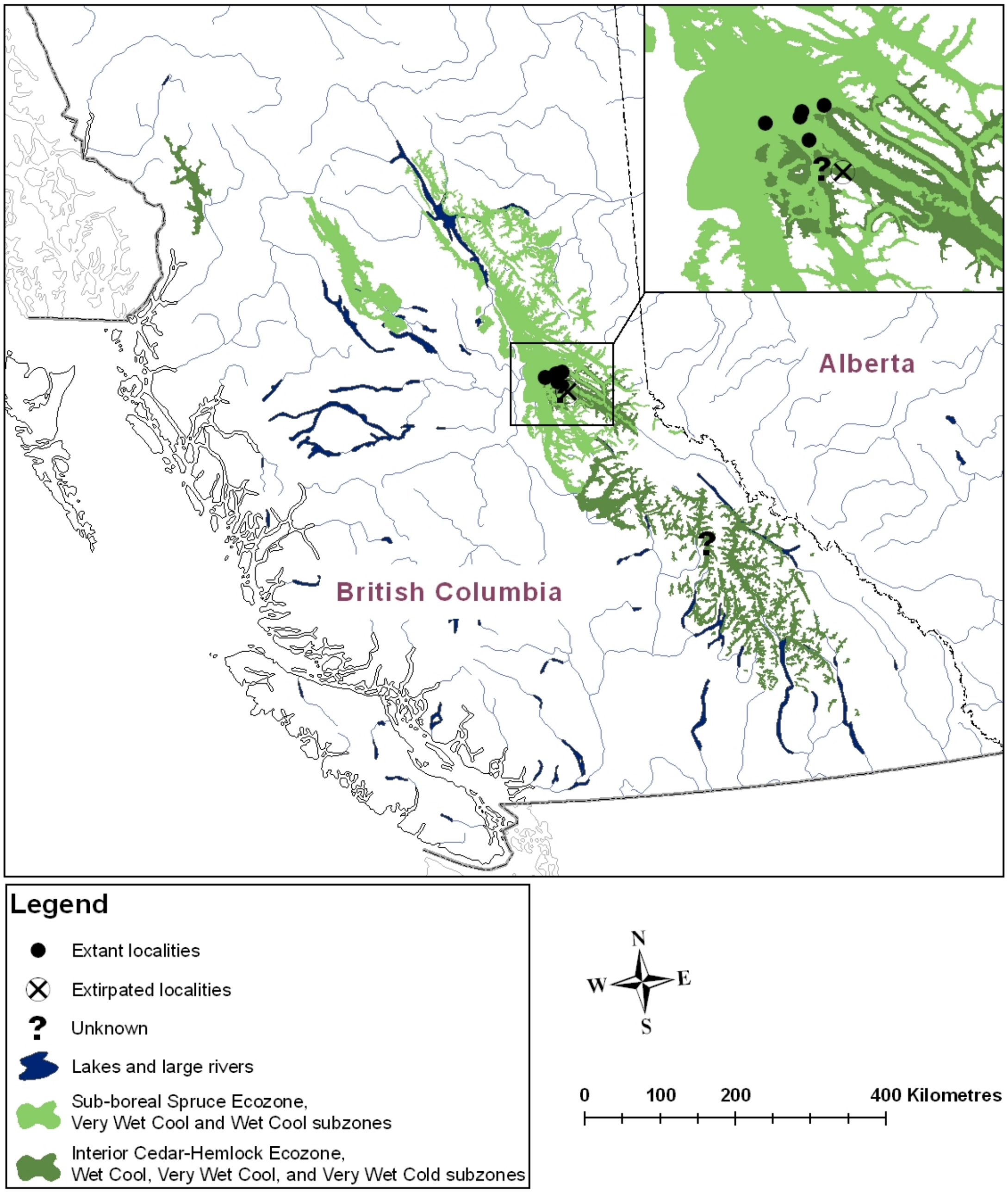

Figure 2. Global distribution of *Collema coniophilum*.

Canadian range

Collema coniophilum has a remarkably circumscribed range (Figure 2). The first known collection was made in 1991, at Hungary Creek, near the north end of the Robson Valley. Since then, it has been observed at two additional localities in the Robson Valley, as well as at four localities near Purden Lake, east of Prince George. (As used in this report, "locality" refers to an occurrence separated from all other occurrences by at least 1 km.) Outside the Robson Valley, *C. coniophilum* has been detected only from the Upper Adams River Valley (Figure 2, Appendix 1). Biogeoclimatically these regions are located within the wettest, coolest subzones of the Interior Cedar-Hemlock Zone and Sub-boreal Spruce Zone (Meidinger and Pojar 1991). Including the Upper Adams and Viking Ridge locations, the extent of occurrence (EO) is 3218 km^2 and the index of area of occupancy is 28 km^2.

Search effort

The lichen flora of British Columbia is well known and collections and inventories have been conducted in many areas of the province. Figure 3 shows a subset of the locations where general documentation of the lichen flora has been done. T. Goward examined many specimens of species in the genus *Collema* in numerous herbaria worldwide, but did not discover additional records for the lichen. It is therefore thought unlikely that other lichenologists would find additional records of this species even if all herbarium collections were fully catalogued.

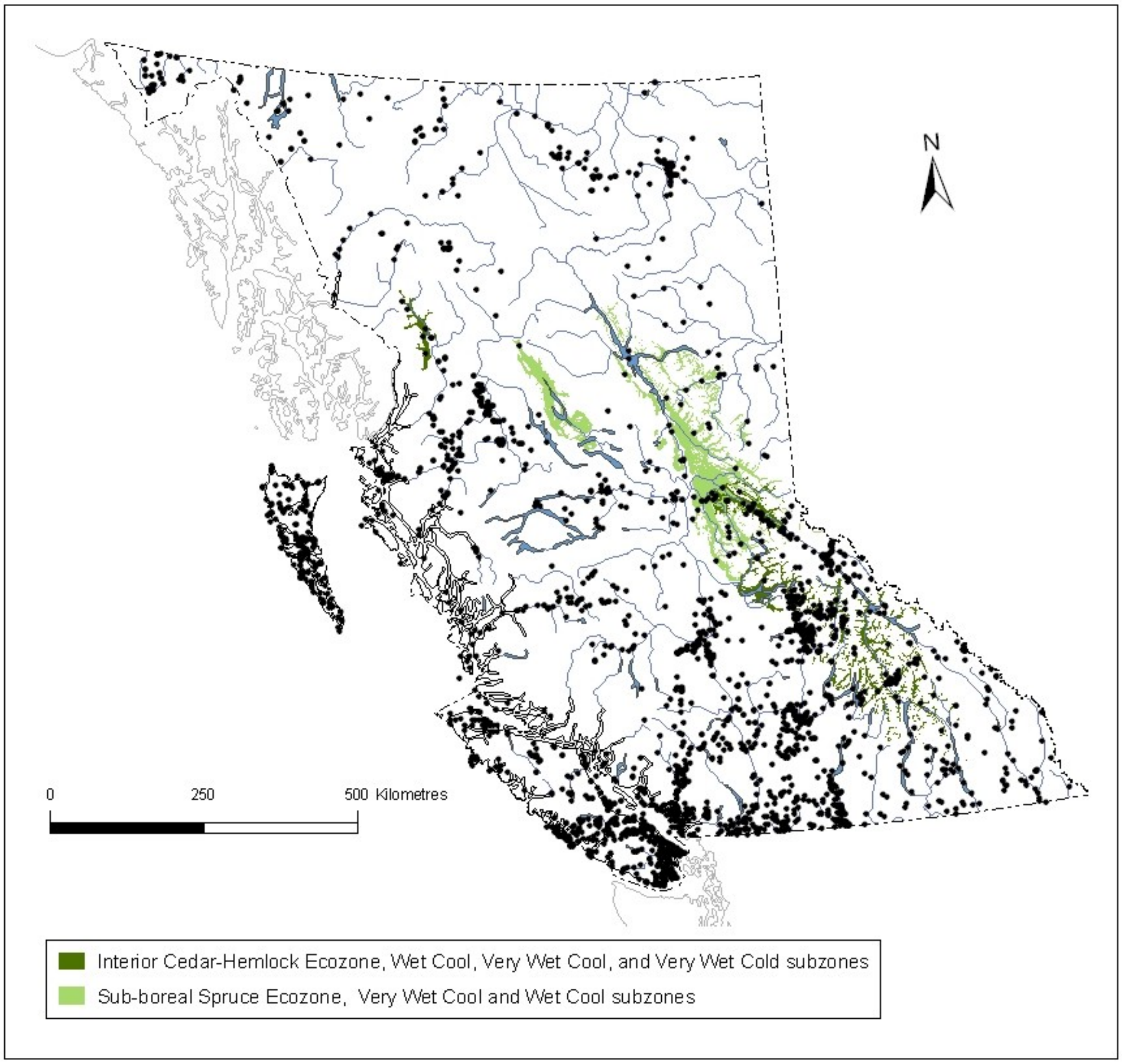

Figure 3. Major collection localities for macrolichens in British Columbia. These localities represent data from approximately 40000 specimens deposited at UBC and currently in the database. Many additional records, not included here, exist in private databases or in other herbaria.

HABITAT

Habitat requirements

Like many other members of its genus (Degelius 1954), *C. coniophilum* appears to be a strong calciphile. As such, it occurs exclusively in habitats subject to appreciable calcium enrichment. Such habitat requirements seem presently to be met in two different contexts, one natural and the other anthropogenic.

Under natural conditions, *C. coniophilum* appears to be restricted mostly to understory conifers growing within the drip zones of larger “pump” trees within 5 m from the ground, especially Black Cottonwood (*Populus trichocarpa*) and Trembling Aspen (*Populus tremuloides*). Goward and Arsenault (2000) have argued that the roots of these trees efficiently absorb nutrients from the soil and translocate them into the forest canopy. Normally the pump tree itself is not colonized, though there are exceptions. Thus *C. coniophilum* was found growing on Red-cedar at the Hungary Creek locality, while in the Upper Adams River it occurred in the crown of a fallen Cottonwood (*Populus* spp). Trees more frequently acting as host trees for this species include Subalpine Fir (*Abies lasiocarpa* s. lat.), White Spruce (*Picea glauca*), and Western Hemlock (*Tsuga heterophylla*). In the wettest subzones of the Interior Cedar-Hemlock Zone, *C. coniophilum* tends to establish only the middle and upper canopies of its host trees, presumably owing to a requirement for higher light levels. Only in mature, open forests of the Sub-boreal Spruce (SBS) Zone, as at the Bowron Road locality, is it known regularly to occur downward into the lower canopy.

Collema coniophilum is also promoted by calcareous dust from gravel logging roads. Representative here is the Bowron Road locality, where dust from a nearby logging road supports the species’ largest known population. Possibly the dust here originates from surfacing material from a nearby limestone quarry (Goward and Campbell, unpublished).

It is of course unknown whether *Collema coniophilum* was present at the Bowron Road locality prior to construction of the road here in the mid- to late 1970s. What is certain is that this locality supports an extraordinary assemblage of epiphytic gel lichens consisting of at least 11 species of *Collema*, *Lempholemma* and *Leptogium* (Goward and Campbell, unpublished). Most of these species are apparently restricted to a narrow band within about 50-100 m of the road. At distances greater than this, the gel lichen flora drops to background levels, with only about four species. A reasonable hypothesis is that at least some members of the current gel lichen flora must have colonized the Bowron Road locality subsequent to the road’s construction. If so, then this locality can perhaps be thought of as a kind of landscape-scale “petri dish” in which stray diaspores of calcium-demanding gel lichens have successfully established over the past three decades. What is truly astonishing here is the rapidity with which the existing flora must have assembled: strong evidence, surely, of a constant influx of gel lichen diaspores. In the absence of enrichment by road dust, most of these diaspores would simply fail to establish.

Finally it should be noted that *Collema coniophilum* has been observed only in older forest types. In the Interior Cedar Hemlock (ICH) biogeoclimatic zone this must at least partly reflect a requirement for good lighting, as old forests in this zone tend to exhibit much more open stand structure than do younger stands that have not yet undergone competitive exclusion. The same seems to be true also in the Sub-boreal Spruce (SBS) biogeoclimatic zone where, in addition, sufficient time is needed to allow the establishment not only of mature pump trees but also, in their lower canopies, of host trees large enough to support this lichen. Though no specific measurements of forest age were attempted in this study, it can be observed that even the Bowron Road stand – the youngest forest found to contain *C. coniophilum* – was certainly more than 100 years of age (Jocelyn Campbell, pers. comm. 2007).

Habitat trends

To date, *Collema coniophilum* has been documented at only eight localities worldwide, all in British Columbia. At three of these – River, Viking Ridge, and Hungary Creek – it occurred on only one or two branches, with a collective count of 11 thalli. Recent attempts to confirm this species at these localities have been unsuccessful, not withstanding that the first two localities now receive legislated protection through the recent establishment of Upper Adams River and Grizzly Den – Sugarbowl Provincial parks, respectively. The third locality has been lost as a result of clearcut logging.

At three of the five remaining localities – North Fraser Road, Herrick Road, Aleza Lake Road – *Collema coniophilum* occurs in rather small numbers, with a total of only 24 thalli observed in 2006. By contrast, the Bowron Road locality supports a relatively large population, currently estimated at more than 140 thalli. To judge from the presence here of numerous dead and dying thalli near the outer perimeter of the dust zone, it appears that *C. coniophilum* was formerly much more abundant along the Bowron Road than it is today. Presumably this reflects declines in vehicle traffic subsequent to the early 1990s, when logging activities ceased. This raises the possibility of more severe reductions in *C. coniophilum* should road traffic there further decline.

As noted above, *Collema coniophilum* appears to be a lichen of older forest types. Putting aside any (temporary) benefit this species may, on rare occasion, receive from calcareous road dust associated with logging, it seems reasonable to infer that extensive clearcutting in the Interior Cedar-Hemlock and Sub-boreal Spruce zones over the past 30 years has contributed considerably to its current rarity. A simple examination of clearcut layout in this region confirms that logging activity here has tended to focus on precisely those “productive” bottomland forest types most likely to have once supported *C. coniophilum*. There can thus be little doubt that clearcut logging must have resulted in declines in its area of occupancy and population size (number of individuals).

BIOLOGY

Life cycle and reproduction

Even on old trees, *Collema coniophilum* is a colonist of young twigs. Apothecia are unknown, suggesting that reproduction is effected entirely via detachable granular outgrowths of the upper surface, i.e., isidia. Isidia are vegetative propagules, consisting of both fungal hyphae and (in *Collema*) cyanobacterial cells. When established in suitable habitat, they give rise to "instant lichens" in which the need to reinstate the lichen symbiosis has been circumvented.

Isidia are abundant in *Collema coniophilum*, but are unlikely to be effective as mechanisms of dispersal. First, they lack any mechanism of adhesion for dispersal by birds or any other potential vectors. Second, even once they have arrived at a new locality, they are at considerable risk of being washed away prior to affixing to the host branch (see Scheidegger 1995). And third, they are too large to be carried more than a few hundred metres on the wind (see Walser 2004). Species dependent for dispersal on coarse thallus fragments are much more likely to be rare than species dispersing by ascospores or soredia (e.g., Sillett *et al*. 2000). In common with *C. coniophilum*, a majority of such species tend to have distinctly discontinuous ranges.

Further contributing to the extreme rarity of *Collema coniophilum* is its strong physiological requirement for nutrient-rich (or nutrient-enriched) substrates. Because this species occurs only in inland rainforests, and because rainforests are subject to heavy precipitation that in turn leaches away any extraneous cations (Farmer *et al*. 1991), *C. coniophilum* is restricted to localities favoured by more or less ongoing nutrient enrichment. Such sites are of course rare under natural conditions and nowhere more so than in the old growth forests characteristic of this species. Even when occurring in optimum habitat, as in a calcareous dust zone as at the Bowron Road locality, *C. coniophilum* is among the least frequently encountered of the gel lichens here.

Herbivory

Collema and other gel lichens are well known to be distasteful to most herbivores, so it is perhaps not surprising that no signs of herbivory have been noted.

Physiology

Though little is known about the physiology of *Collema coniophilum*, this species appears to require good illumination for optimum establishment and/or growth. This observation, at any rate, is consistent with its behaviour in the field; for in common with *Collema curtisporum* (Goward, unpublished observations), this species seems to be restricted in wetter areas to the middle and perhaps upper forest canopies; only in very open forests does it extend downward into the lower canopy. Such vertical stratification in the forest canopy could equally be interpreted as a negative response to prolonged wetting, but in that case one would need to account for the apparent fidelity of *C. coniophilum* to some of the wettest forest ecosystems in inland North America (see above).

The other salient physiological feature of *Collema coniophilum* is its obvious requirement for high levels of nutrient enrichment, whether directly as a result of nutrient uptake by nutrient pumps such as cottonwoods and aspens, or indirectly, as a result of road dust or nutrient dripzones (see above).

Dispersal and migration

Collema coniophilum is apparently an asexual species in which reproduction occurs solely by means of coarse, granular isidia, which it bears over the upper surface of the lobes. Isidia are assumed to be most effective for dispersal over relatively short distances (Walser 2004). In forest ecosystems they doubtlessly adhere to the feet and feathers of small forest birds, especially chickadees and kinglets, which thus transport them from tree to tree as they continuously explore for invertebrates. Wind may also contribute to dispersal, at least in the case of thalli established in the upper canopy, but again probably only over short distances (Walser 2004). In short, even medium-range dispersal in *C. coniophilum* is likely to occur only infrequently.

Interspecific interactions

Collema coniophilum can be characterized as a pioneer species, that is, it typically becomes established rather early in the life of its host branch. At this stage, the branch is usually devoid of other epiphytes, so *C. coniophilum* is able to grow without direct interaction with other species. Sooner or later, of course, other lichens become established; and as they do so, *C. coniophilum* gradually goes into decline. It is doubtful that this species persists on a given branch for more than about a decade. This could partly reflect an inability to compete successfully with other lichens, especially foliose species, which soon begin to overgrow it. At the same time, it could also be related to decreasing nutrient levels as lengthening branches in the crown of the tree increasingly shelter it from dust and other exogenous forms of nutrient enrichment (Goward, unpublished).

Adaptability

Compared to most epiphytic lichens, *Collema coniophilum* operates within a rather narrow set of ecological tolerances. Specifically, it tends to occur only on calcium-rich or calcium-enriched twigs and branches situated in low elevation, open old growth stands in humid portions of southern inland British Columbia. Doubtless this low level of ecological adaptability contributes to this species' status as a narrow western North American endemic.

POPULATION SIZES AND TRENDS

Sampling effort and methods

The first known collection of *Collema coniophilum* was made in 1991, at Hungary Creek, in close proximity to what is now the Lunate Creek Research area, operated by the University of Northern British Columbia (UNBC). Since then, considerable research has been conducted on the epiphytic lichens of the Robson Valley. This work has been led largely by Darwyn Coxson, of UNBC, and has resulted in the publication of several papers in refereed journals, including Goward (1994), Goward and Arsenault (2000), Benson and Coxson (2002), Campbell and Fredeen (2004, 2007), and Radies and Coxson (2004). Three additional projects are still in progress. The respective field portions of these studies represent a total search effort of 454 person days. Nearly half of this effort has been directed toward the vertical stratification of macrolichens in the forest canopy. To date, a total of 316 trees have been climbed and assessed, while the crowns of an additional 20 recently wind-fallen trees have also been examined. Collectively, these studies represent a level of search effort unique in western North America. Search efforts in other portions of inland British Columbia have varied in intensity, but are certainly sufficient to detect the presence of *C. coniophilum* well beyond its known range (Figure 3, Appendix 1). Notwithstanding these efforts, *C. coniophilum* has been observed at only eight localities since 1991, and indeed at only five localities since 1999.

In searches at suitable habitats since 1991, Trevor Goward has examined approximately 5000 trees for this lichen across British Columbia, and found it on only 20 trees at eight localities. It is not possible to estimate the number of host trees that the lichen may inhabit, given the lichen's restriction almost entirely to the branches of young conifers growing under older deciduous trees – *Populus* – in late Pleistocene lakebed localities that are enriched with calcium in high concentration. The combination of these conditions ensures that such sites are highly restricted in the area, and that the species is also similarly restricted.

Abundance

At the present time, the known global population of *Collema coniophilum* consists of only about 170 thalli, of which 140 are at a single locality (Bowron Road). Of the remaining thalli, the North Fraser Road locality accounts for 17, the Herrick Road and North Fraser Bridge localities for six each, and the Aleza Lake locality for one (Table 1). All of these localities are situated within the Sub-boreal Spruce Zone; earlier records from the Interior Cedar-Hemlock Zone could not be relocated. Though future fieldwork in the Sub-boreal Spruce Zone is likely to yield additional localities for *C. coniophilum*, the ongoing loss of old growth forests to logging is likely to enforce its continued status as a rare species.

Table 1. Summary of the locations of Canadian populations of *Collema coniophilum* and their historical and current status.

Area	Locality	Years Reported	Original population size (no. of thalli)	Population size (2003-2007) (no. of thalli)
Canada, British Columbia, Robson Valley: Hungary Creek	Hungary Creek	1991	3	None found
Canada, British Columbia, Upper Adams River Valley	Upper Adams River	1998	4 (possibly more)	None found
Canada, British Columbia, Robson Valley: Viking Ridge	Viking Ridge	1999	4	None found
British Columbia, Robson Valley Bowron Road	Bowron Road	2006	140	140
British Columbia, Robson Valley North Fraser Road	North Fraser Road	2006	17	17
British Columbia, Robson Valley Herrick Road	Herrick Road	2006	6	6
British Columbia, Robson Valley Aleza Lake Road	Aleza Lake Road	2006	1	1
British Columbia, Robson Valley: upper Fraser Bridge	Upper Fraser Bridge	2007	unknown	6

Fluctuations and trends

Efforts to relocate *Collema coniophilum* at the three earliest localities – Hungary Creek (1991), Upper Adams River (1998) and Viking Ridge (1999) – were unsuccessful. This is not surprising, first because the populations at Hungary Creek and Upper Adams River occurred in the canopies of recently fallen trees – a habitat not easy to locate – and second because the collection from Viking Ridge involved destructive sampling of the host branches (D. Radies, pers. comm.). Though the Hungary Creek locality has since been logged, the two remaining localities have lately acquired a degree of protection through the establishment of Upper Adams River Provincial Park and Grizzly Den Provincial Park and Protected Area, respectively. Unfortunately, it remains uncertain whether *C. coniophilum* still occurs at these localities.

On the other hand, there can be little doubt that the Bowron Road locality, subject to artificial nutrient enrichment from calcareous road dust, currently supports *Collema coniophilum* in numbers vastly greater than could have established here under natural conditions. This locality provides a interesting instance of a rare lichen actually benefiting from human activity, here involving a decision to surface the Bowron Road using calcareous gravel. But though the Bowron Road population is large in terms of numbers, the locality itself is rather small, consisting of a 13 ha old growth remnant surrounded on all sides by cutblocks and young regenerating stands. It is thus highly vulnerable to stand-replacing events of various kinds, including wildfire, insect outbreak, or severe windthrow. The future of *C. coniophilum* at this locality is by no means secure. As noted the Bowron Road population seems to have declined in recent years, as evidenced by the presence of many dead and dying thalli near the outer limits of the road dust zone. Ironically, this decline has apparently been brought about by a reduction in logging intensity (and hence vehicle traffic, and hence road dust) since about 1985, and especially since 2001, following the closure of the Upper Fraser Sawmill (J. Campbell, pers. comm. 2007).

Rescue effect

If it is true, as currently thought, that *Collema coniophilum* occurs exclusively in inland British Columbia, then there can be no rescue effect for this species; the global responsibility for *C. coniophilum* rests with Canada alone.

THREATS AND LIMITING FACTORS

Not only is *Collema coniophilum* endemic to Canada, it also appears to number among British Columbia's rarest epiphytic macrolichens. This status is certainly attributable to its pronounced sensitivity to several environmental factors that collectively limit its ability to disperse to and establish itself in new localities. At least three such factors can be recognized. First, *C. coniophilum* is a strong calciphile, requiring an elevated pH for successful establishment. This requirement alone restricts it to valley-bottom forests below about 1000 m; higher than this, host trees become too acidic to support this species. Second, *C. coniophilum* appears to be a pronounced hygrophyte capable of establishing only within the wettest subzones of the Interior Cedar-Hemlock and Sub-boreal Spruce zones. And third, it appears to require considerable illumination. This last limitation may partly account for this species' strong tendency to associate exclusively with older forest types which, as noted by Oliver (1981), are generally more open than young forests. Actually only one of *C. coniophilum*'s ecological requirements is not specifically promoted by increasing forest age, namely its need for nutrient-rich (or nutrient-enriched) substrates; and it is probably this, more than any other single fact, that accounts for its relative rarity under natural conditions. From the above it follows that the ongoing rapid loss of old forests to clearcut logging in inland British Columbia is being accompanied by a corresponding decline in *C. coniophilum* throughout its range.

Running counter to the decline of *Collema coniophilum* under natural conditions has been the creation of artificially enhanced populations associated with calcareous road dust. To be sure, roadside localities doubtlessly now provide critical source populations for this species (sensu Pulliam 1988). Unfortunately, there seems to be no easy way to ensure that old growth stands will continue to intersect with calcareous roadside dust in the long term. At the same time, the increasing tendency for *C. coniophilum* to occur more or less exclusively in a few small roadside stands is certainly placing this species at increased risk of extirpation as a result of wildfire, insects, disease or other agents of stand replacement.

The ability of *Collema coniophilum* to persist across its current range must ultimately depend on the maintenance of old forests. Especially critical are old stands situated over nutrient-rich soils, and containing at least some aspen and/or cottonwood. Though these trees rarely host *C. coniophilum* themselves, they nevertheless introduce calcium and other cations into the forest canopy, thereby continuously "enriching" the branches of understory conifers, and so promoting the establishment of *C. coniophilum* and other calciphilic lichens.

At the present time, the dust-enhanced Bowron Road population represents a major source of diaspores for future long-distance dispersal. Even so, successful establishment will still depend, more or less, on the existence of remnant old growth forests combining the required attributes of stand spacing, humidity, and high nutrient status. As these old growth remnants become smaller and increasingly isolated, the principles of island biogeography can be expected to come into play, leading to a decreased likelihood of successful establishment.

PROTECTION, STATUS, AND RANKS

Legal protection and status

Collema coniophilum is not specifically protected by any legislation, either in Canada or British Columbia. Two sites (Upper Adams River, Viking Ridge; Table 2) have recently been protected through the creation of Upper Adams River Provincial Park and Sugarbowl – Grizzly Den Provincial Park and Protected Area. However, these sites are no longer known to support the species.

Table 2. Summary of localities supporting *Collema coniophilum*: their histories of documentation and any potential threats. Detailed locality information is given in Appendix 1.

Locality	First Record Abundance (No. of thalli)	Last Record Abundance (No. of thalli)	Ownership Threats
Canada, British Columbia, Robson Valley, Hungary Creek	4 September 1991 3 thalli	13 September 2006 Not found	Crown land: B.C. Ministry of Forests Colony extinguished by 2000, first by cutting for shakes, then by clearcut logging
Canada, British Columbia, Upper Adams River Valley:	21 September 1998 4 thalli (possibly more)	16 July 2006 Not found	Crown Land: B.C. Parks: Upper Adams River Provincial Park Wildfire, insect outbreak
Canada, British Columbia, Robson Valley: Viking Ridge	26 August 1999 4 thalli	27 September 2004 Not found	Crown land: B.C. Parks: Sugarbowl – Grizzly Den Provincial Park and Protected Area
Canada, British Columbia, Bowron Road	29 August 2006 140 thalli	29 August 2006 (last checked by Jocelyn Campbell, 26 October 2006) N/A	Crown land: B.C. Ministry of Forests Logging, wildfire, insect outbreak
Canada, British Columbia, North Fraser Road	1 June 2006 (Jocelyn Campbell) No thalli count	26 October 2006 (Jocelyn Campbell) No thalli count	Crown land: B.C. Ministry of Forests Logging, wildfire, insect outbreak
Canada, British Columbia, Herrick Road	1 June 2006 (Jocelyn Campbell) No thalli count	26 October 2006 (Jocelyn Campbell) No thalli count	Crown land: B.C. Ministry of Forests Logging, wildfire, insect outbreak

Locality	First Record Abundance (No. of thalli)	Last Record Abundance (No. of thalli)	Ownership Threats
Canada, British Columbia, Aleza Lake Forest Road:	1 June 2006 (Jocelyn Campbell) No thalli count	26 October 2006 (Jocelyn Campbell) No thalli count	Crown land: Research Area: University of Northern B.C., Prince George Logging, wildfire, insect outbreak
Canada, British Columbia, Upper Fraser Bridge	10 May 2007 (Trevor Goward) 6 thalli	10 May 2007 (Trevor Goward) 6 thalli	Crown land: Logging, wildfire, insect outbreak

Non-legal protection and status

At five localities (North Fraser Road, North Fraser Bridge, Herrick Road, Aleza Lake, and Bowron Road; see Table 2), *Collema coniophilum* has as yet received no long-term protection against resource extraction; and though it must be acknowledged that even an appropriate level of legislated protection will not necessarily safeguard these rather small localities against, for example, wildfire, insect outbreak, or wind-throw, the precautionary principle would seem to dictate that rare species such as *C. coniophilum* ought to be retained across as many sites as possible.

Habitat protection and ownership

All eight localities from which *Collema coniophilum* has been reported are located on crown land and are thus under the jurisdiction of the British Columbia government. Two (Viking Ridge and Upper Adams River) are situated within the boundaries of provincial parks, one (Upper Fraser Bridge) is apparently in an old growth management area, one (Hungary Creek) has already been clearcut, three (Bowron Road, North Fraser Road and Herrick Road) are scheduled eventually to be logged, and one (Aleza Lake) is currently situated in a Research Forest administrated by the University of Northern British Columbia, in Prince George. *C. coniophilum* is currently known to occur at only five localities; attempts to relocate it at the other three localities were unsuccessful.

ACKNOWLEDGEMENTS AND AUTHORITIES CONSULTED

Assistance with this report was received from many people. Significant field assistance was received from Jocelyn Campbell, Rachel Botting, Dave Radies, Curtis Björk, Tim Wheeler and Kenneth G. Wright, who accompanied Trevor Goward in the field in 2006, and Darwyn Coxson and Craig Delong who in 2007 joined Trevor Goward in the search for additional localities. Jocelyn Campbell and Dave Radies generously put their personal collections of *Collema coniophilum* at my disposal, and provided critical information concerning the Bowron Road locality. Tor Tønsberg kindly made available authentic European material of *C. auriforme*, thereby permitting detailed comparison with what has subsequently proved to be a distinct species, *C. coniophilum*.

Linda Geiser, Katie Glew, Martin Hutten, Bruce McCune, Peter Nelson, Roger Rosentreter and the curator at Oregon State University herbarium all graciously responded to requests for loan of American material. Curtis Björk, Jocelyn Campbell and Jason Hollinger all generously read earlier drafts of this report, thereby contributing much to its clarity. Ruben Boles gave unstintingly of his time during preparation of this report. Jenny Wu and Alain Filion produced the maps in Figures 2 and 3. Tim Wheeler generously provided the image appearing in Figure 1. Finally, T. Goward wishes to extend sincere thanks to the members of the Mosses and Lichens Specialist Subcommittee of COSEWIC for their understanding when prior commitments obliged T. Goward to delay production of this report. Funding to offset the cost of field work and report preparation was received from Environment Canada.

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Campbell, Jocelyn. 2006/2007 (joc_camp@telus.net), lichen ecologist, PhD student currently studying the role of cyanolichens in forest nutrient cycling. University of British Columbia, Vancouver.

McCune, Bruce. 2006 (Bruce.McCune@science.oregonstate.edu), lichenologist, expert on lichens of the American northwest. Oregon State University, Corvallis.

Radies, David. 2007 (davidradies@yahoo.ca), lichen ecologist, Master's student currently examining the spatial distribution of cyanolichens in inland rainforests. University of Northern British Columbia, Prince George.

Tønsberg, Tor. 2006 (tor.tonsberg@bot.uib.no), lichen taxonomist, authority on rare epiphytic lichens of coastal western North America. University of Bergen, Norway.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Trevor Goward (tgoward@interchange.ubc.ca) began studying lichens in 1976, while completing an undergraduate degree in French and Latin at Mount Allison University, New Brunswick. Since then he has developed and maintained a broad interest in lichen taxonomy and distributional ecology, and has written or co-authored five books on lichens and published about 62 papers in refereed journals. Currently a consulting lichenologist based out of Clearwater, British Columbia, Trevor maintains a special interest in the lichens of old growth forests as well as in the ecology of rare lichens. In 1989, he was appointed as curator of lichens at UBC, a position he has held ever since. Most of his 30,000+ lichen collections are on deposit with the UBC herbarium. From 1995 to 2009, Trevor served on the lichen subcommittee of COSEWIC.

COLLECTIONS EXAMINED

All known collections of *C. coniophilum* have been examined in connection with this study. Specimens are listed in Appendix 1.

Appendix 1. Known collections of the North American endemic macrolichen *Collema coniophilum.*

Specimen Location	Locality Habitat Substrate	Collector Collecting # Date	Determined / Examined by
UBC	Canada, British Columbia, Robson Valley, Hungary Creek branch of Western Red-cedar	T. Goward 91-1732 4 September 1991	T. Goward
UBC	Canada, British Columbia, Upper Adams River Valley branch of Black Cottonwood	T. Goward 98-115 21 September 1998	T. Goward
UBC	Canada, British Columbia, Robson Valley: Viking Ridge branch of Western Hemlock	D. Radies (no number) 26 August 1999	T. Goward
UBC	Canada, British Columbia, Bowron Lake Road branch of sub-alpine fir	T. Goward 06-666 29 August 2006	T. Goward
UBC	Canada, British Columbia, Bowron Lake Road branch- tree species not available	J. Campbell (no number) 2006	T. Goward
UBC	Canada, British Columbia, Bowron Lake Road branch- tree species not available	J. Campbell (no number) 2006	T. Goward
UBC	Canada, British Columbia, Bowron Lake Road branch- tree species not available	J. Campbell (no number) 2006	T. Goward
UBC	Canada, British Columbia, Bowron Lake Road branch- tree species not available	J. Campbell (no number) 2006	T. Goward
UBC	Canada, British Columbia, North Fraser Bridge branch- tree species not available	T. Goward (no number) 10 May 2007	T. Goward