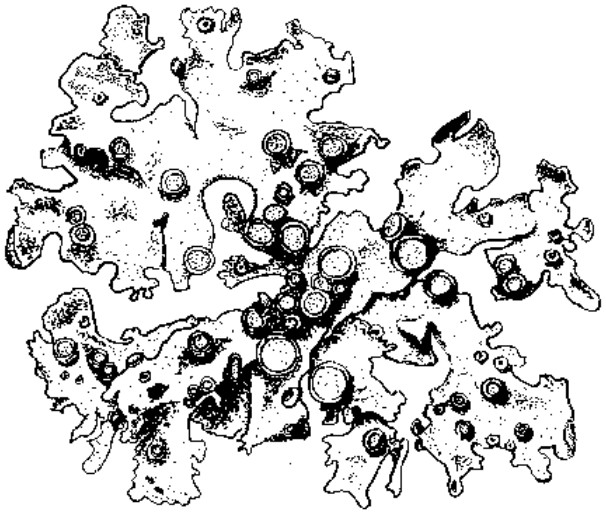
COSEWIC
Assessment and Status Report

on the

Flooded Jellyskin
Leptogium rivulare

in Canada



THREATENED
2004

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

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

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COSEWIC
Assessment Summary

Assessment Summary – May 2004

Common name
Flooded Jellyskin

Scientific name
Leptogium rivulare

Status
Threatened

Reason for designation
This is a globally rare species currently known in Canada from only 4 locations, all in Ontario and Manitoba. The species has very restricted habitat requirements, found primarily at the margins of seasonal (vernal) pools, where it grows on rocks and at the base of living deciduous trees between seasonal high and low water marks. It is vulnerable to changes in normal patterns of annual flooding, as well as to death of host trees. Major threats to the largest populations include urban development and recreational activity.

Occurrence
Manitoba, Ontario

Status history
Designated Threatened in May 2004. Assessment based on a new status report.

COSEWIC
Executive Summary

Flooded Jellyskin
Leptogium rivulare

Species information

Leptogium rivulare (the Flooded Jellyskin) is a small foliose lichen characterized by blue-grey lobes with a smooth, unwrinkled surface, abundant small brown discs with thin, even margins, which are the fruiting bodies, and especially the spores, which are produced 4 in each spore sac rather than 8, as in most other species of the genus. It is also confined to a very distinctive habitat (see below).

Distribution

Scattered northern temperate to temperate localities in eastern North America and western Europe. In Canada, known from 6 localities in Ontario and Manitoba, in the Mixedwoods Plains and Boreal Shield ecozones.

Habitat

Restricted to periodically inundated substrate, usually the bark of trees along the banks of ponds and waterways, and in wet lowland forests flooded every spring. It occurs almost exclusively on the bark of living deciduous trees, and always below the high-water mark.

Biology

Flooded jellyskin lichen reproduces readily, presumably by spores, and disperses over at least short distances. It is able to colonize newly developing substrates (tree bark), and once established is able to survive dry years. It persists long enough to form dense mats on some trees. Its spread may be limited by an ineffective means of dispersal.

Population sizes and trends

This species has been considered rare wherever it occurs, in North America or in Europe. In Canada, it is currently known almost entirely from trees in just a few small, seasonal ponds at each of two localities. At these sites, such trees number in the dozens to hundreds, and the lichen populations appear to be healthy and well established. Very small amounts of the lichen have also been found on seasonally submerged rocks at two additional localities under very different substrates: a turbulent stream and a rocky lakeshore.

Limiting factors and threats

Flooded jellyskin lichen is limited to a very narrow strip of land – and usually tree trunk – between the seasonal high and low water marks. The species is therefore especially vulnerable to changes in the normal pattern of annual flooding. A drier climate could deprive the species of much suitable habitat. The removal or death of the trees would eliminate most of the substrate.

Special significance of the species

The rarity of this species worldwide indicates its vulnerability. It is of scientific interest because of its requirement for and ability to thrive in a very unusual habitat.

Existing protection or other status designations

There is no specific protection, and the species has no status designation in Canada, other than an SH ranking in Ontario, signifying a lack of recent records.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS (AFTER MAY 2004)

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

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

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

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

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Canada

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

COSEWIC Status Report

on the

Flooded Jellyskin

Leptogium rivulare

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2004

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SPECIES INFORMATION

Name and classification

Leptogium rivulare (Ach.) Mont. in Gaudichaud, Bot. Voy. Monde La Bonite: 117 (1846). [nomen sed non planta]. *Lichen rivulare* Ach., Lich. Suec. Prodr. 131 (1798); type: Sweden (H-Ach 1915B, lectotype designated by Jørgensen & James [1983])

Leptogium crenatellum Tuck. Amer. J. Arts Sci., ser. 2, 28: 200 (1859); type: USA, Vermont, Brattleboro, Frost (FH, holotype; US, isotype).

Leptogium sernanderi Du Rietz, Bot. Notiser 1922: 318 (1922); type: Sweden, Uppland, Knivsta, Noorsån, 27 July 1917, G. Sernander (UPS, lectotype designated by Jørgensen & James [1983]; isolectotypes distributed in Malme, Lich. Suec., no. 851).

English name: Flooded jellyskin lichen (which refers to both the habitat, and the fact that *Leptogium*, along with the genus *Collema*, form a group known as the "jelly lichens").

French name: (le) leptoge des terrains inondés.

Classification: Fungi, Ascomycota, Lecanorales (order), Peltigerinae (suborder), Collemataceae (family).

This species, which is in the *Leptogium azureum* complex, is distinctive because of its 4-spored asci and unique habitat. In North America, it was long known as *L. crenatellum* Tuck. (e.g., Fink 1935, Sierk 1964), but that species was found to be a synonym of *L. rivulare* by Jørgensen & James (1983), who discussed the nomenclature of the species in some detail. The relevant types have been studied by both the monographer (H.A. Sierk) and by the Norwegian lichenologist Per Magnus Jørgensen.

Description

When dry, *Leptogium rivulare* is a small grey or bluish-grey foliose lichen that is dotted or speckled with rather minute, light reddish-brown apothecia (Figure 1). The lobes are smooth (without the wrinkles, soredia, or isidia that characterize similar species) and are rounded to somewhat elongate, 0.7 to 3.5 mm wide. The cortex of the upper and lower surfaces consists of a single layer of roundish cells; the medulla is extremely thin. The photobiont is a cyanobacterium (*Nostoc*).

When wet, the lobes swell with water and become gelatinous and translucent, hence the name “jellyskin” lichen.

Apothecia are commonly produced, sometimes so thickly as to give the lichen a brownish cast. This abundance of apothecia readily distinguishes *Leptogium rivulare* from the very common, and much larger *L. cyanescens* (Rabenh.) Korber. The

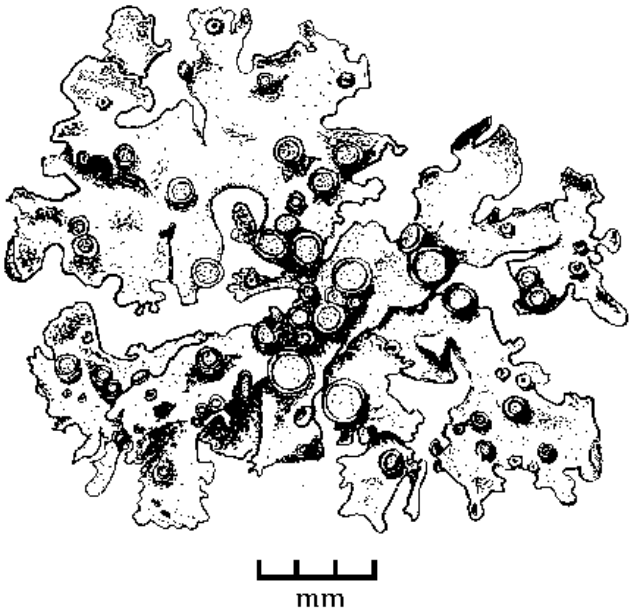

Figure 1. Individual *Leptogium rivulare* thallus.

apothecia may be superficial or constricted at the base, 0.4 to 0.6 (but up to 1.2) mm in diameter. The disk is light brown to reddish brown, flat to slightly concave, with margins that are smooth and even, relatively thin, and partly disk-colored, but with an outer layer of grey thalloid tissue. The spores are colourless and multicellular (submuriform, with 3 [or 4] transverse septa and one longitudinal septum [or none at all]). The spores are elliptical, but rather pointed at the tips, and measure 15-21 x 7.5-10 µm. There are consistently 4 spores per ascus.

Chemistry: No lichen substances are known (Brodo *et al.* 2001). (A more detailed description is found in Sierk [1964].)

DISTRIBUTION

Global range

Eastern North America and western Europe; possibly eastern Eurasia (Goward *et al*. 1998). Defined by isolated and sometimes very old collections (1800s) in Sweden, Finland, Estonia, and France, and in the United States by very old specimens from Illinois and Vermont. The species appears to be genuinely rare in eastern North America. According to Dr Irwin Brodo (pers. comm., 2003), “I wrote to the curators of the large lichen herbarium in Minnesota (MIN), New York Botanical Garden (NY) and Michigan State University (MSC) and all three curators reported no specimens of *Leptogium rivulare*, even under its synonymous names. That means that such excellent

and experienced collectors as Clifford Wetmore, Richard Harris and Henry A. Imshaug never found the species in their extensive collection efforts in the Great Lakes Region. Wetmore covered Isle Royale (Michigan) and Minnesota, Harris has collected all over eastern North America, including throughout the Adirondack and Catskill Mountains, and Imshaug covered all parts of Michigan and parts of the Lake Superior shore, all of them regions where the species might have been expected to occur judging by its known localities."

Detailed European and American localities are given by Sierk (1964) and Jørgensen & James (1983), with additions in Jørgensen (1994). A world map can be found in Jørgensen (1994).

Canadian range

Within Canada, *Leptogium rivulare* is known only from Ontario and Manitoba (Figure 2). It has been found in six places, five of them in Ontario and one in Manitoba (discovered after this report was originally submitted). It was formerly known from just three of these localities, each hundreds of kilometers from the next, and known only from herbarium specimen notations:

Carleton County (Ottawa Region): on base of *Fraxinus* in swamp, 10 Oct. 1971, I.M. Brodo no. 18746 (with F. Brodo and H.L. Dickson); determined by P.M. Jørgensen (CANL!)

Algoma District: Wawa, near "washout" on Magpie River, on base (partly flooded in spring) of *Fraxinus nigra*, 24 June 1965, Fabius LeBlanc, no. 1-7; determined by I.M. Brodo (CANL!)

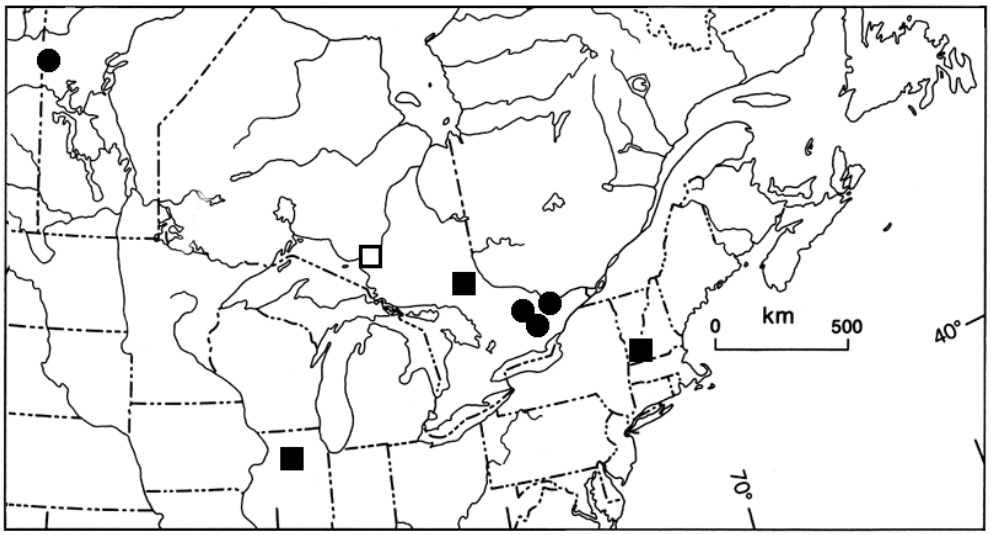

Figure 2. Distribution of *L. rivulare* in North America and Canada showing historical records more than 50 years old (solid squares), the record from 1965 that probably cannot be re-examined (open square), and extant populations (solid circles).

Nipissing District: Lake Temagami, 'Long Point," on base of ash tree at edge of pond, 13 Aug. 1946, R.F. Cain, no. 21688, determined by G. Degelius (TRTC!)

A very recently collected specimen from Manitoba is in the process of being accessioned by the Canadian Museum of Nature. It was found on rock on a stony lakeshore near Flin Flon, together with other semi-aquatic lichens.

In connection with this report, the lichen has been relocated at the first of the above places (Ottawa), and found in two additional localities (indicated by asterisks, below) in Ontario 35 and 50 km to the west of the original location. The Ontario sites are listed below.

- Ottawa (formerly Carleton County, or the Regional Municipality of Ottawa Carleton). The lichen is now known to occur in a cluster of six seasonal ponds and swamps. This population was well established and viable as of February, 2003.

- *Lanark County, Darling Township: On trees in a cluster of seven seasonal ponds at the south end of White Lake. Discovered by Robert Lee in April 2001. Population well established and viable in April 2003.

- *Lanark County, Pakenham Township. A very small, anomalous population on a few rocks in a high-energy flow streambed (Indian Creek). Possibly the result of an accidental introduction in 1994. Discovered by Robert Lee in August, 2002.

For the three currently known locations in Ontario, the extent of occurrence is approximately 130 km^2. Inclusion of the site in Manitoba increases this area to 107,000 km^2. The area occupied by suitable habitat for all four sites would be in the order of 2 or 3 hectares (0.2-0.3 km^2). The total area of substrate (mainly tree bark) occupied by the lichen is about 40 m^2 (Appendix 1).

Consultation with Parks Canada (R. Alvo, S. Frey, D. Masse, E. Meleg, A. Promaine, and K. Wade) has failed to turn up any record of *Leptogium rivulare* in National Parks from La Mauricie in Québec, to Riding Mountain in Manitoba. All these informants agree, however, that lichens have hardly been studied, if at all, in these parks.

With only a few known occurrences well within a potentially broader Canadian range (suggested by the Vermont and Manitoba records to the east and west), it is not possible to say anything about changes in range. However, given the paucity of records across time (two centuries) and space (two continents), the lichen has evidently always been rare throughout its range. In Europe, it is listed as endangered in the Red List of Lichens of Estonia, and as regionally extinct in Finland (Randlane 1998; ArtDatabanken SoknigRodlista, Rödlistade arter i Sverige 2000; and Government of Finland 2000). In the United States and in Canada, the old collection sites (from 1858 to 1965) do not

appear to have been revisited in recent times. The locations were simply too vaguely recorded, too many years ago.

Apart from the six currently known and historical localities, this lichen has apparently not been found elsewhere in Canada. With respect to seasonally flooded forests (an unusual habitat preference), it seems possible that it has been overlooked by lichenologists, who perhaps do not frequent such places (as suggested by Jørgensen & James, 1983). Indeed, in the National Herbarium (CANL) there are only six specimens from this specific habitat, five of them very old, of the crustose lichen *Lecania cyrtella* (Ach.) Th. Fr., which has been seen to be abundant and frequently intermixed with *L. rivulare* on tree bases in the ponds currently under study (no *Leptogium rivulare* was inadvertently included in this material).

Rocky streambeds and lakeshores, however, while they may seem to be anomalous environments for *Leptogium rivulare*, are the normal habitat of other semi-aquatic lichens, and these places have been given proper attention. Two species that have occurred on rock with *L. rivulare* are the foliose *Dermatocarpon luridum* (With.) J.R. Laundon, and the crustose *Staurothele fissa* (Taylor) Zwackh. There are about 100 specimens of these two species from streams and lakes in the National Herbarium. Most (84) of these were fairly evenly distributed across those parts of the country that include the core of the Canadian range of *L. rivulare*, from the Ottawa region in eastern Ontario westward to Thunder Bay. Other collections of these associated lichens have been made outside the known range, to the west in Alberta, north beyond Flin Flon, Manitoba, and to the east in Quebec and New Brunswick. (No *L. rivulare* was inadvertently included in any of these collections, 25 of which are on the original substrate.)

At the very least, it can be said that at 100 rocky shoreline sites across the country, lichenologists have collected other lichens from the right substrate in suitable habitat without *Leptogium rivulare* ever coming to light. Six of these were made by R.F. Cain, who first found *L. rivulare* in Canada, and he did not find it on those rocks, but only on the base of a tree in a pond, as previously described.

Could it have been missed? Perhaps it could be, when very young or not well established. But although *Leptogium rivulare* is regarded as a small species in its genus, it is a macrolichen and it is almost the only foliose lichen in these environments. It is distinctively coloured, and when it grows in large patches, it can be seen 10 metres away and recognized on sight.

In a broader context, general lichenological work has also failed to turn up any specimens of *Leptogium rivulare* in Ontario or adjacent parts of Quebec. It was not found in the 1860s by any of several collectors, including John Macoun, who, according to Wong and Brodo (1973) worked along the St. Lawrence River or the north shore of Lake Ontario. More recently, P.-Y. Wong has made a concerted effort over several decades to collect all across southern Ontario, an area that includes all of the locations known up to the time of this report's original submission (I.M. Brodo, personal

communication 2003). Flooded habitats were not specifically targeted. In conjunction with that survey, Wong also consulted the herbarium collections at the Canadian Museum of Nature and the University of Toronto (Wong & Brodo 1992). Over a 35-year period, I.M. Brodo has made an even more comprehensive collecting effort within "the Ottawa District," which is encompassed by a circle of 50 km radius centred on the city of Ottawa (Figure 3).

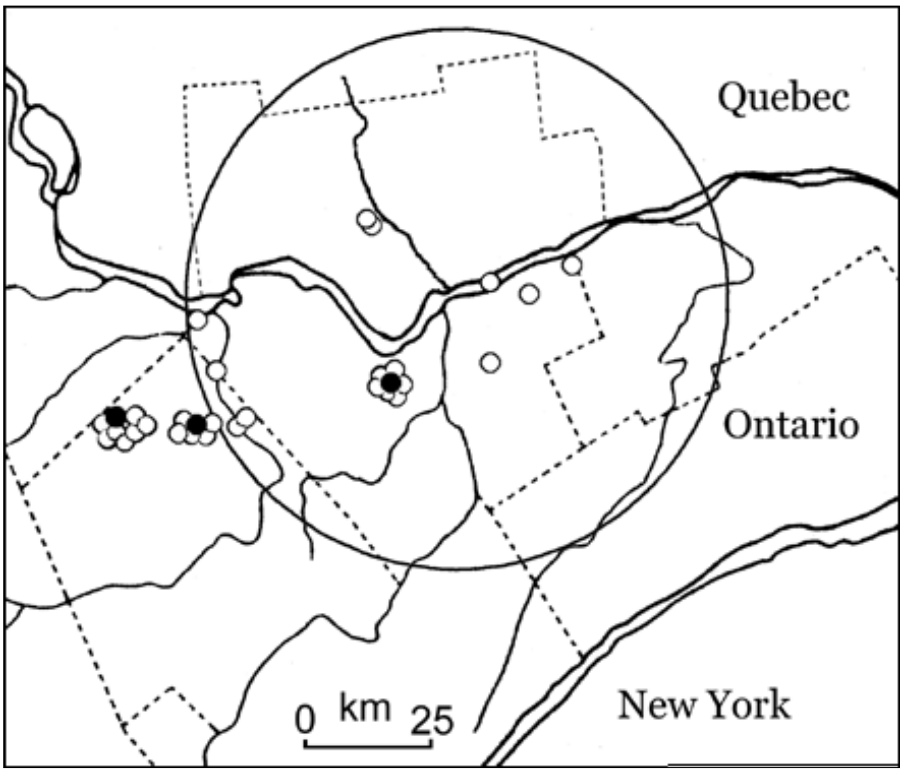

Figure 3. Distribution of *L. rivulare* (solid circles) in the eastern-most part of Ontario and some of the apparently suitable sites that are without *L. rivulare* (open circles) in relation to the 50-km radius of the "Ottawa district" covered by Brodo (1988).

In consequence, in spite of its seeming abundance in a few ponds in eastern Ontario, *Leptogium rivulare* appears to have always been rare everywhere in its global range. Its restrictive dependence on a limited and unstable habitat may be one factor, but ineffective dispersal may be more important.

Distribution within the range appears to be quite restricted. Searching of much suitable habitat over a period of three decades by I.M. Brodo (pers. comm., 2002), and more recently by Robert Lee (see Figure 3 and Appendix 2), has shown that the currently known localities in Ontario are rather circumscribed, with the lichen being absent from all suitable habitat (about 40 sites) within one kilometer of the localities where it is known, and from another 20 places that are more distant (Upper Duck and Petrie Islands, 15 and 25 km to the east of Ottawa; at Chelsea, Québec, 30 km to the north; along the middle reaches of the Noire River, Québec, 160 km northwest of

Ottawa; and at Anima Nipissing Lake, 20 km north of Lake Temagami in Ontario). The extent of the population near Flin Flon, Manitoba is not known.

To determine if it might still have been underreported, Robert Lee searched specifically for it at more than 60 sites during the years 2001 and 2002, with efforts first being concentrated immediately around the known populations. All suitable habitats within about a kilometer of these populations were examined, with negative results showing that they are limited in extent. Secondly, almost all other patches of habitat that came to attention in the general region of these populations were searched. Thirdly, extensive areas of apparently suitable habitat (river floodplains) were sampled, in case *Leptogium rivulare* should turn out to be abundant within some major but neglected watershed. None was found.

HABITAT

Habitat and substrate requirements

Like collections elsewhere, almost all the occurrences in Canada have been in virtually identical habitats: the periodically inundated bases of trees, usually around the margins of basins that fill with meltwater each spring to form seasonal ponds. The water in these places is typically still and clear, beginning as ice-cold meltwater in March, and if still present in June, warming up considerably in the sunshine.

The trees in these places are those few species that, like Black Ash (*Fraxinus nigra*), can thrive in, or at least withstand, substantial springtime flooding to a depth of as much as 2 metres, for 3 to 12 weeks each year. About 98% of the lichen observed by Robert Lee in 2002 occurs on the bark of flooded tree bases. None is known to occur on permanently flooded trees.

To the old records of ash (*Fraxinus sp*., especially *F. nigra*), observations at the new localities add as the most common bark substrates: Red Maple (*Acer rubrum*), Silver Maple (*A. saccharinum*), Red Ash (*Fraxinus pennsylvanica*), and American Elm (*Ulmus americana*). Bur Oak (*Quercus macrocarpa*) and Balsam Poplar (*Abies balsamea*) are less frequently available. Still less commonly, Red Osier Dogwood (*Cornus stolonifera*), wild grape (*Vitis riparia*), and willow (*Salix sp*.) provide significant amounts of substrate. In one or two instances, the lichen also occurs on White Cedar (*Thuja occidentalis*) and Glossy Bluckthorn (*Rhamnus frangula*). Other reported bark substrates are shrubs (e.g., Buttonbush [*Cephalanthus sp*.] and alder [*Alnus sp*.]). About 1% of the lichen is growing on shrubs and fallen branches.

Almost all of the currently known sites are, in spring, watery openings in forests, in which various forms of herbaceous vegetation (ferns, sedges, Poison Ivy) may or may not appear after the water subsides. To some extent the flood zone habitat is therefore a forest edge. However, the lichen occurs both at the more sunlit margin, and in the

more deeply shaded portions of the zone, and on shady southern shores as well as the more exposed northern side of the ponds.

The best growths of *Leptogium rivulare* occur on rough bark, and the most extensive are usually on old, rough bark. Bare, weathered wood does not normally support the lichen, even when the two substrates are contiguous (weathered lignum contributes about 0.1% to the total substrate coverage).

Rock has rarely been reported as a substrate, and remains extremely rare even where boulders and bedrock occur among trees that bear the lichen (Robert Lee, pers. obs. 2002). However, once established, growth there can be good, and the coverage on just 2 large boulders accounts for almost 1% of the total known. *Leptogium rivulare* grows directly on the mineral surface, even when intermixed with moss. One minute instance of growth on soil has been observed by Robert Lee.

Seasonally submerged tree bark is an extremely unusual habitat for lichens, probably because most corticolous lichens cannot withstand immersion. Just as the lichen growth on those parts of rocks above the high water mark provides an obvious waterline around lakeshores, so the growth of all the usual arboreal lichens extends down the tree trunks only to the high water mark in seasonal ponds. By contrast, *Leptogium rivulare* grows only below that mark. Usually there is a gap of several to many centimetres between them. On just three out of many hundreds of trees examined has there been any overlap, and then by only a few millimetres.

Although aquatic and semiaquatic lichens on rocks along streams and lakeshores are well known and are not uncommon (e.g., *Dermatocarpon luridum* (With.) J.R. Laundon, *Ionaspis lacustris* (With.) Lutzoni, *Rhizocarpon lavatum* Hazsl., and *Staurothele fissa* (Taylor) Zwackh), the few species that have been observed to share the Flooded Jellyskin's usual habitat are not so well recognized as being semi-aquatic.

One species, *Lecania cyrtella* (Ach.) Th. Fr., which is fairly common in the Ottawa region (Brodo 1988), has often been found by Robert Lee (pers. obs, 2002) to be abundantly present with *Leptogium rivulare*. It favours the moist lower parts of tree species that grow in seasonally flooded places, but is not restricted to them. Another, rather rare and minute species of *Leptogium*, *L. tenuissimum*, has been noted several times, but it also is clearly able to grow in habitats that are never flooded.

Several other species of minute to almost microscopic lichens, as yet unidentified as to species, or sometimes even genus, have also been noted, sometimes rarely, sometimes abundantly, but thus far only within the flood zone. Two are in the order Lichenales, and two others are in the family Collemataceae, genus *Leptogium*.

Forested swamp habitats such as those used by *Leptogium rivulare* are of frequent, albeit much fragmented, occurrence throughout the deciduous and mixed-woods regions of Ontario. The collection at Wawa would represent an area close to the northern limit of that vegetation zone. As several of the tree species that the lichen

grows on occur well into the boreal forest, however, on that basis the range could conceivably extend north of Lake Abitibi, west to Lake Winnipeg, and east to the Maritimes. The recent collection from near Flin Flon, northwest of Lake Winnipeg, bears out this possibility.

The tree species that thrive in flood-zones are able to establish themselves early in ecological succession. Of those that can grow in the flood zone, and that are being used by the lichen as substrate, Black Ash, Bur Oak and American Elm are also able to persist into old-growth conditions. *Leptogium rivulare* has been found on trees approaching 150 years old, and does not seem bound to any particular stage of succession.

Historically, some of the ponds where *Leptogium rivulare* now occurs have been subject to a major forest fire (>130 years ago), agricultural use of some kind (ca. 100 years ago), and bulldozing for sandpit operations (ca. 50 years ago). In each of these cases, it could have survived either on unaffected substrate (rock or old trees) or in nearby, undisturbed habitat where it is now absent.

Leptogium rivulare may be able to re-establish rapidly, growing on the first woody plants to appear in the flood zone, within a very few years. This is suggested by its occasional appearance on small bushes, such as Red Osier Dogwood. However, as of 2003, Robert Lee has observed this lichen on shrubs only in places that already have heavy growths of *L. rivulare* on nearby trees. It may not spread to bushes until they are flooded with spores from large, existing populations.

Excessive sediment loads in rivers, which leave tree trunks in the floodplain coated in silt when the water subsides, would surely be harmful to *Leptogium rivulare*. Such conditions occur wherever agriculture has become a significant part of a watershed. This degree of siltation has been observed by Robert Lee (during the 1990s and in 2002) in otherwise suitable habitat on islands like Upper Duck Island in the Ottawa River.

Although sediment is not a problem in seasonal ponds, sometimes *Leptogium rivulare* becomes so coated with dried-up algae (*Scytonema* sp.) after the water recedes that its true colour is not evident. Whether this harms the lichen is not yet known.

At the two main locations currently known, the underlying bedrock is limestone and the pH of the floodwater should be well buffered. The historical locations at Lake Temagami and Wawa, however, would have been on soils based on acidic bedrock. In this connection, where the lichen has been observed on rock, that rock has also been granite — not the sign of a lichen susceptible to acidity. When bark is a substrate, it may also be either neutral (elms) or acidic (maples). Among conifers, the only one noted as a substrate, Eastern White Cedar, has bark most like that of deciduous trees (I.M. Brodo, personal communication 2002).

As one or two trees at a given location have been seen to be sufficient to support a vigorous growth of *Leptogium rivulare*, and since it is found in wet places as little as 5 or 10 metres across, there is probably no minimum size of habitat patch, as long as flooding is adequate.

Habitat trends

As trees are the usual substrate, and flooding dictates the type of forest in the flood zone, rather than the stage of ecological succession, the general opening up of the landscape by European colonization probably did not create any additional habitat for *Leptogium rivulare*. Indeed, clearing for agriculture would have removed the trees that are the lichen's necessary substrate around ponds, and, through muddy runoff, would have rendered riverine habitat unusable. In less settled regions, only dams for lumbering and for hydroelectric power are likely to have removed habitat, by drowning it. These are mainly, but not entirely, historical factors. Dams are still being built for small-scale power generation, and for habitat modification.

At present, the threats to habitat known to be occupied by *Leptogium rivulare* are incremental degradation associated with increasingly heavy recreational use at one site, and development outside a major urban centre at the other.

If there is a trend towards a warmer, drier climate, however, then lower springtime flood levels will shrink the habitat and significantly reduce both its horizontal and vertical extent.

Protection/ownership

Unless good populations of *Leptogium rivulare* can be rediscovered in old locations, or found at more than just the two principal localities currently known, its range in Canada must considered to be very restricted. For now, then, the details of land ownership and protection in these places are especially important.

The wetland complex occupied by *Leptogium rivulare* in the locality west of Bells Corners, in Ottawa, is on land owned by the National Capital Commission (NCC). This land has been held for almost 50 years as part of a conservation-oriented greenbelt, and may reasonably be expected to remain in that category. The NCC develops management plans for sensitive features of the environment. But the land in question has no definite protection in law or regulation, and other NCC lands have been sold, traded away, used for highways, and opened to certain forms of development deemed acceptable.

In Pakenham Township, the lichen is present on private land. Although the waterway is subject to both natural and artificial impoundments, these have taken place upstream without appearing to affect the population, minute as it is, or the stream-flow conditions that support it.

The other significant locality, in Darling Township, comprises seven small ponds scattered over about a kilometre of forested land. Ownership is divided among at least seven owners, including the Province of Ontario, Lanark County, and five or more private owners. Two of the ponds are themselves subject to multiple ownership.

The Crown lands are subject to general forestry management practices, including logging. The County land is in the form of an unopened road allowance that cuts across the middle of one of the ponds. In both of these cases, protection could be achieved through formal planning processes — but for only about 6% of the local population.

At present, three of the private landowners are aware of the rarity of *Leptogium rivulare* on their properties, and, with reservations, are informally agreeable to protecting the habitat. (They fear that restrictions might be imposed on them.) Two others are aware, but have not stated their intentions.

It is possible that still more owners are already represented, because some properties are in the process of being subdivided. The location is adjacent to a major recreational lake, and is within commuting distance of Ottawa.

Given the divided and changing ownerships, future protection of the Darling Township locality is in doubt.

BIOLOGY

General

The genus *Leptogium* is one of the jelly lichens, and is characterized by its thin, skin-like thallus containing cyanobacteria (*Nostoc*). The cynaobacteria are not confined to a narrow "algal layer" as in most other foliose lichens, and this genus is therefore considered to be "non-stratified." Cyanobacterial lichens are most often shade and moisture-loving, and they often are found in forests or close to water. This is especially true of *Leptogium*. *Leptogium rivulare* has a special requirement for periodic flooding, making it much more limited in its habitat potential. Cyanobacterial lichens are also notoriously sensitive to air pollution, especially pollution due to sulphur dioxide (Ferry *et al*. 1973).

Leptogium rivulare has previously been known almost exclusively from old herbarium material and the briefest of accompanying notes on habitat and substrate. Although an investigation of its biology is beyond the scope of this report, certain observations made in the field by Robert Lee (pers. obs., 2002) may be pertinent.

Reproduction

This lichen is always abundantly fertile. Apothecia develop when the lichen is small and young, and spores are readily produced. Presumably spores are the major factor in the lichen's reproduction and dispersal. Like all lichens, though, *Leptogium rivulare* can also reproduce by fragmentation. Tiny lobules are formed in some populations and could easily break off the parent thallus and serve as propagules.

If the spores were water-borne, rather than air-borne, as would be more usual in a lichen, this could explain the apparently restricted distribution within a much broader range, and the apparent absence from much suitable habitat.

Leptogium rivulare is regarded as a small lichen, and could probably reach full size (6 cm across) within a decade. But heavy encrustations up to 0.5 m across have now been observed, and if these do not simply result from the confluence of many smaller thalli, the maximum size, and associated age, could be greater.

Leptogium rivulare grows below the high-water mark, mainly on flood-zone trees, in a zone from which most other lichens are excluded. It is the largest of the few lichens that do grow there, and the only one that could overgrow those around it. It may be that lack of competition with other lichens is important. But *L. rivulare* is sometimes found among thick growths of moss over its usual substrate. Some members of the genus (e.g., *L. cyanescens* (Rabinh.) Korber) are able to grow vigorously in such circumstances. Others (e.g., *L. dactylinum* Tuck.) seem to die out as moss grows over them and their substrate. From what has been observed by Robert Lee, *L. rivulare* seems most like *L. dactylinum*, with thalli disappearing under thick mats of rapidly growing moss.

Nothing is known about its growth rate or life span, except what has been observed by Robert Lee. One thallus 2 cm across has been found on a Dogwood stem only 4 years old (as determined by counting both rings and whorls of leaf scars). This suggests a potential growth rate of 2.5 mm per year, which is comparable to other arboreal foliose lichens (Brodo *et al*. 2001).

Most growth may well take place during or immediately after spring immersion, as the margins of several different thalli, measured against pins driven into the bark a month after the waters receded, extended outward only 0.2 to 0.6 mm between early August and November in 2002. Growth was equally limited during the whole of 2003, when floodwaters did not rise high enough to immerse the lichen.

Survival

The survival of this species depends on periodic or at least occasional inundation, coupled with subsequent prolonged exposure to the air. This necessitates its inhabiting somewhat unstable habitats. Such flooding, however, does not appear to be absolutely necessary for the year-to-year survival of individual lichens. In recent years, at some

ponds, spring water levels have fallen 25 to 50 cm short of known maximums, and equally short of covering all the existing lichen. Most, but not all of the lichen, which has been stranded for at least six seasons, appears to be healthy.

In most of the ponds where *Leptogium rivulare* occurs, it occupies only a part of the substrate available, whether tree bark or rock. There would seem to be room for further growth of the population in these places. There are also innumerable places within the Canadian range with suitable habitat. The problem may well be one of dispersal.

Physiology

Little is know about the physiology of even the most common species of *Leptogium*, other than they seem to require fairly shaded, humid habitats (Brodo, pers. comm., 2002).

The most northerly region where *Leptogium rivulare* is known to have occurred in Canada (near Flin Flon, in Manitoba) has a subhumid high boreal ecoclimate, with mean annual precipitation of 400-500 mm, and mean temperatures summer and winter of 12.5º and -18.5º C, respectively (Ecological Stratification Working Group, 1995). The Ontario localities are more humid, with 800-1000 mm of precipitation, and warmer (16º and -7º C). *L. rivulare* is a cool-temperate to boreal species, and given its greater range in Europe (north to Finland, and south to the Seine in France), it may be able to withstand greater temperature extremes than the limited Canadian distribution would indicate.

The restriction to periodically flooded places implies a physiological capacity to survive immersion that is evidently lacking in all but a select few other lichens observed in the same or similar habitats. And while it can withstand immersion at depths of up to 2 metres, for periods as long as three months, this lichen also seems to require eventual exposure to the air.

Although, as a species, *Leptogium rivulare* has an absolute requirement for substrate that is flooded periodically, this seems to be related to some very early stage in the lichen's life cycle, rather than physiology. While this could have to do with some alteration of the substrate (such as leaching of bark) necessary for spore germination, it more probably relates to spore dispersal.

Dispersal

The general dispersal ability of *Leptogium rivulare* is probably low, as indicated by its very restricted distribution, occurring at very widely scattered points across an extensive geographic range, despite the widespread availability of habitat. Conversely, very local dispersal, within the range of a single wetland, appears to be excellent. Dispersal at intermediate range, between nearby ponds, is spotty.

This pattern of distribution could be explained if water were the medium for dispersal of the spores. Long-range dispersal would be extremely unlikely; intermediate-range dispersal by four-footed animals acting as carriers would be possible, but limited, and dispersal within the reach of spore-bearing waters could be highly effective.

Several observations lend support to this possibility. Firstly, as noted above, the lichen's requirement for flooding seems to have to do with spore dispersal or germination, rather than long-term survival.

Secondly, Robert Lee (pers. obs., 2002) has found spores that appear to be those of *Leptogium rivulare* in the floodwaters around trees that bear the lichen, while spores from almost all other lichens are absent. These spores adhere to substrate surfaces (such as plastic "microscope slides," which were set out experimentally) as the water levels fall.

Thirdly, on some trees and boulders in one of the ponds with unique characteristics, *Leptogium rivulare* sometimes forms a thick growth like a collar or bathtub ring just below the high water mark. This pond differs from the others in that it floods to the same level every year (additional water spills out into adjacent swamps). This would repeatedly bring water-borne spores that are floating on the surface to that point. All of the other ponds with *L. rivulare* occupy basins that lack such well defined sills. Meltwater and spring rains fill them to different depths every year. In these places, the lichen occurs irregularly down the tree trunks.

Although the waterborne mechanism of dispersal is not proven, and other interpretations could be advanced, the possiblity does have implications.

Along waterways, downstream dispersal by water ought to be very effective. But waterways are subject to damming and siltation, and the habitat may well have been seriously disrupted or lost in much of eastern North America and Western Europe.

The widely scattered points of occurrence, usually separated by many hundreds of kilometers, could also derive from water-borne spores, as the result of long-distance migration of ducks, as carriers. Two species, the Wood Duck (*Aix sponsa*) and the Hooded Merganser (*Lophodytes cucullatus*) have regularly been observed courting on some of these ponds in full flood, before their final dispersal for breeding. But it is obvious from the lichen's rarity that, if it occurs, dispersal by such means is not very effective.

It has been suggested by Jørgensen & James (1983) that these scattered occurrences could also represent relict populations from a more widespread distribution. This is suggested by the amphi-Atlantic distribution, which may date from a time when Europe and North America had a more continuous flora.

Without intervention, repopulation from sources outside Canada seem most unlikely, for *Leptogium rivulare* is at least as rare everywhere else. If the spores are waterborne, however, it may be possible to introduce the species to new sites. That this might turn out to be rather easy is suggested by the circumstances surrounding the anomalous site in Pakenham Township, discussed below under Population Sizes and Trends.

Nutrition and interspecific interactions

Nothing is known, other than the fundamental symbiotic relationship between the fungus that gives form to the lichen, and its photobiont, the cyanobacterium *Nostoc*. Through photosynthesis, the latter generates the carbohydrates that are used by both partners.

Adaptability

Leptogium rivulare is extremely habitat-specific throughout its global range, and within that habitat effectively requires a substrate provided by only those few species of deciduous trees that can withstand regular flooding. On such trees, it grows almost exclusively on the bark, and not on exposed wood; hence the trees must be alive, or else serve as a substate only until the bark falls off. It does grow on shrubs and saplings, as well as mature trees, so has the potential to establish itself in recently disturbed and also newly developed habitats. However, almost all occurences on shrubs, rocks, and unusual tree species have been in the midst of heavy populations of the lichen on surrounding trees, where extraordinarily abundant reproduction may flood all substrates in the immediate area with spores.

POPULATION SIZES AND TRENDS

What populations might have been, or might still be, at the sites of two of the old records (at Lake Temagami and Wawa) are not known. Such records (herbarium specimens) indicate only the presence of the species there at the time of collection (1946 and 1965, respectively). These sites were too vaguely recorded to facilitate a renewed search for them.

The finding, in 2001, of a substantial population of the lichen in the area of the original Ottawa collection, made in 1972, suggests that they are one and the same, although it has not been possible to verify that it coincides with the exact same site (I.M. Brodo, personal communication).

Apart from the recently discovered occurrence in Manitoba, *Leptogium rivulare* is therefore currently known from only three circumscribed localities 15 to 35 km apart, which are treated here as separate populations. At this point, long-term trends can only be inferred from what is currently observable.

Examination of every tree and rock in all but one of the flood zones, together with rough but thorough measurement of the amount of lichen on each one, has provided a good basis for estimating the remainder. There is a total of about 40 square metres of the lichen (plus or minus 15%), with 70% being in the Ottawa location, and 30% in Darling Township. The six thalli in the Pakenham Township population account for only 0.03% of the total.

Within the two main populations, there is a similar range of distribution from pond to pond, with about 70 to 85% being in one main pond in each case, and lesser to quite minute amounts in the associated ponds. The detailed notes that have been taken will allow these populations to be tracked in the future.

In these two localities, Ottawa and Darling Township, the lichen occurs almost exclusively on tree bases around seasonal ponds. It forms irregular growths on dozens to many hundreds of trees in these places. On some trees, it is barely present; on others, it forms large, encrusting patches about 50 cm across. The great numbers of small thalli often scattered over the bark indicate that successful reproduction is occuring, while the large patches show persistence over many years. Almost all individuals are fertile, and are capable of reproducing when only a few years old. There is no general sign of decline, but on one pond it appears senescent and may have been stranded above the floodwaters for too many years. In another pond, heavy and extensive growths of moss seem to be rapidly covering the lichen on a significant number of trees.

The lichen has sometimes been reported from sluggish waterways, so the third locality, being on a quite turbulent section of Indian Creek in Pakenham Township, raises some interesting questions. Could *Leptogium rivulare* exist on rocks in similar watercourses elsewhere? Careful checking upstream from this site, and examination of similarly placed rocks in other creeks and rivers, has failed to reveal any.

It is also questionable whether the Indian Creek site is a natural population. There is reason to think it may be the inadvertent result of a unique and accidental introduction. Thorough checking of all known habitat that might feed into Indian Creek failed to reveal the lichen anywhere but in the creekbed, and there, it has been found only downstream from a certain point.

All six thalli that came to light in three hours of intense searching among hundreds of boulders were at the same level in the dry creekbed, at the top of the zone occupied by the semi-aquatic lichen, *Dermatocarpon luridum*. In 2002, four of the six thalli were the same size (about 6 cm across), and two were about half that size. The growth rate inferred elsewhere indicates that the larger specimens might all be about 10 years old. These observations suggested a single point introduction, at a time when the water stood at one particular level.

Review of Robert Lee's notes reveals that on June 23, 1994, during a heat wave that followed heavy rainstorms, he and some fellow naturalists went wading, fully

clothed, for an hour in the Ottawa pond where *Leptogium rivulare* has subsequently been found to grow most abundantly. On yet another very hot day about a week later, he and one of these same people sat for a long time with their pant legs in the cool, turbulent water just upstream of the Indian Creek site. The floodwaters were just beginning to subside. If, as is discussed below, the spores are dispersed in water, they could have accumulated on clothing at the first site, and been washed out at the second. The spores would have landed on the tops of flat rocks where the lichen is now found, just as the water was falling away from them for the season. The timeline and the spatial distribution seem to allow for this interpretation.

Whether or not the lichen reached Indian Creek by accidental transfer, perhaps the important point is that it has established itself there. The discovery of *Leptogium rivulare* on a stony beach in Manitoba, also in close association with *Dermatocarpon luridum*, suggests that these apparently anomalous habitats are at least viable possibilities.

LIMITING FACTORS AND THREATS

Given its restriction to seasonally inundated habitats, the most obvious threat to the survival of populations of *Leptogium rivulare* is alteration of the water levels or the periodicity of their fluctuations. Changes of these kinds commonly occur when swamps are drained for agricultural uses or to make land areas available for urban development or road building. The damming of rivers greatly affects periodic flooding downstream, and would thus affect the potential habitat of *L. rivulare*. Hardly a river system anywhere within the range of this species is not regulated to some extent by damming for flood control or hydroelectric power generation.

Across much of its range, lakes were also dammed at their outlets for early timber operations. If the lichen existed on their shoreline rocks, as is now known to be the case at a single Manitoba site, permanent flooding may have eliminated it.

Seasonal ponds that fill with meltwater should be unaffected by alterations to waterways or lake systems. But in unusually dry years, most of the ponds where the lichen occurs do not fill to normal levels in spring. As the species typically occurs in the upper 50 cm of the flood zone, a shortfall of 25 cm, such as has been observed in two recent years, may deprive the top half of the lichen population of the condition that is an absolute requirement for its persistence. If spore dispersal is by water, then that part of the population left stranded will not contribute to reproduction, either.

Another possible threat is the loss of the trees that are almost the only substrate the lichen grows on. Commercial logging is unlikely, because of the usually low quality of the tree species involved. But in some ponds, the species has been found on as few as two trees. Hence, even removal or destruction of trees on a small scale, such as a surveyor cutting a sight line, could have a significant impact. In the past four years at the Darling Township site, such trees have occasionally been removed for firewood (two

properties), surveying (one property), recreational trail cutting (two properties) and private, personal-use, sandpit operations (one other property).

Increasingly, too, trees are subject to potentially devastating alien diseases and pests. One of this lichen's substrate trees, American Elm, has already been decimated by an introduced fungus, which we call Dutch elm disease. Two other species, Black Ash and Red Ash, face a new threat. In 2002, an alien beetle, the Emerald Ash Borer, appeared in North America. It not only killed great numbers of ash trees in southeastern Michigan, but prompted the clearing of these trees from quarantine zones (Roberts 2003). The beetle has been found in Canada, in southwestern Ontario (Ash Rescue Coalition 2003).

At the Ottawa site, the potential for damage to the trees by vandalism is to be expected. Recreational users from massive new subdivisions nearby have recently created a new, unauthorized footpath immediately beside the two heaviest populations of the lichen. Also, as the nature of this location changes from freely rural to a large urban park, declining air quality may ultimately become a survival issue for *Leptogium rivulare* there.

ABORIGINAL TRADITIONAL KNOWLEDGE

There seems to be no indication that *Leptogium rivulare* ever found use among aboriginal peoples (e.g., Moerman 1999). This is not surprising, considering how rare it seems to be. Also, it does not seem to have any of the features that have made other lichens useful: it contains no special substances that would give it properties for the dyeing of other materials; it has no structural integrity, such as would make it useful fiber; and it is too insubstantial to have attracted attention even as a starvation food.

SPECIAL SIGNIFICANCE OF THE SPECIES

Given the paucity of records (about a dozen) across both time (two centuries) and space (two continents), the lichen has evidently always been rare throughout its range. In Europe, it is listed as endangered in the Red Lists of Lichens of both Estonia and Sweden, and as regionally extinct in Finland (Randlane 1998; ArtDatabanken SoknigRodlista, Rödlistade arter i Sverige 2000; and Government of Finland 2000). In the United States and in Canada, the old collection sites do not appear to have been successfully revisited in recent times. In Ontario, it has an SH ranking, signifying an absence of any records in the last 20 years. No G or N ranking has been assigned (NHIC 2002).

Of the three localities currently known in Ontario, only one is in any way protected.

The unique habitat requirements of *Leptogium rivulare* make it very special, not only among other species of *Leptogium*, but among lichens in general. Understanding

its physiological requirements and capacities with respect to periodic inundation may help to interpret the requirements and life cycles of other riparian organisms.

SUMMARY OF STATUS REPORT

Leptogium rivulare is a globally rare lichen with very restrictive habitat requirements. In Canada, it has previously been known only from a few herbarium specimens. These have indicated nothing about the populations involved. Four localities are now known. Populations at two sites are relatively large but the two others are much smaller. The largest population is protected, albeit weakly, by federal regulations.

Both of the major localities are susceptible to degradation associated with the observed increase in use and development of the lands. More generally, potential habitat is easily diminished or even eliminated by interference with the extent or duration of spring flooding. This lichen also has a requirement for living tree bark as a substrate, and thus depends on the existence of a living flood-zone forest. The main threats to these forests are introduced pests and diseases. The lichen itself appears to be susceptible to competition from mosses, which overgrow it.

The central question is whether the lichen is truly as rare as the extremely sparse records indicate. On the one hand, there are innumerable patches of potential habitat across its range, and it is unikely that we have found all the *Leptogium rivulare* that exists.

On the other hand, the region where the species is now found has been well studied by lichenologists, and careful searching of the full range of habitat possiblities in more than 60 sites, in the vicinity and region of the existing and historical populations, has failed to turn up any sign of it.

TECHNICAL SUMMARY

Leptogium rivulare
Flooded jellyskin — Leptoge des terrains inondés
Range of Occurrence in Canada: ON, MB

Extent and Area Information	
Extent of occurrence (EO)(km²) Three currently known sites in Ontario only: All four currently known sites (Ontario and Manitoba):	 130 km² 107,000 km²
• *Specify trend in EO*	stable
• *Are there extreme fluctuations in EO?*	no
• *Area of occupancy (AO) (km²)*	0.2-0.3 km^2 (2-3 hectares of lowland forest)
• *Specify trend in AO*	stable
• *Are there extreme fluctuations in AO?*	no
• *Number of known or inferred current locations*	4
• *Specify trend in #*	unknown
• *Are there extreme fluctuations in number of locations?*	no
• *Specify trend in area, extent or quality of habitat*	stable
Population Information	
• *Generation time (average age of parents in the population)*	3-4? years
• *Number of mature individuals*	10's of thousands
• *Total population trend:*	stable
• *% decline over the last/next 10 years or 3 generations.*	not applicable
• *Are there extreme fluctuations in number of mature individuals?*	unknown
• *Is the total population severely fragmented?*	yes
• *Specify trend in number of populations*	not applicable
• *Are there extreme fluctuations in number of populations?*	unknown
List populations with number of mature individuals in each:	see appendix 1
Threats (actual or imminent threats to populations or habitats)	
Habitat reduction resulting from climatic change; substrate loss through invasive alien pests and disease; habitat loss from urban development	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* Restricted to Canada in North America	
• *Is immigration known or possible?*	No
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Yes
• *Is rescue from outside populations likely?*	No
Quantitative Analysis	Not applicable
Other status	Not applicable

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** D2

Reasons for Designation:
This is a globally rare species currently known in Canada from only 4 locations, all in Ontario and Manitoba. The species has very restricted habitat requirements, found primarily at the margins of seasonal (vernal) pools, where it grows on rocks and at the base of living deciduous trees between the seasonal high and low water marks. It is vulnerable to changes in normal patterns of annual flooding, as well as to death of host trees. Major threats to the largest populations include urban development and recreational activity.

Applicability of Criteria

Criterion A (Declining Total Population): does not meet thresholds for decline

Criterion B (Small Distribution, and Decline or Fluctuation): meets some criteria for Endangered (area of occupancy < 500km^2, severely fragmented populations) but does not meet decline criteria.

Criterion C (Small Total Population Size and Decline): does not meet threshold for small population size (population estimate > 10,000)

Criterion D (Very Small Population or Restricted Distribution): does not meet threshold for Endangered, small population (population estimate > 10,000), but does meet criteria for Threatened, area of occupancy < 20km^2 and small number of locations (<5)

Criterion E (Quantitative Analysis): not applicable

ACKNOWLEDGEMENTS

I wish to acknowledge the invaluable help of Dr. I.M. Brodo for examining the existing collections in the National Herbarium at the Canadian Museum of Nature with me, reviewing my own collections in the field and in the laboratory, directing me to the relevant literature, and for discussing the possible biology of the species with me.

I also thank David Cornell for alerting me to the Darling Township locality, by bringing a sample of the lichen to my door; and Barbara Gaertner for general assistance in the field. Sarah Coulber invited me to search her Bramble Hill Farm ravine. Other landowners gave me general permission to search for lichens on their lands.
Ian Huggett searched the Lake Temagami area for suitable habitat.

Being familiar with this species, both Irwin Brodo and Barbara Gaertner have searched additional sites for *Leptogium rivulare*, giving Robert Lee greater confidence in his own assessment of its rarity.

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BIOGRAPHICAL SUMMARY OF THE REPORT WRITER

Robert Lee is a general naturalist with progressively more specialized interests in trees, forest ecology, and lichens as indicators of old-growth. Among lichens, he prefers the generally more inconspicuous crustose species, especially the calicioid old-growth indicators, but he has also taken an interest in the genus *Leptogium*. He received a B.Sc. in Wildlife Biology from the University of Guelph in 1978. He carries out long-term field studies on trees, frogs, and mammals, in which the organisms are identified as individuals and followed.

For 18 years, Mr. Lee has been much involved in the outdoor education of children and young adults through the Macoun Field Club, of which he is Chairman. He received the Anne Hanes Natural History Award in 2000 from the Ottawa Field-Naturalists' Club for his work on Leopard Frogs, and other field studies.

His most recent publication is a 55-page chapter detailing the findings of a four-year field investigation carried out by the National Museum of Canada in the 1950s, in "The Sheguiandah Site: Archaeological, Geological and Paleobotanical Studies at a Paleoindian Site on Manitoulin Island, Ontario," P. Julig (ed.), Archaeological Survey of Canada, Mercury Series, Paper 161. 2002.

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Ethan Meleg, Outreach Co-ordinator, Bruce Peninsula National Park, Fathom Five National Marine Park.

Richard Pratt, Canadian Wildlife Service, 49 Camelot Drive, Ottawa, Ont. K1A 0H3.

Andrew Promaine, Bruce Peninsula National Park, Ontario (negative response forwarded by Robert Alvo).

Keith Wade, Pukasaw National Park, Ontario (negative response forwarded by Robert lvo).

COLLECTIONS EXAMINED

Canada, Ontario. Carleton County (Ottawa Region): on base of *Fraxinus* in swamp, 10 Oct. 1971, I.M. Brodo no. 18746 (with F. Brodo and H.L. Dickson); determined by P.M. Jørgensen (CANL); Algoma District: Wawa, near "washout" on Magpie River, on base (partly flooded in spring) of *Fraxinus nigra*, 24 June 1965, Fabius Le Blanc, no. 1-7; determined by I.M. Brodo (CANL). Manitoba. Red Rock Bay in Payuk Lake, ca. 30 km SE of Flin Flon. Rocky island with pre-Cambrian granite and *Pinus banksiana*, and opposite shore with shaded brook and cascade. 16 June 2003, I.M. Brodo no. 31235 with Michele Piercey-Normore, Tom Booth & Fenja Brodo.

Robert Lee has placed about 25 specimens in his own collection and that of the Macoun Field Club, from each of the Ontario sites he has visited. Ottawa: R.E. Lee nos. 756, 926, 1152; Lanark County (Darling Township) R.E. Lee nos. 731, 732, 864, 865, 866, 867, 868, 869, 875, 878, 880, 887, 888, 889, 892, 894, 899, 936, 1088; Lanark County (Pakenahm Township), R.E. Lee nos. 919, 924, 925, 927. Selected specimens will be donated to the National Herbarium (CANL).

Appendix 1. Amount of *Leptogium rivulare* at each site.

Locations & sites	Amount of lichen (m^3)	Number of trees available	Comments on distribution within each site
Ottawa			
Pond IX	24	2400	Lichen evenly distributed
Pond X	3.5	250	Evenly distributed
Pond XI	0.1	150	Sparse and dispersed
Area C21d	0.5	300	Sparse and dispersed
Area B10f	0.05	50	Sparse
Area B10g	0.005	50	On one tree
Subtotal	28.155		
Darling Twp.			
Pond 18	0.07	55	On only three trees
Pond 19	1.2	630	Concentrated on E side
Pond 21	0.25	100	Unevenly distributed
Pond 22	8.1	1590	Concentration on N side
Pond 23	0.25	29	Concentrated on E side
Pond 24	0.6	230	Concentrated in NW corner
Pond 26	1.5	600	Evenly distributed
Subtotal	11.97		
Pakenham Twp.	0.01	On rocks	Dispersed on a few of the many boulders and ledges
Total from all three localities	**40.135**		**Plus or minus 15%**

Appendix 2. Suitable habitat where *Leptogium rivulare* was not found.

Within 1 km of the Ottawa, Ontario population:

Area C12a: Black Ash swamp

C13j: Black Ash/ White Cedar swamp

C33: Open American Elm swamp

W of Pond XI: Black Ash/ Glossy Buckthorn swamp

B5b: Black Ash swamp

B5e: Black Ash swamp

A5a: Black Ash floodway

A5b: Red Maple swamp

Pond SE of Pond XI: Red Maple swamp

Pond VIII: seasonal pond with fringe of Red Maple and Black Ash

A1e: Small seasonal pond with American Elms

Within 1 km of Darling Township population:

Old-growth East: Old-growth White Cedar swamp with Black Ash

Old-growth Main: Old-growth White Cedar swamp with Black Ash

Old-growth S branch: Old-growth Black Ash

Opposite Cedar Cove: Seasonal pond fringed with American Elms

Twice S of sandpit:: Seasonal pond fringed with American Elms

Pit near Butternut den: Seasonally flooding hollow with Balsam Poplar

Pond near road: Swampy pond with Black Ash

Pond near hawk nest: Seasonal pond with Black Ash

Swamp by lake: Cedar/ Black Ash swamp

Within 1 km of the Pakenham Twp., Ontario population:

W of High Pond: Red Maple swamp

W of High Pond: another Red Maple swamp

W of High Pond: a third Red Maple swamp

Stream from High Pond: Black Ashes in floodplain

Far Field-end Pond: Black Ash swamp

Buttonbush pond: Thick with Cephalanthus

Below Butternut Pond: Black Ash floodway

Above Butternut Pond: Black Ash floodway

Car-door Pond: Black Ashes standing in water

Stream below access road: Black Ash floodway

Old-road stream: Black Ash floodway

W of Rock-wall Pond: Red Maple swamp

Stanley Ck. culvert: Black Ash floodway

Stanley Ck streambed: Boulders and bedrock

Indian Ck. at dam: Black Ashes and boulders that flood

Indian Ck. below dam: Boulders of streambed

Indian Ck. waterfall: Black Ashes and boulders of floodway

SE of High Pond: Red Maple swamps

Willis Lake, Darling Twp., Ontario:

Poplar hollow: Vernal pool with poplars

Rock-bound pool: Seasonally flooded hollow with Red Maples

Hanging valley: Black Ash swamp

S of White Lake, Darling Twp. Ontario:

High ravine: Small-stream floodplain with Black Ash

Trail to Darling Long Lake: Small-stream floodplain with Black Ash

Trail to Darling Long Lake: Black Ash swamp

Arnprior, Ont. (Gillies Grove):

Hollow with American Elms

Pakenham Village, Ont.:

Creek floodplain: ashes and elms

Blakeney Rapids on the Missisippi River, Ont.:

Riverbank willows

Bramble Hill Farm on the Missisippi River, Ont.:

Narrow floodplain in forested ravine: Black Ash and American Elm

Petrie Island in the Ottawa River, below Ottawa:

Flooding Red Maple forest; checked by I.M. Brodo

Upper Duck Island in the Ottawa River, below Ottawa:

Flooding sandbar island with Red and Silver Maple forest

Leitrim wetlands, E side of Ottawa, Ont.:

Old-growth Black Ash swamp; checked by I.Brodo

Greens Ck., E. side of Ottawa, Ont.:

Silver Maple floodplain forest; checked by B. Gaertner

Sawmill Ck, near Wakefield, Que.:

Red Ash, American Elm, and willow on ravine floodplain

Old Sawmill Ck. Rd., near Wakefield, Que.:

Small swamp with Black Ash and American Elm

Noire River, Que. - island at Forant Ck.:

Silver Maple forest on floodplain

Noire R., Que. - lowest rapids on Forant Ck.:

Boulders in mid-stream, exposed by low water levels

Noire R., Que. - Mountain Chutes portage:

Small Black Ash swamp on hillside

Noire R., Que. - below Mountain Chutes:

Riverbank boulders and bedrock exposed by low water levels

Noire R., Que. (meander camp):

Silver Maple forest and Black Ash swamp on river floodplain

Noire R., Que. (1st ox-bow lake):

Silver Maples along old riverbank in flood zone

Noire R., Que. (2nd ox-bow lake):

Silver Maples and alders fringing old riverbank, in flood zone

Anima Nipissing Lake, N of Lake Temagami, Ont.:

Black Ash swamp, checked by I.M. Brodo