The Status of
Graceful Felt Lichen
(*Erioderma mollissimum*)

in Newfoundland and Labrador

Photo: John E. Maunder

THE SPECIES STATUS ADVISORY COMMITTEE
REPORT NO. 19

April 28, 2008

ASSESSMENT

Assessment: Endangered	**Current designation:** None
Criteria met: B1. Extent of occurrence < 5,000 km^2 and B2. Area of occupancy < 500 km^2, a) known to exist at < 5 locations, b) continuing decline observed, inferred and projected in iii) area, extent and quality of habitat, and D1. Number of mature individuals < 250	
Reasons for designation: Qualifies as "*endangered*" under the SSAC/COSEWIC criteria B1and B2 (a) and (b) iii, and D1. • Restricted to two disjunct locations on the Avalon Peninsula • Only 18 individuals known from a total of 9 trees • Continuing overall decline in habitat resulting from forestry and other human activity • Availability of future trees for colonizing compromised by moose browsing • Rescue effect unlikely	

The original version of this report was prepared by David H.S. Richardson and was subsequently edited by the Species Status Advisory Committee.

STATUS REPORT

Erioderma mollissimum (Samp.) Du Rietz

Synonomy: *Lobaria mollissima* Samp.
Erioderma wrightii var. limbatum Nyl.
Erioderma limbatum (Nyl.) Vain.

Common Name: Graceful Felt Lichen

Family: Pannariaceae
Life Form: foliose epiphytic cyanobacterial macrolichen

Distribution

Global:

Erioderma mollissimum occurs in both the northern and southern hemispheres and is found in North America (Mexico, USA and Canada), Central America (Costa Rica), the Caribbean (Dominican Republic), South America (Brazil, Colombia, Ecuador and Venezuela), Southern Europe (Spain, Portugal), the Atlantic Islands (Azores, Madeira and the Canary Islands) and Africa (Kenya) (Jørgensen & Arvidsson, 2001; Jørgensen & Sipman, 2002; Sipman & Wolf, 1998; and Spielman, 2006) (Figure 1). There are additional reports of *E. mollissimum* from Asia (Thailand, and Indonesia), and Macronesia (Buaruang *et al.*, 2004; Jørgensen, 2000; Jørgensen & Sipman, 2002; and Boonpragob, 2006).

In the USA, *Erioderma mollissimum* was first found at high elevations in the Great Smoky Mountains of North Carolina, in 1941; and was later found in Tennessee, in 1962 (Maass, 1983). The species was also recently reported from SE Alaska, north of Juneau (collection verified by Irwin M. Brodo) (Geiser *et al.*, 1998). However, Jørgensen (2000) expressed doubt regarding the Alaska record; this matter requires further investigation. These three are the only known USA records.

Figure 1: Known worldwide distribution of *Erioderma mollissimum* based upon information gathered from publications and on-line data on herbarium holdings. The dots mark the localities where *E. mollissimum* is definitely known to occur. Records from Thailand, Indonesia, Macronesia, and Alaska are not shown as the identities of the collections from these localities require confirmation. The map was produced by R. Cameron based upon data gathered by David Richardson and Robert Cameron.

National:

The first record of *E. mollissimum* from Canada was by Jørgensen (1972) who found a fragment of the species associated with the 1902 type specimen *of Erioderma pedicellatum*, the Boreal Felt Lichen, from Campobello Island, New Brunswick (Jørgensen, 2003). The species was later found in New Brunswick's Fundy National Park, and subsequently in Nova Scotia (Maass 1983). Recent field research, in Nova Scotia, aimed at establishing the distribution of rare pollution-sensitive cyanolichens such as *E. pedicellatum*, has resulted in the discovery of new *E. mollissimum* localities. *E. mollissimum* is now known from 18 localities in southern and eastern Nova Scotia (for Nova Scotia, researchers have defined a "locality" as an occurrence which is 1 kilometre or more from the next known occurrence). Of the two localities reported for New Brunswick, the one in the Fundy National Park is

on a mossy cliff face in a brook ravine near the Fundy Coast (Gowan & Brodo, 1988); it has not been revisited since the original 1980 collection as the site is difficult to reach. The other locality, at Campobello Island, has been searched intensively for *E. mollissimum* since it was first reported there, but without success; thus the species appears to have been extirpated there, possibly as a result of environmental changes (Maass, 1980).

Provincial:

E. mollissimum was first discovered in Newfoundland and Labrador by Wildlife Division botanist Claudia Hanel, on October 6, 2006, while visiting a field site on the Avalon Peninsula west of Ninth Fox Pond, close to the Hall's Gullies forest access road. Hanel noted soredia (asexual propagules) on an *Erioderma* thallus, and brought this fact to the attention of Tom Neily and Robert Cameron, who identified the lichen as *E. mollissimum* on the basis of their experience in Nova Scotia (Pitcher, 2007). This identification was confirmed by the recognized *Erioderma* authority, Per Magnus Jørgensen, University of Bergen, Norway, who examined material from Hall's Gullies in December 2007.

E. mollissimum is still known only from two localities on the Avalon Peninsula, at Hall's Gullies and Southeast Placentia (Figure 2). These localities are approximately 33 kilometres apart. The present total population consists of eighteen mature *E. mollissimum* on nine individual trees.

Annotated range map

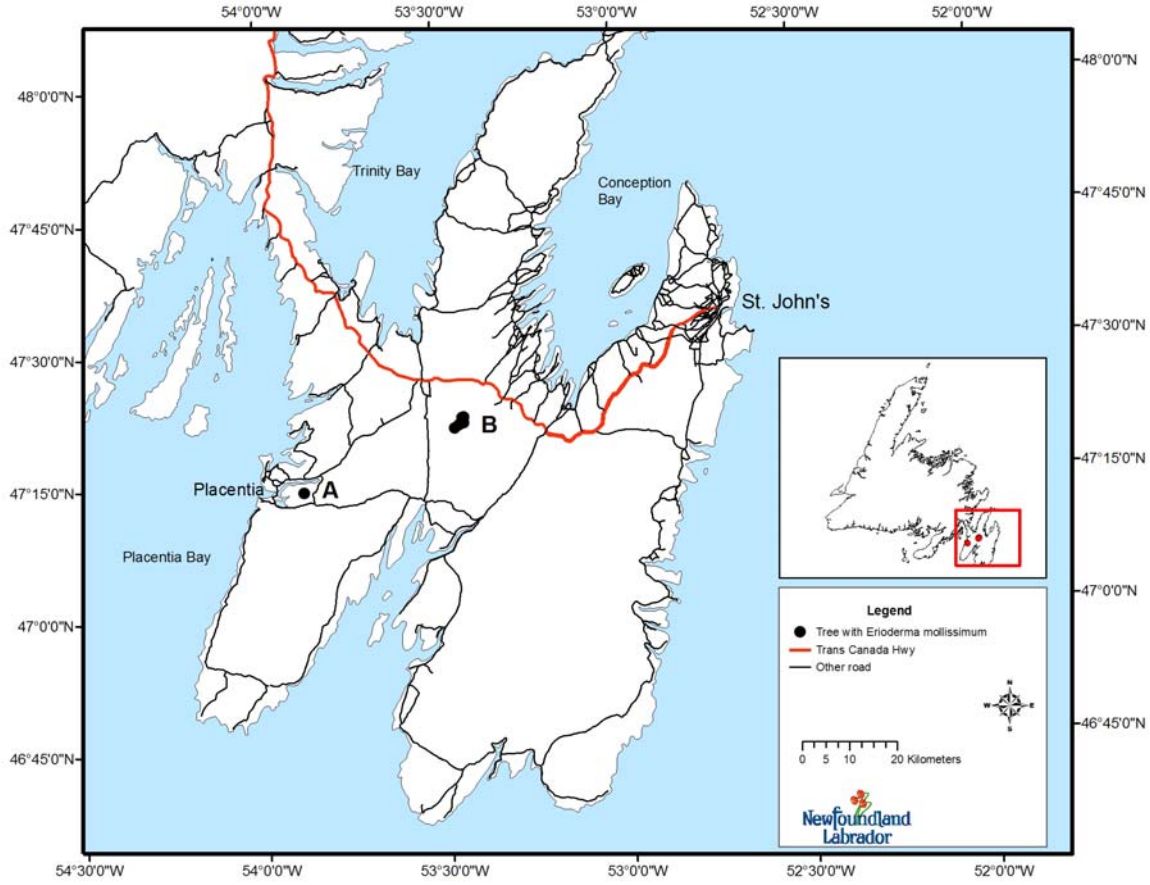

Figure 2: The known distribution of *Erioderma mollissimum* on the Avalon Peninsula, Newfoundland: (A) Southeast Placentia, (B) Hall's Gullies. Map produced by Claudia Hanel.

Description

E. mollissimum is a foliose (leafy) lichen, grayish when dry to brownish-green when wet. It forms roundish patches that are very seldom more than 10 cm in diameter, and generally less than half this size. The lobes are thick (up to 0.5 mm), and rounded with upturned edges. There is a felt-like tomentum (fine hairy covering) on the upper surface and soredia (granular asexual reproductive structures) occur on older thalli on the lobe margins and scattered in clusters on the upper surface. There may be marginal hairs. The lower surface is brownish except for a narrow zone at the margin which is white. This species is the sorediate counterpart of the subtropical species *Erioderma wrightii*, from which it differs mainly in possessing marginal granulose bluish soralia (Jørgensen 2001). Individual

thalli are quite variable in appearance within its range, especially with respect to the abundance of soredia, hairiness and colour.

Apothecia (fruit bodies) are extremely rare, (Jørgensen, 2000), and had not been found in North America until March 2008 when a fertile specimen, with apothecia, was discovered by Tom Neily near Jones Harbour, Shelburne County, Nova Scotia. The diagnostic features of the fruit bodies (apothecia) on *E. mollissimum* are the presence of hairs on the margins and the dark brown colour of the discs. The fertile specimen was growing on a Red Maple (*Acer rubrum*) in a somewhat exposed treed swamp. The thallus appeared to be very mature as it was abundantly sorediate (Tom Neily, pers. comm.)

Habitat

E. mollissimum, over much of its range, grows as an epiphyte on the bark of tree boles (i.e. the trunk below the branches), typically at elevations below about 2500 metres, in moist montane rain forests. Occasionally it is found on moss-covered rocks, banks or roadsides, or on secondary growth shrubs (Jørgensen & Arvidsson, 2001).

In continental North America, *E. mollissimum* occurs within the combined ranges of the firs *Abies balsamea* and *A. fraseri* (Maass, 1983). In its more southerly localities of the southeastern USA, this lichen colonizes the trunks of deciduous trees along lowland rivers. In upland and northern areas, it is confined to forests where it grows on firs, especially Balsam Fir. It can be occasionally found on other trees such as Red Maple, Yellow Birch (*Betula alleghaniensis*) and Red Spruce (*Picea rubra*). In Fundy National Park, New Brunswick, there is a single historic (1980) record of one thallus collected from a wet, mossy cliff face in a brook ravine.

In Newfoundland, *E. mollissimum* occurs in two separate ecoregions. The Hall's Gullies locality, within the Avalon Forest Ecoregion (Damman, 1983), is a mosaic of wetlands and forests characterized by very humid conditions (Delaney *et al.*, 1978). The Southeast Placentia locality, within the Maritime Barrens Ecoregion (Damman, 1983), is characterized by forest cover limited to protected valleys and coves, while slope-bogs, basin-bogs and fens are also common. At this locality, *E. mollissimum* occurs on the north-facing side of a valley that is 1 km wide and approximately 5 km long, runs east-west and is surrounded on three sides by large water bodies, again creating a very humid condition (Cameron *et a*l., 2008).

In Newfoundland *E. mollissimum* has only been encountered on Balsam Fir (*Abies balsamea*). In Nova Scotia it is also occasionally found on this

tree, but the usual host is Red Maple; it has also been found twice on Yellow Birch. Red Maple and, particularly, Yellow Birch have a base-rich bark which has a better buffering capacity than that of Balsam Fir. Thus, Red Maple and Yellow Birch may become preferred hosts in areas exposed to acid rain.

In Nova Scotia, *E. mollissimum* is most frequent on trees of rather open forests that grow on very wet *Sphagnum* moss-covered ground. In Newfoundland the presence of extensive carpets of *Sphagnum* appears not to be essential. The key factors in both provinces seem to be high humidity, high rainfall (or coastal fog), and a moderate temperature. The Avalon Peninsula with its high level of precipitation (some 80% of this falling as rain), and lack of extreme temperatures, appears to be very suitable for the growth of this cyanolichen. It is not yet understood why some trees carry one or more thalli while others nearby are not colonized. It may be a question of competition by other epiphytes or the result of grazing damage to young thalli by invertebrates, particularly mites and slugs. Such damage has been observed on *E. pedicellatum* and could well occur on the related *E. mollissimum* (Maass & Yetman, 2002; Mac Pitcher, pers. comm.).

Overview of Biology

E. mollissimum belongs to the cyanolichens, which comprise approximately 10% of all lichen species. These lichens contain cyanobacteria as the photosynthetic partner (photobiont). Many of the large and conspicuous lichens that inhabit mature and old forests are cyanolichens. The remaining 90% of lichens have green algae as their photobiont and tend to colonize younger forests and are more tolerant of stress and pollution (Cameron & Richardson, 2006). The cyanobacteria in *Erioderma* not only provide the fungal partner with carbohydrates, but also supply it with nitrogen. The cyanobacteria convert atmospheric nitrogen into ammonia which is then synthesized to form amino acids and proteins.

Little is known about the biology and life cycle of the lichen fungus that forms the *E. mollissimum* thallus. Like other lichens, it obtains nutrients from marine aerosols, dust, or dissolved constituents of rain water. The cyanobacterial photobiont is *Scytonema.*

E. mollissimum usually reproduces via soredia, throughout its range. Soredia are asexual reproductive structures, comprised of granules made up of fungal filaments wrapped around cyanobacteria. The two elements are dispersed together and can be distributed by wind, rain or animals. *E. mollissimum* has only once been found to form apothecia (fruit bodies) (see “Description” section) in North America. Thus, different from *E.*

pedicellatum, re-formation of the symbiosis, as a result of contact between a germinating fungal spore and a strand of the *Scytonema*, is not normally required. It might thus be expected that *E. mollissimum* would be more abundant than *E. pedicellatum* in Newfoundland, where conditions occur that are suitable for the growth of both. In fact the reverse is true. The reasons for this are currently not understood.

A second means whereby this lichen increases thallus numbers is by fragmentation. As large thalli grow, the central areas often decline in vigour and die. The outer lobes remain healthy and continue growing so that one established thallus can in time give rise to several smaller, independent thalli (Figure 3). Consequently, "juvenile" thalli can arise by fragmentation as well as by colonization and growth of soredia. It is important to note that although fragmentation results in a higher number of individual thalli, it also results in a net loss in terms of the species' biomass. To date there is little evidence of reproduction by this lichen, in Newfoundland, through the growth of soredia. This may, perhaps, be because any 'tiny juvenile thalli' that develop from soredia here are prone to loss by slug herbivory or over-growth by more ubiquitous, faster-growing lichens, under the conditions that prevail in the Avalon Peninsula.

Figure 3: A photo showing the fragmentation of what was once a single large thallus of *E. mollissimum*. Note that there is a thallus of *E. mollissimum* in the extreme top left hand corner of the photo which has become separated from the thallus in the centre. There is a bare spot between these two indicating that the two were once part of a single large lichen thallus.

Population Size and Area of Occupancy

In Newfoundland, the surveys carried out by Eugene Conway (see: www.erioderma.com) indicate that, as of February 2008, at Hall's Gullies, Avalon Peninsula, Newfoundland, there were 6 trees each hosting a single mature thallus and one tree hosting 10 thalli. At a separate location at Southeast Placentia, approximately 33 km southwest of Hall's Gullies, there were 2 trees hosting a total of 2 thalli. A total of 18 mature thalli, on 9 trees, have thus been confirmed to date for Newfoundland.

The rarity of *E. mollissimum* can be inferred from the fact that it was not previously recorded for Newfoundland despite over a decade of intensive surveys for the relatively similar *E. pedicellatum.* A review of previous reports of *E. pedicellatum* dating from 1996 to 2006 was undertaken by several field surveyors. Approximately 1500 photographed thalli and an additional approximately 800 thalli were re-examined. No *Erioderma mollissimum* thalli were encountered and all thalli were confirmed to be *E. pedicellatum* (E. Conway, pers. comm.; M. Pitcher, pers. comm.)

The size of the Newfoundland *E. mollissimum* population is very small in comparison with the Nova Scotia population, which is presently 118 thalli at 18 localities, on three species of host tree (Cameron *et al*., 2008). The New Brunswick population, known from only 2 historical records, is likely smaller than the Newfoundland population, if it is still extant.

The extent of occurrence of *E. mollissimum* for Newfoundland, calculated as the total area contained within a non-indented polygon encompassing all provincial localities, is about 18.25 km^2.

The area of occupancy for *E. mollissimum* in Newfoundland has been calculated on the basis of the potential area of habitat available on each host tree, multiplied by the number of host trees. *E. mollissimum* thalli occur between one and two metres above the ground (or at about "breast height"). The host tree boles average 10 cm dbh (diameter at breast height). Thus, about $2 \times \pi \times 5 = 0.31416$ m^2 of potential habitat occurs on each tree. The total area of occupancy for *E. mollissimum* is therefore estimated to be $0.31416 \times 9 = 2.8$ m^2 (0.0000028 km^2).

Traditional and Local Ecological Knowledge

The Mi'kmaw in Conne River, on the south coast of Newfoundland, have undertaken *Erioderma* surveys in their area and confirmed the existence of populations of the related *E. pedicellatum.* However, there have been no reports of *E. mollissimum*. Neither of these lichens is known to have had a traditional use among the aboriginal peoples. Although there seems

to be no known Aboriginal Traditional Knowledge (ATK) with respect to this lichen, aboriginal peoples in North America did use other lichens for food and dyes (see Turner, 1978; Richardson, 1988; Casselman, 2001).

There is local interest and ecological knowledge about lichens by naturalists in the areas where *E. mollissimum* grows. A poster 'Lichens of Sir Robert Bond Park, Whitbourne, Newfoundland' is locally available and there has been considerable publicity surrounding the occurrence of the very rare Boreal Felt Lichen, *E. pedicellatum,* on the Avalon Peninsula.

Trends

In Newfoundland, the existence of *E. mollissimum* has been known for little more than a year (since its discovery here in October 2006). Thus, it is far too early to detect any trends. Moreover, because of the extremely small size of the known Newfoundland populations, any future trends will be very prone to random events.

Considerable recent focus on the more conspicuous *E. pedicellatum* has contributed to the discovery of *E. mollissimum* in Newfoundland, as well as to a significant increase in the known distribution of the latter in Nova Scotia.

While *E. pedicellatum* has declined at many stations and has completely disappeared from a number of previously documented localities over the last 30 years (Maass, 1983; Maass & Yetman, 2002), there is no evidence to suggest that this decline in *E. pedicellatum* will necessarily be matched by a decline in *E. mollissimum*. While the two share the same pollution sensitive cyanobacterial symbiont, they differ in their biology. It is interesting to note that *E. mollissimum* is more common than *E. pedicellatum* in Nova Scotia, while the reverse appears to be true for Newfoundland.

Threats and Limiting Factors

It is clear that the outlook for the continued existence of *E. mollissimum* throughout its current range is poor unless positive steps are taken to reduce the threats and limiting factors that are ranged against it.

The threats and limiting factors discussed below are presented in order of perceived immediacy.

1. Forest Exploitation

Forestry operations in Newfoundland are a significant threat to *E. mollissimum* because the industry focuses on harvesting mature to over-mature forests which are the ones that become colonized by this lichen. *E. mollissimum* is found on trees that are at least 10cm in diameter and at least 50 years old. An indication of the severity of the problem can be determined by examining the Annual Allowable Cut (AAC) and actual harvest level. The AAC is the level of harvest that does not exceed the level of new growth that replaces cut trees. To maximize wood volume, the forestry industry harvests forest-stands at their maximum volume (maturity), i.e. before they become over-mature and begin to lose volume. Thus the difference between the actual harvest level and the AAC is an indication of the trend in the amount of available mature and over-mature habitat available for *E. mollissimum.*

The harvest levels in Forest District 1, Avalon, between 2003 and 2004 were slightly less than the AAC for the district. In 2004-05, the harvest levels increased slightly, exceeding the AAC. Since then harvest continued to rise to about 19% above AAC (2007). Of particular concern is the Avalon Forest South which had an average harvest (2001 to 2005) 14% higher than the AAC. The Avalon Forest Ecoregion is where most known locations for *E. mollissimum* have been documented in Newfoundland. The amount of currently available habitat for *E. mollissimum* is a consequence of the past harvest pattern. The age class distribution indicates that currently about 28% of the forest trees are in the 60-80 age class and 23% in the 80+ class. In 50 years, the percentage of trees in the 60–80 year old class, and in the 80+ age class, are predicted to be 13 and 34% respectively. If harvesting is not curtailed, the opportunities for colonization by reproductive propagules of *E. mollissimum* will clearly be curtailed (Cameron *et a*l., 2008).

The use of buffer zones in a forest harvest area is a management strategy currently employed to protect *E. pedicellatum*. However, this strategy may in fact be detrimental to rare lichen species. Following a forest harvest, moose (*Alces alces*) tend to become more concentrated in small “leave areas”, and thus tend to increase the rate of loss of lichen thalli through direct mechanical contact with host trees. In addition, trees in small “leave areas” are highly prone to blowdown. It has also been demonstrated that wind and solar exposure is increased in “leave areas”, which reduces the internal stand moisture levels and results in lichen mortality through desiccation (Maass & Yetman, 2002).

Also associated with forest exploitation is the development of a network of roads into formerly undeveloped areas. Road building directly destroys

lichens and their habitat. And, newly available roads allow further encroachment into potential habitat for *E. mollissimum* through cottage developments.

2. Moose Browsing

Moose are not native to Newfoundland, being first introduced in 1878 and then in 1904. The population has now grown to about 125,000 animals. This represents >10% of the total continental number of moose while the island area, including areas unsuited to moose, is less than 2% of the estimated continental moose range (McLaren *et al*., 2004). On the Avalon Peninsula browsing by moose on Balsam Fir and birches is a widespread problem, and has caused a change in the successional pattern of the forest. Under natural conditions, a harvested Balsam Fir stand would naturally regenerate to Balsam Fir; however, with increase in moose browsing "ungulate induced White Spruce [*Picea glauca*] savanna" develops (McLaren, *et al.*, 2004). This change results in the loss of the Balsam Fir component of the forest, and threatens the survival of lichens that grow on this tree.

3. Air Pollution

Lichens are long-lived organisms that absorb and retain substances that they come into contact with. Sulphur is not just an atmospheric pollutant, but is also an essential nutrient for all vegetation, including lichens. Nonetheless, the correlation between unduly high concentrations of atmospheric sulphur, and lichen decline, is well established (Wadleigh, 2003).

Acid deposition is the end product of reactions between sulphur oxides (SOx), nitrogen oxides (NOx) and water in the atmosphere (Vet *et al*., 2004). These reactions, which occur both in water films covering a moist substrate (primarily dry acid deposition), and in the high atmosphere (wet acid deposition), produce acidic products that are damaging to living organisms in general. Lichens are particularly affected since they do not have a protective waxy cuticle.

The cyanolichens, including E. *mollissimum,* are particularly sensitive to gaseous and particulate air pollutants (dry acid deposition) and acid rain (wet acid deposition) (Richardson & Cameron, 2004; Cameron & Richardson, 2006). This sensitivity is due to the sulphur dioxide induced inhibition of nitrogenase activity within the photobiont, which affects the lichen's ability to fix atmospheric nitrogen (Denison *et al.*, 1977; Maass, 1980). Acid deposition further affects lichens since it can acidify the substratum on which they grow, making it too acid for colonization. Juvenile lichens are more sensitive than mature thalli (Richardson, 1992).

Sources of sulphur and nitrogen oxides include non-ferrous metal smelting, the burning of oil and fuel for thermal electric power generation, home and industrial heating, and transportation. Prevailing winds blow the compounds that cause both wet and dry acid deposition across local regions, state and national borders, and beyond. However, in eastern Newfoundland, dry deposition (gaseous and particulate pollutants) from local sources has been shown to be of much greater concern than is wet deposition (acid rain) from Canadian and American sources.

Wadleigh and Blake (1999) traced sources of atmospheric sulphur in Newfoundland, using the epiphytic lichen *Alectoria sarmentosa* as a biomonitor. Their study showed the strong influence of local point sources of sulphur, particularly on the Avalon Peninsula, in addition to a significant influence from sea spray sulphate near the coasts. More specifically, Wadleigh (2003: Figure 2) showed that $\delta^{34}S$ values for the SE Placentia region of eastern Newfoundland are "influenced mainly by sea salt sulphur ($\delta^{34}S > 12\ ^{o}/_{oo}$)", while $\delta^{34}S$ values for the Hall's Gullies area are influenced more by "local [ie. point source] anthropogenic sulphur ($\delta^{34}S < 10\ ^{o}/_{oo}$)". Significantly, Wadleigh and Blake (1999) found that there was "little evidence of long-range-transported sulphate from the Canadian mainland". Wadleigh (2003) wrote further: "There is little isotopic evidence to support deposition of long-range transported continental sulphate on the island apart from the region of low $\delta^{34}S$ values stretching from central Newfoundland to the mid-western coast of the island".

Vet *et al.* (2004) showed, in their Figures 1.1 and 1.2, that, not only are levels of wet deposition of both non-sea-salt-sulphate and $N0_3^-$ decreasing in Newfoundland, but also that the levels of both of these pollutants in Newfoundland are very minimal when compared to equivalent levels for the Great Lakes region and south. Indeed, whether the measure of $N0_3^-$ deposition (the "best case scenario"), or the measure of SO_4^{2-} deposition (the "worst case scenario"), is used, it seems clear that the Avalon Peninsula of Newfoundland is on the very edge of any air pollution influence from mainland Canada and the United States (Figures 1.3 and 1.4 in Vet *et al.,* 2004). Moreover, "critical load exceedances", used to estimate the immediate impact on the environment of current levels of acid deposition, are calculated on the basis of S and N accumulations in both soil and fresh water bodies. While arboreal lichens are clearly susceptible to airborne pollutants, they are not directly affected by the acidity of the soils or fresh waters in their area, except where such acidity actually affects the growth of the host trees.

In eastern Newfoundland, the greatest deposition of non-sea-salt-sulphate airborne pollutants can be seen in areas to the northeast of the Holyrood Thermal Generating Station, and the Come-by-Chance Oil Refinery, both of which burn sulphur-rich Bunker C oil (Wadleigh and Blake, 1999).

These, and additional local “hotspots”, associated with paper mills at both Corner Brook and Grand Falls, and with various mining operations throughout the Island, are confirmed in Figures 1.7 and 1.8 in Vet *et al*. (2004). The northeasterly depositional directionality observed by (Wadleigh and Blake, 1999) is related to the southwesterly prevailing winds of the region. There is, nevertheless, no doubt that, on the Avalon Peninsula, when winds blow from more northerly directions, significant deposition occurs in the areas to the south and west, where *E. mollissimum* occurs.

Possible new pollution sources in eastern Newfoundland, of very considerable concern, include: [1] an expanded Come by Chance oil refinery (Morgan, 2008; Anon, 2006), [2] a new oil refinery on Southern Head, proposed by the Newfoundland and Labrador Refining Corporation, and [3] the development of the Long Harbour Commercial Nickel Processing Plant, proposed by Voisey's Bay Nickel Company Ltd. (Anon 2008b).

The Come by Chance/Southern Head locality is situated about 60 km north of the nearest E. *mollissimum* locality in Southeast Placentia, and about 63 km NW of the *E. mollissimum* locality at Hall's Gullies). The proposed Voisey's Bay Nickel processing plant at Long Harbour is situated about 22 km north-northwest of the nearest E. *mollissimum* location in Southeast Placentia, and about 29 km west-northwest of the E. *mollissimum* location at Hall's Gullies.

4. Climate Change

Changes in local climate may prove adverse to lichens, especially the boreal and montane elements (Ellis *et al.*, 2007). However, these changes and their potential effects on *E. mollissimum* in Newfoundland are unknown.

Rank or Status

Global	
G-rank	G4G5
IUCN	not assessed
National	
N-rank	NNR (not ranked)
National General Status	not assessed
COSEWIC	report in preparation
Provincial	
Provincial General Status	not assessed
Newfoundland S-rank	not ranked
Newfoundland General Status	not assessed
Labrador S-rank	not present
Labrador General Status	not present
Adjacent Jurisdictions	
Nova Scotia S-Rank	not ranked
Nova Scotia General Status	not assessed
Prince Edward Island S-Rank	not present
Prince Edward Island General Status	not present
New Brunswick S-Rank	S1
New Brunswick General Status	not assessed
Québec S-Rank	not present
Québec General Status	not present

Existing Protection

None

Special Significance

E. mollissimum is rare and disjunct in North America and on a worldwide basis.

TECHNICAL SUMMARY

Distribution and Population Information	**Criteria Assessment**
• *extent of occurrence (EO)(km²)*	18.25 km^2
• *area of occupancy (AO) (km²)*	0.0000028 km^2
• *number of extant locations*	2
• *specify trend in # locations, EO, AO (decline, stable, increasing, unknown)*	unknown
• *habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	declining
• *generation time (average age of parents in the population) (indicate years, months, days, etc.)*	unknown, probably less than 20 years
• *number of mature individuals (capable of reproduction) in the Provincial population (or, specify a range of plausible values)*	18
• *total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals or number of populations*	unknown
• *are there extreme fluctuations (>1 order of magnitude) in number of mature individuals, number of locations, AO and/or EO?*	unknown
• *is the total population severely fragmented (most individuals found within small and isolated populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	yes
Rescue Effect (immigration from an outside source)	
• *does species exist elsewhere?*	Yes. In Nova Scotia and historically in New Brunswick
• *status of the outside population(s)?*	undetermined
• *is immigration known or possible?*	unknown
• *would immigrants be adapted to survive here?*	unknown
• *is there sufficient habitat for immigrants here?*	declining

Sources of Information and List of References

Anon. (2006) Owners guarded on refinery expansion plans. *CBC News*, August 24th, 2006.

Anon. (2008) Global Biodiversity Information facility http://data.gbif.org/occurrences/searchCountries.htm?c[0].s=20&c[0].p=0&c[0].o=14960962. (Last accessed: March 2008)

Anon. (2008b) Voisey's Bay to close Argentia demo plant. *The Nova Scotian, Chronicle Herald*, Halifax, Sunday February 17, p8.

Boonpragob, K., Homchantara, N., Coppins, B.J., Mc Carthy, P.M. & Wolseley, P.A. (1998) An introduction to the lichen flora of Khao Yai National Park, Thailand. *Botanical Journal of Scotland* **50**:209-220.

Buaruang, K., Boonpragob, K., Homchantara, N. & Sangvichien, E. (2004) Distribution and ecological aspects of foliose and fruticose lichens at Khao National Park. *Poster Session 2, Proceedings of 5th International Association for Lichenology Meeting, Tartu*, August, 2004.

Cameron, R.P, Clayden, S. & Neily, T. (2008) *COSEWIC Assessment and Status Report on the Felt Lichen, Erioderma mollissimum, in Canada*. Committee on the Status of Endangered Wildlife in Canada, Ottawa (in preparation).

Cameron, R. P. & Richardson, D. H. S**.** (2006) *Occurrence and Abundance of Epiphytic Cyanolichens in Protected Areas of Nova Scotia, Canada. Opuscula Philolichenum*. **3**: 5-14.

Casselman, K.D. (2001) *Lichen Dyes: the new source book*, Dover publications, New York, pp. 19-21.

Damman, A. W. 1983. *An ecological subdivision of the Island of Newfoundland.* In R. South. (Editor) *Biogeography of the Island of Newfoundland.* D. W. Junk Publishers, London. Pp. 163-206.

Delaney, B.B. & Cahill, M.J. (1978) A pattern of forest types on ribbed moraines in eastern Newfoundland. Canadian Journal of Forest Research 8:116-120

Denison, R., Caldwell, B., Bormann, B., Eldred, L., Swanberg, C. & Anderson, S. 1977. The effects of acid rain on nitrogen fixation in Western Washington coniferous forests. Water, Air, and Soil Pollution 8: 21-34.

Department of Natural Resources (2002) *Five Year Operating Plan for Forest Management District 1 (The Avalon Peninsula), Newfoundland.* February 14th, 2002, 20pp. St. Johns.

Ellis, C.J., Coppins, B.J., Dawson, T.P. & Seaward, M.R.D. (2007) Response of British lichens to climate change scenarios: trends and uncertainties in the projected impact for contrasting biogeographic groups. *Biological Conservation* **140**: 217-235.

Geiser, L.H., Dillman, K.L., Derr, C.C. & Stensvold, M.C. (1998) Lichens and allied fungi of southeast Alaska. In *Lichenographia Thomsoniana: North American Lichenology in honor of John W. Thomson* (M.G. Glen, R.C. Harris, R. Dirig & M.S. Cole eds) Mycotaxon, New York.

Gilbert, O. (2000) *Lichens.* New Naturalist, Harper Collins, London.

Gowan, S.P. & Brodo, I.M. (1988) The lichens of Fundy National Park, New Brunswick, Canada. *Bryologist* **91**:255-325.

Jørgensen, P.M. (1972) *Erioderma pedicellatum* (= *E. boreale*) in New Brunswick, Canada. *Bryologist* **75**:369-371

Jørgensen, P.M. (2000) Surveys of the lichen family Pannariaceae on the American continent north of Mexico. *Bryologist* **103**:670-704.

Jørgensen, P.M. (2001) The present status of the names applicable to species and infraspecific taxa of *Erioderma* (lichenised ascomycetes) included in Zahlbruckner's Catalogus. *Taxon* **50**:525-542.

Jørgensen, P.M. & Arvidsson, L. (2001) The sorediate species of the lichen genus *Erioderma* Fee. *Nova Hedwigia* **73**:497-512.

Jørgensen, P.M. & Sipman, H.J.M. (2002) The lichen genus *Erioderma* in Southeast Asia. *Annales Botanici Fennici* **39**:201-211.

Keeping, B. & Hanel, C. (2006) A five year (2006-2001) Management plan for the boreal felt lichen (*Erioderma pedicellatum*) in Newfoundland and Labrador. http://www.env.gov.nl.ca/env/wildlife/wildatrisk/BOREAL.pdf (Last accessed: March, 2008).

Maass, W.S.G. (1980) *Erioderma pedicellatum* in North America, a case study of a rare and endangered lichen. *Proceedings of the Nova Scotia Institute of Science* **80**:69-87.

Maass, W.S.G. (1983) New observations on *Erioderma* in North America. *Nordic Journal of Botany* **3**:567-576.

Maass, W.S.G & Yetman, D. (2002) *COSEWIC Assessment and Status Report on the Boreal Felt Lichen, Erioderma pedicellatum, in Canada*. Committee on the Status of Endangered Wildlife in Canada, Ottawa, 50pp

McLaren, B.E., Roberts, B.A., Djan-Chékar, N. & Lewis, K.P. (2004) Effects of Overabundant Moose on the Newfoundland Landscape. *Alces* **40**:45-59.

Morgan, I. (2008) Refinery Expansion. *The Independent*, St. John's. January 18th, 2008.

Otnyukova, T. (2007) Epiphytic lichen growth abnormalities and element concentrations as early indicators of forest decline. *Environmental Pollution* **146**: 359-365.

Pitcher, M. (2007) *Erioderma mollissimum* in Newfoundland. The *Osprey.* Nature Journal of Newfoundland and Labrador*.* Volume 38, No. 2. (July 2007)

Richardson, D.H.S. (1988) Medicinal and other economic aspects of lichens. In *Handbook of Lichenology III* (M. Galun ed.) CRC Press, Boca Raton, pp. 93-108.

Richardson, D.H.S. (1992) *Pollution Monitoring with lichens*. Richmond Publishing, Slough. U.K.

Richardson, D.H.S. (2002) Reflections on lichenology: achievements over the last 40 years and challenges for the future. *Canadian Journal of Botany* **80**:101-113.

Richardson, D.H.S. & Cameron, R. P. (2004) Cyanolichens: their response to pollution and possible management strategies for their conservation in Northeastern North America. *Northeastern Naturalist* **11:**1-22.

Sipman, H.J.M. & Wolf, J.H.D. (1998) Provisional checklist for the lichens of Chiapas. *Acta Botanica Mexicana* **45**:1-29.

Spielmann, A.A. (2006) Checklist of lichens and lichenicolous fungi of Rio Grande do Sul (Brazil). *Caderno de Pesquisa Ser. Bio. Santa Cruz do Sul*. **18**:7-125.

Turner, N.J. (1978) *Food Plants of the British Columbia Indians, Part II, interior peoples.* B.C. Provincial Museum, Victoria pp, 35-39.

Vet, R., Brook, J., Ro, C.-U., Shaw, M., Narayan, J., Zhang, L., Moran, M. D. & Lusis, M, 2004, Atmospheric Response to Past Emission Changes. Chapter 3, pp. 15-90 *in 2004 Canadian Acid Deposition Science Assessment. Summary of Key Results.* Morrison, H. A. (editor and lead author). Environment Canada, Meteorological Service of Canada, Downsview, Ontario.

Wadleigh, M. A. 2003. Lichens and atmospheric sulphur: what stable isotopes reveal. Environmental Pollution 126: 345-351.

Wadleigh, M. A. & Blake, D. M. 1999. Tracing sources of atmospheric sulphur using epiphytic lichens. Environmental Pollution 106: 265-271.

Collections Examined

Populations of *E. mollissimum* on the eastern Shore of Nova Scotia were examined in company with Tom Neily and Robert Cameron in the fall of 2007 during two days of field survey. Populations of *E. mollissimum* in Newfoundland were examined in September 2007 during the Tuckerman workshop in the company of Eugene Conway, Robert Cameron and others. Specimens have also been examined in the Museum of Natural History, Halifax, Nova Scotia. The data on occurrences of *E. mollissimum* documented in this report are based on records provided by Robert Cameron, Protected Areas Branch, Department of Environment and Labour, Nova Scotia; Claudia Hanel, Ecosystem Management Ecologist (Botanist) Wildlife Division, Dept. Environment and Conservation, Newfoundland and Labrador; and Eugene Conway (Newfoundland Lichen Education and Research Group).

Appendix A. Population Information

Recently Verified Occurrences/Range Use

The known occurrences of *Erioderma mollissimum* in Canada are shown in the table, below. For Nova Scotia, a "locality" is defined as an occurrence which is more than 1 km from the next known occurrence. "Populations" are defined as locations within a 60 km radius. The Blandford population is a single isolated locality that is 80 km from the Southshore population and so has been included in that population.

Table A-1. Known occurrences of *Erioderma mollissimum* in Canada.

Population	Province	Locality	Year of discovery	Most recent survey	Number of mature thalli
Southwest NB	NB	Campobello Island	1902	1979?	?
Upper Bay of Fundy	NB	Fundy National Park	1980		1
	NS	Cape Chignecto	1991	1992	1
Southshore NS	NS	Lake John Road1&2	2007	2007	22
	NS	Lake John Road3	2007	2007	6
	NS	Clyde River Road1	2008	2008	1
	NS	Clyde River Road2	2008	2008	1
	NS	Martin Brook	2008	2008	1
	NS	Canada Hill1	2008	2008	7
	NS	Canada Hill2	2008	2008	1
	NS	Bon Mature Lake	2008	2008	1
	NS	Blandford	2006	2007	4
	NS	Roberts Pond	2008	2008	1
	NS	Jones Harbour	2008	2008	2
	NS	Thomas Raddell	1980	2008	32
	NS	Port L'Hebert	2008	2008	1
	NS	Mud Lake Creek	1981	1999	0
	NS	Glenwood	1981	2008	0
	NS	Haley Lake	1981	2008	7

Eastern shore NS	NS	Fuller Lake	2006	2007	8
	NS	Bear Lake	2006	2007	2
	NS	Otter Pond	2006	2007	6
	NS	Dooks Pond	2005	2007	4
	NS	Webber Lake	2007	2007	7
	NS	Beech Hill	1980	1980	4
	NS	Clam Harbour	1979	1998	0
	NS	Eisan Lake Road	1981	1998	0
	NS	Tangier Ferry	1982	1999	0
	NS	Marinette	1983	1985	0
	NS	Lochabor Mines	1981	1984	0
	NS	New Chester	1982	1998	0
NL - Avalon	NL	Hall's Gullies	2006-07	2007	16
	NL	SE Placentia	2007	2007	2

Recently Verified Occurrences/Range Use (recorded within the last 25 years)

CANADA: Newfoundland. Avalon Peninsula, Halls Gullies, elevation 114 m. Mesic forest of *Abies balsamea*, with an admixture of *Picea mariana*, scattered *Betula cordifolia*, and feather moss-dominated understory, on low moraine-ridge in complex of forested ridges alternating with open peatlands. On trunk of *Abies*, c. 1.7 m above ground. S. R. Clayden. NBM # 17450 and #17451 (with Claudia Hanel & Mac Pitcher) [lobes from two, distinct, neighbouring thalli]. 14 June 2007. These specimens were examined by Per Magnus Jørgensen, who confirmed their identity as *Erioderma mollissimum* on September 10, 2007.

To date, all existing thalli (18) reported for Newfoundland as *Erioderma mollissimum* have been examined in the field and confirmed by either Robert Cameron, Christoph Scheidegger, or both.

Recent Search Effort

Since the first identification of *E. mollissimum* in Newfoundland in 2006, local amateur lichenologists have searched for this species while conducting *E. pedicellatum* surveys. Their search efforts have focused on Hall's Gullies and Southeast Placentia and have resulted in the discovery of five new sites that were verified by Robert Cameron, and 2 new sites that were verified by Dr. C. Scheidegger.

The Newfoundland and Labrador Department of Natural Resources (DNR) conducted surveys involving several hundreds of survey hours for *E. pedicellatum* in suitable habitat throughout the island of Newfoundland since 1997. Surveys conducted in 2007 by DNR focused additionally upon *E. mollissimum* and amounted to about 10 hours, mostly in the Hall's Gullies area. No *E. mollissimum* were located.

Claudia Hanel, of the Newfoundland and Labrador Department of Environment and Conservation, conducted surveys in the Bay D'Espoir area over a 5 day period in June 2007. No *E. mollissimum* were located.

Historical Verified Occurrences/Range Use

None

Potential Sites Unexplored

To date, In Newfoundland, *E. mollissimum* has only been confirmed from the Avalon Peninsula. *E. mollissimum* seems to be quite sporadic in its distribution and rather overlooked. It may be mistaken for several other lichens including *Peltigera collina, Nephroma parile* or even *Sticta weigelii* (Jørgensen, 2000). Although it is possible that the species occurs elsewhere in Newfoundland, its extreme rarity is demonstrated by the fact it has not been encountered during extensive surveying for the Boreal Felt Lichen, *E. pedicellatum*, over the past twelve years.

Appendix B. Supplementary Details

Habitat

The occurrence of lichens such as *Lobaria scrobiculata, Fuscopannaria ahlneri, Lichinodium sirosiphoideum, Parmeliella parvula* and *Coccocarpia palmicola* is often a good indicator for the presence of *E. mollissimum.* Other rare or uncommon cyanolichens are found in the same habitat as *E. mollissimum* but not necessarily on the same tree. The rarest of these is *Moelleropsis nebulosa* ssp. *frullaniae,* while uncommon taxa include *Coccocarpia palmicola, Erioderma pedicellatum and Pannaria rubiginosa* (Cameron *et al*., 2008).

In Newfoundland, *E. mollissimum* was initially discovered in the Hall's Gullies area on the Avalon Peninsula. The habitat aspect is variable and the sites are well to poorly drained, with a gently sloping topography. The slopes support mature or uneven-aged coniferous forests dominated by Balsam Fir which makes up at least 67% of all trees by basal area (in several cases the number exceeds 90%). Black Spruce (*Picea mariana*) is the next commonest tree, and Yellow and White Birch are found occasionally. The proportion of dead trees in these forests varies from 19% to 54%. The average age of trees from breast height cores averages 73 years but the range is small with the oldest cored tree being 86 years old and the youngest 45 years. This indicates a rather even-aged forest. At Hall's Gullies, crown closure averages 55% or more at all sites and tree density can be very high, e.g. >14,000 stems/ha to very low e.g. 5000 stems per ha at a site only 1 km away. Bryophyte ground cover is high at all sites (*Hylocomium, Pleurozium, Rhytidiadelphus, Ptilium* and *Bazzania*) with *Sphagnum* occurring in patches where there are pockets of poor drainage on the slopes. Usually there is little herb or shrub cover except on the lower wetter slopes where there is a moderate herb layer of the fern *Osmunda cinnamomea* (M. Pitcher, pers. comm.).

In contrast, the Southeast Placentia forests are less even-aged and comprised of trees from only a few years old to 180 years old. Tree height and diameter (at breast height) are also more variable at Southeast Placentia because of the uneven-aged structure, and crown closure is very low (19%). At Hall's Gullies, *E. mollissimum* is never found more than 80 m from wetlands. At Southeast Placentia, the sites are about 500 m from a mapped wetland but small unmapped peatlands occur throughout the area (Cameron *et al*., 2008).

Photo: John E. Maunder

Figure B-1. The general habitat in which the *Erioderma mollissimum* occurs in Newfoundland is shown in the attached photo taken at Hall's Gullies. The trees are about 10 cm in diameter and covered by liverworts, especially *Frullania* and a rich community of lichens.

Threats and Limiting Factors

Air Pollution:

Sulphur dioxide: the pollutant gas sulphur dioxide (SO_2) is very soluble and forms undissociated sulphurous acid, bisulphite ions, or sulphite ions depending on the acidity of the solution. The sulphur component in all these forms is highly reactive and damaging to living organisms, especially lichens which unlike other plants do not have a protective waxy cuticle covering them. As a result when SO_2 dissolves in water films on the moist lichen it can damage both the fungus and the contained cyanobacteria. Sources of sulphur dioxide can be fuel oil for home or industrial heating or emissions from local industry.

Acid Rain: When sulphur dioxide is emitted from high chimney stacks, it is often accompanied by nitrogen oxides resulting from the high temperature combustion of coal or oil. These compounds remain in the atmosphere for a relatively long time before being washed out by rain. The sulphur dioxide becomes oxidized to sulphur trioxide, especially in the presence of metal particulates, and the sulphur trioxide reacts with water to form sulphuric acid.

Changes in Emission Levels: Expansion of the Come by Chance oil refinery in Newfoundland (Morgan, 2008, Anon, 2006) clearly has the potential to expose the populations of *E. mollissimum* growing in the Avalon Peninsula to increased pollution loads. The $63 million expansion may lead to further investment over the next few years amounting to at least $600 million and a doubling of the amount of oil refined from the current 115,000 barrels a day.

The Newfoundland and Labrador Refining Corporation, has proposed building a refinery at Southern Head. This refinery received provincial approval to proceed through the environmental assessment (EA) process in January of this year. It could begin operation in 2011, processing 300 000 barrels of crude oil per day. There is a possibility of increasing the production capacity to 600 000 barrels per day at a later date. If this expansion happens, emissions from the new refinery will roughly double (see table B-1, below). The refinery will be about 60 km north of the nearest *E. mollissimum* location in Southeast Placentia.

Another project under development in the Come by Chance area is the Long Harbour Commercial Nickel Processing Plant proposed by Voisey's Bay Nickel Company Ltd. This project has also entered the provincial EA process. The province requested revisions to the submitted EA in January of this year, and no further information has been released from the province or the company. At the time the EA was submitted, it was unknown what type of nickel processing plant technology will be used. Two sets of emissions are given in Table B-2, one for each possible process. The demonstration hydrometallurgical processing plant in Argentia will close in June 2008 (Anon 2008b) and construction of a full-scale processing plant will follow. Whichever process is adopted for the refinery, its operation will release sulphur dioxide into the atmosphere. The proposed Nickel processing plant at Long Harbour is about 23 km north of the nearest *E. mollissimum* location in Southeast Placentia.

There is the possibility that *E. mollissimum* which is very pollution sensitive could be affected if the lichens in the Avalon Peninsula become exposed to significantly increased air pollution levels from these

developments. Whether damage occurs will depend upon the stringency of emission limits and the effectiveness of subsequent monitoring.

Sulphur dioxide is emitted when domestic fuel oil, industrial heating oil or coal is burned to provide heat or energy. When emitted from houses, chimneys or factories without high stacks, this gas will dissolve in water films on or within moist lichen thalli to form, depending on the pH, one of the following:

$H_2O + SO_2$	=	H_2SO_3	=	$H^+ + HSO_3^-$	+	$2H + SO_3^{2-}$
sulphur dioxide		undissociated sulphurous acid		bisulphite		sulphite

Dissolved sulphur dioxide is most toxic to cyanolichens, including *Erioderma*, under acidic conditions where bisulphate forms and less so at higher pH where sulphite predominates. For this reason, sensitive lichens are better able to thrive on substrata with a high pH and thus better buffering capacity. Low level emissions are less common than in the past (Richardson, 1992).

Acid rain is a combination of sulphuric acid and nitric acid formed from the nitrogen oxides.

$SO_2 + O_2$	=	$SO_3 + H_2O$	=	H_2SO_4	=	$2H^+$ + SO_4^{2-}
sulphur dioxide		sulphur trioxide		sulphuric acid		hydrogen ions sulphate ions

and ….

$NO_x + H_2O$	=	HNO_3	=	H^+	+ NO_3^-
nitrogen oxides		nitric acid		hydrogen ions	nitrate ions

It is the hydrogen ion component of acid rain that is toxic, and affects cell membranes, acidifies the substrata, and leaches metals such as calcium from the lichen.

Local Emissions from Industrial Developments. The following tables provide information of the emissions of sulphur dioxide and other pollutants from proposed industrial developments that could have an impact on *Erioderma mollissimum.*

Contaminant	tonnes/year
PM (total)	609
PM_{10}	544
$PM_{2.5}$	406
NO_x	3228
SO_2	6589
CO	1093
CO2 eq	3 688 449
VOC	834
Benzene	6.9

Table B-1: Emissions provided in the EA (July 2007) for the Southern Head Refinery, Newfoundland and Labrador Refining Corp.

	Hydromet	Matte
Contaminant	kg/year	kg/year
Cl_2	34	0
HCl	4 262	306
H_2SO_4	7 381	357
Mn	131	93
Fe	3 599	2 393
Co	81	401
Ni	3 185	5 723
Cu	239	896
Pb	99	27
PM_{10}	48 152	84 300
$CaCO_3$	7 753	14 721
$Ca(OH)_2$	0	0
Na_2CO_3	0	0
Escaid	902	651
CaO	8 344	9 595
SO_2	212 227	201 770
NO_x	93 701	56 929

Table B-2: Emissions provided in the EA (November 2007) for the Long Harbour Nickel Processing Plant – Voisey's Bay Nickel Company Ltd.