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Occurrence and Abundance of Epiphytic Cyanolichens in Protected Areas of Nova Scotia, Canada

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ABSTRACT. – Epiphytic cyanolichens occurrence and abundance was recorded in thirteen Wilderness Areas and one Nature Reserve in Nova Scotia, Canada. Twenty-one species were found. Very common species include those in the genus *Lobaria*, as well as *Collema subflaccidum*, *Leptogium cyanescens* and *Parmeliella triptophylla*. Uncommon species include *Collema furfuraceum, Collema nigrescens, Nephroma bellum* and *Pseudocyphellaria crocata*. Rare species are *Coccocarpia palmicola, Degelia plumbea, Erioderma pedicellatum, Leptogium corticola, Leptogium laceroides, Leptogium saturninum, Nephroma laevigatum, Nephroma helveticum, Pannaria conoplea, Pseudocyphellaria perpetua* and *Sticta fuliginosa*.

INTRODUCTION

Cyanolichens are lichens in which cyanobacteria are one of the symbiotic partners. For some species of lichen, like those of the genus *Collema* or *Leptogium*, the cyanobacteria are the photosynthesizing partner. In other species, like *Peltigera apothosa* and *Lobaria pulmonaria*, algae are the primary photosynthesizing partner with cyanobacteria occurring in delimited areas called cepholodia. In all cases cyanobacteria can fix atmospheric nitrogen.

Only about 10% of lichen species worldwide, are cyanolichens but cyanolichens can be locally abundant in certain habitats such as mature, old growth or sub-oceanic forests (Nash 1996). Indeed, cyanolichen abundance can sometimes exceed that of other green algal lichens as in the cedar-hemlock forest of British Columbia (Campbell and Fredeen 2004). In the humid coastal forests of Nova Scotia cyanolichens make up a significant component of the lichen diversity (Selva 1999, Seaward et al. 1997, Casselman and Hill 1995).

Cyanolichens have been shown to contribute significant amounts of nitrogen to ecosystems in Sweden (Huss-Danell 1977, Kallio 1974), North Carolina (Becker et al. 1977, Becker 1980), Columbia (Forman 1975), Chile (Godoy et al. 2001) and British Columbia (Campbell and Fredeen 2004).

Cyanolichens, particularly epiphytic cyanolichens, are sensitive to acidifying air pollution (Gries 1996). The decline in the cyanolichen *Lobarion* community in Europe provides some of the most compelling evidence of the effect of air pollution (Wirth 1988). Studies have continued to document declines in cyanolichens (Hallingbäck 1989, Richardson 1992, Krivorotov 1998). The loss of the boreal felt lichen (*Erioderma pedicellatum*) from New Brunswick and Europe and a 90% decline in Nova Scotia has been attributed to pollution, particularly acid rain and to habitat destruction (Maass and Yetman 2002). Habitat destruction is largely due to forestry practices (Maass and Yetman 2002). Particular forestry practices have been shown to be detrimental to cyanolichens (Richardson and Cameron 2004) and even forestry practices aimed at maintaining rare cyanolichens have had limited success (Pykälä 2004).

The Atlantic population of the boreal felt lichen has been listed as endangered and the Nova Scotia Department of Natural Resources initiated a process to assess the populations of all cyanolichens in Nova Scotia. A team of experts was assembled but it was quickly realized that very little was known about the status of cyanolichens in Nova Scotia. This study documents occurrence and abundance of epiphytic cyanolichens in Nova Scotian protected areas. This will aid in status assessment, conservation planning and long-term monitoring.

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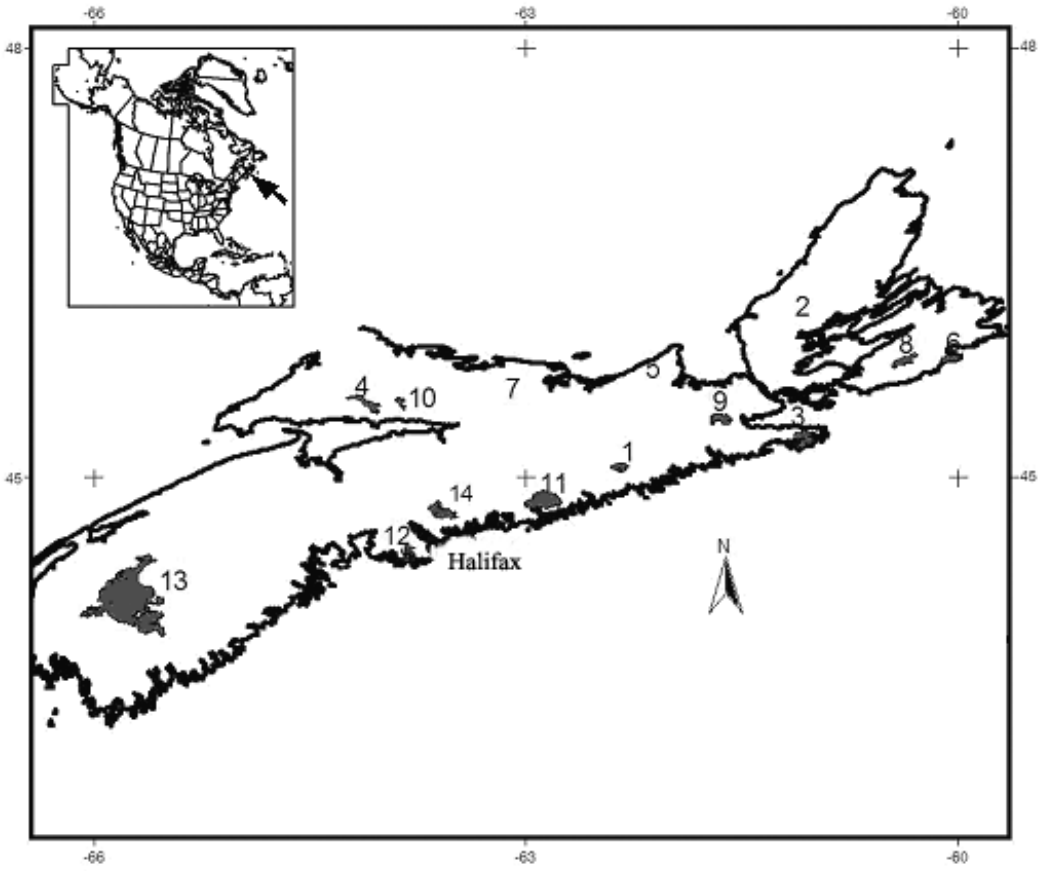

Figure 1. Nova Scotia protected areas surveyed for presence and abundance of cyanolichens: **1**=Boggy Lake Wilderness Area; **2**= Bornish Hills Nature Reserve; **3**=Canso Coastal Barrens Wilderness Area; **4**=Economy River Wilderness Area; **5**=Eigg Mountain Wilderness Area; **6**=Gabarus Wilderness Area; **7**=Gully Lake Wilderness Area; **8**=Middle River Framboise Wilderness Area; **9**=Ogden Round Lake Wilderness Area; **10**=Portapique River Wilderness Area; **11**=Tangier Grand Lake Wilderness Area; **12**=Terence Bay Wilderness Area; **13**=Tobeatic Wilderness Area; **14**=Waverley Salmon River Long Lake Wilderness Area.

STUDY SITES

Fourteen protected areas were selected for study, including thirteen Wilderness Areas and one Nature Reserve (see above figure and Table 1). The selection was stratified to include study sites across the province. Western Cape Breton Island was not included in the surveys because of the extensive lichen sampling done in protected areas there by Selva (1999). Southwestern Nova Scotia was under represented in this study because of time constraints.

Nova Scotia has a temperate maritime climate and is dominated by forests. Annual precipitation ranges from 1200 to 1600 mm with a mean annual temperature of 6°C (Davis and Browne 1998). Forests are made up of tree species typical of the Acadian Forest Region and include deciduous forests of sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*) and American beech (*Fagus grandifolia*), well as coniferous forests of red and black spruce (*Picea rubens* and *P. mariana*), balsam fir (*Abies balsamea*), pine (*Pinus spp.*) and hemlock (*Tsuga canadensis*) (Farrar 1995).

Table 1. Protected Areas surveyed for presence and abundance of epiphytic cyanolichens in Nova Scotia. From Cameron (2004). WA = Wilderness Area, NR = Nature Reserve.

Protected Area	Size (ha)	Number of Locations Surveys Occurred	Dominant Forest Type	Climate Region*
Boggy Lake WA	3700	1	shade-tolerant deciduous and coniferous	eastern
Bornish Hills NR	1112	1	shade-tolerant deciduous	eastern
Canso Coastal Barrens WA	8000	1	coastal coniferous	Atlantic
Economy River WA	6123	1	shade-tolerant deciduous	northern
Eigg Mountain-James River WA	4170	2	shade-tolerant deciduous	northern
Gabarus WA	3745	1	coastal coniferous	Atlantic
Gully Lake WA	3810	2	shade-tolerant deciduous	northern
Middle River Framboise WA	5636	1	shade-tolerant deciduous and coniferous	eastern
Ogden Round Lake WA	5490	1	deciduous	eastern
Portapique River WA	2054	1	shade-tolerant deciduous	northern
Tangier Grand Lake WA	16040	3	coastal coniferous	Atlantic
Terence Bay WA	4450	1	coastal coniferous	Atlantic
Tobeatic WA	103780	2	coniferous	western
Waverley-Salmon River Long Lake WA	8707	1	coniferous	eastern

*From Davis and Browne (1999)

METHODS

Within protected areas, study sites were selected that were likely to harbour the greatest diversity of epiphytic cyanolichens. For inland protected areas, all old growth forests were surveyed, but where no old growth forests occurred, representative mature shade-tolerant hardwood forest were selected. For the Tangier Grand Lake and Terence Bay Wilderness Areas, *Erioderma pedicellatum* habitat suitability maps (Cameron 2004) were used to identify study sites. For other coastal areas (Gabarus and Canso Coastal Barrens Wilderness Areas), forests with balsam fir and red maple (*Acer rubrum*) were selected for study.

Only epiphytic cyanolichens were surveyed because they are at the most risk from impacts of air pollution and habitat destruction. A floristic approach to surveys was taken to ensure rarer species were included (Newmaster et al. 2005). Surveys consisted of walking the site and examining tree boles at heights between 0.5 and 2 m. Lower boles were not examined to avoid inclusion of terricolous or saxicolous species. Branches were ignored because there was very few branches on lower boles in these mature and old growth forests. The area of survey at each site varied from four to about 20 hectares and was largely determined by on-the-ground subjective assessment of the habitat for cyanolichen diversity. Voucher specimens were collected for each species, except the most rare, and deposited at the Nova Scotia Museum of Natural History. Nomenclature follows Esslinger (1997). The forest type at each site was described by tree maturity, tree species occurrence and relative abundance.

Abundance for each lichen species at each site was rated according to the following scale.

1.On <10% of the tree bole and on <10% of the trees.
2.On < 10% of the tree bole and on >10% of the trees.
3.On >10% of the tree bole and on <10% of the trees.
4.On >10% of the tree bole and on >10% of the trees.

The abundance scale was based on a predicted distribution pattern of lichen species. Many groups of organisms demonstrate a logarithmic distribution, with a few species at very high abundances and most species with low abundances (Krebs 1989). Unpublished data on macrolichen abundance and frequency on one hundred and sixty trees in Nova Scotia was examined to determine distribution pattern. More than half of the macrolichen species occurred on less than 10% of the trees. Abundance data also revealed that about half the species had less than 10% tree coverage. The tree species on which particular lichens was found at each site was also recorded.

To determine if the majority of epiphytic lichen species had been sampled within protected areas in Nova Scotia a species accumulation curve was done using methods employed by Roberts-Pitchette and Gillespie (1999).

RESULTS

Twenty-one species of cyanolichen were found at twenty sites in fourteen protected areas (Table 2, proceeding page). Of all surveyed protected areas, Tangier Grand Lake and Terence Bay Wilderness Areas had the most cyanolichen species (15 and 12 species respectively). Protected areas immediately on coastal headlands had the fewest number of species. Only four species were found at Canso Coastal Barrens Wilderness Area and only two species were found at Gabarus Wilderness Area. The low numbers of species may be attributable to lack of suitable substrate and the drying effects in these windy locations. Inland sites ranged in species richness between 4 and 10 species. Bornish Hills Nature Reserve and Tobeatic Wilderness Area had consistently high cyanolichen abundance values but also tended to have fewer species.

SPECIES RESULTS

Coccocarpia

Coccocarpia palmicola was found at several sites within the Tangier Grand Lake Wilderness Area (Table 1). Abundance was low for all sites. Balsam fir was the dominant tree species on which it was found, although occasionally it was found on black spruce. Forest types included balsam fir dominated stands with some black spruce and scattered red maple. Other cyanolichens occurring with *C. palmicola* were *Lobaria scrobiculata, Leptogium laceroides, Parmeliella triptophylla* and *Erioderma pedicellatum*.

Coccocarpia palmicola is rare in Fundy National Park, New Brunswick (Gowan and Brodo 1988) and elsewhere in Canada (Goward et al.1998). One other unpublished record is from Thomas Raddall Provincial Park in southwest Nova Scotia. This lichen was discovered during the Tuckerman Workshop in 1998 (Richardson pers. comm.) and was one of the rarest epiphytic cyanolichens found in this study.

Collema

Three species of *Collema* where found on sugar maple or red maple. *Collema subflaccidum* had the widest distribution, occurring in six of thirteen protected areas. Abundance for this species ranged from 1 to 4 *Collema subflaccidum* was found once on white spruce *(Picea glauca*) in Gabarus Wilderness Area. *Collema furfuraceum* and *C. nigrescens* were found at only two and three Wilderness Areas respectively.

The forests where surveys were conducted were dominated by sugar maple, yellow birch with some beech, red maple and red spruce with the exception of Gabarus Wilderness Area which was dominated by white spruce and balsam fir and Tangier Grand Lake and Terence Bay Wilderness Area where forests were dominated by balsam fir with some black spruce and red maple.

Collema subflaccidum has also been collected in northeastern Nova Scotia (Sneddon unpublished data, Selva 1999). Gowan and Brodo (1988) found *C. subflaccidum* common on their study site in Fundy National Park in New Brunswick. Selva (1994) suggests that this species may be faithful to old forest. However, the wide distribution indicates that the species may not be restricted to old forests. Brodo et al.

Table 2. The abundance of epiphytic cyanolichens in selected protected areas in Nova Scotia. 1= on <10% of the tree bole and on <10% of the trees; 2 = on < 10% of the tree bole and on >10% of the trees; 3 = on >10% of the tree boles and on <10% of the trees; 4 = on >10% of the tree bole and on >10% of the trees.

	Boggy Lake	Bornsih Hills	Canso Coastal Barrens	Economy River	Eigg Mountain	Gabarus	Gully Lake	Middle River Framboise	Ogden Round Lake	Portapique River	Tangier Grand Lake	Terence Bay	Tobeatic	Waverley Salmon River
Coccocarpia palmicola											1			
Collema furfuraceum								1			1	1		
Collema nigrescens				3			1							
Collema subflaccidum		4		3		1	2		1	3				
Degelia plumbea												3		
Erioderma pedicellatum											1			
Leptogium corticola											1			
Leptogium cyanescens			1				3	2	1	3				
Leptogium laceroides							1		1	1	1	1		
Leptogium saturninum	1									1				
Lobaria pulmonaria	4	4	3	4	4	3	4	4	3	4	2	3	4	3
Lobaria quercizans	4	4		4	2		3	4	1	4	3	3	4	
Lobaria scrobiculata			1	1	3		3		3		3	1	3	3
Nephroma bellum	2							2	1		1	1		
Nephroma helveticum									1		1			
Nephroma laevigatum			1				1				1			
Parmeliella triptophylla		3					1	1	2	1	3	1		
Pannaria conoplea											1	1		
Pseudocyphellaria crocata							1				3	1	3	1
Pseudocyphellaria perpetua											1	1		
Sticta fuliginosa										1		1		

(2001) suggests *C. furfuraceum* is common in North America and Selva (1994) suggests the species may be faithful to old forests in northeastern North America. Seaward et al. (1997) report finding *C. furfuraceum* in central Nova Scotia. Selva (1999) found *C. furfuraceum* common on his study sites in Cape Breton while Gowan and Brodo (1988) found the species rare in New Brunswick. Data from the current study suggests this species is uncommon with low abundance on the trees on which it is found. The seemingly contradictory evidence suggests this species may need further investigation. Brodo et al (2001) suggests *C. nigrescens* is common in North America, however there are no published records of this species from Nova Scotia. It may be an overlooked species that requires more effort to assess its status.

Degelia

Degelia plumbea was found at one site in Terence Bay Wilderness Area on red maple. Coverage on the trees was high (greater than 10% of the bole). The forest type was poorly drained and dominated by black spruce and balsam fir with scattered red maple adjacent to a black spruce bog.

Degelia plumbea is considered very rare in North America (Brodo et al. 2001) and rare in Canada (Goward et al. 1998). Only six locations have been published for North America from Maine to Newfoundland including one from Cape Breton (Goward et al. 1998).

Erioderma

Erioderma pedicellatum was found at two locations within the Tangier Grand Lake Wilderness Area. Abundance was low for both sites. All thalli were found on balsam fir. The forest type was balsam fir dominated stands with some black spruce and scattered red maple; in both cases adjacent to a bog. Other cyanolichens occurring with *E. pedicellatum* were *Coccocarpia palmicola, Lobaria scrobiculata, Leptogium laceroides* and *Parmeliella triptophylla*.

The Maritime population of *E. pedicellatum* is listed as endangered under the Canadian Species At Risk Act, as well under the Nova Scotia Endangered Species Act. Prior to the current record, only one other location of the species was known for Nova Scotia (Cameron 2004).

Leptogium

Leptogium cyanescens was the most common *Leptogium*, occurring in five of the thirteen protected areas studied. The abundance for this species ranged from 1 to 3. *Leptogium laceroides* was the next most common species, occurring in 5 protected areas with low abundance at all sites. *Leptogium corticola* and *L. saturninum* were both rare occurring in only one and two protected areas respectively, with only one thallus present at each site. *Leptogium corticola* and *L. laceroides* were found on red maple in coastal coniferous forest dominated by balsam fir with some red maple and black spruce. *Leptogium laceroides* was also found with *L. cyanescens* and *L. saturninum* at Portapique River Wilderness Area in forests dominated by sugar maple, yellow birch with some beech, red maple and in a floodplain forest of mixed sugar maple and white ash (*Fraxinus americana*).

Brodo et al. (2001) suggest *L. cyanescens* is the most common *Leptogium* in North America; indeed it is common in New Brunswick (Gowan and Brodo 1988), Cape Breton (Selva 1999) and in this study. Brodo et al. (2001), Goward et al. (1998), Selva 1999 and Gowan and Brodo (1988) all suggest *L. laceroides* is rare. It was found in the present study, in central Nova Scotia (Seaward et al. 1997) and in eastern Cape Breton (Sneddon unpublished data). *Leptogium saturninum* is considered rare in New Brunswick (Gowan and Brodo 1988) and in Canada (Brodo et al.2001) and not common in Cape Breton (Selva 1999). Little has been documented for *L. corticola*. No published studies have recorded *L. corticola* in Nova Scotia and it is considered rare in Canada by Brodo et al. (2001). *Leptogium corticola, L. laceroides* and *L. saturninum* were reported for Thomas Raddall Provincial Park in southwest Nova Scotia during the Tuckerman Workshop in 1998 (Richardson pers. comm.). *Leptogium corticola* and *L. saturninum* are both rare within Nova Scotia, occurring at few sites and with low abundance where they do occur. *Leptogium laceroides* appears to be more common than *L. corticola,* and *L. saturninum,* yet is still considered uncommon to rare.

Lobaria

All three *Lobaria* species known to occur in Nova Scotia were found with relatively high abundance in most protected areas. *Lobaria pulmonaria* was the most common and abundant species occurring in all sites with abundances of 3 or 4. *Lobaria quercizans* was next most common occurring in 9 protected areas commonly with abundances of 3 or 4. *Lobaria scrobiculata* occurred in 8 protected areas with abundances of 1 or 3. *Lobaria scrobiculata* tended to occur on many trees at a site but had low coverage on the trees. *Lobaria pulmonaria* and *L. quercizans* often had high coverage on trees as well as occurring on many trees at a site. All three species were found on red maple and sugar maple. *Lobaria pulmonaria* and *L. quercizans* were also found on yellow birch. At coastal sites (Canso Coastal Barrens, Gabarus, Tangier Grand Lake and Terence Bay Wilderness Areas), *L. pulmonaria* and *L. scrobiculata* occurred on balsam fir, black spruce and white spruce. *Lobaria quercizans* did not occur at sites within 10 km of the coast (Canso Coastal Barrens and Gabarus Wilderness Areas).

Both *L. pulmonaria* and *L. quercizans* were found to be common in Cape Breton (Selva 1999) and in New Brunswick (Gowan and Brodo 1988). Casselman and Hill (1995) found *L. pulmonaria* extremely abundant and *L. quercizans* abundant in Pictou County. *Lobaria scrobiculata* was found to be common in New Brunswick (Gowan and Brodo 1988) and in central Nova Scotia (Casselman and Hill 1995) but Selva (1999) observed that it was not common in Cape Breton. All three *Lobaria* species are common and widespread in Nova Scotia but *L. quercizans* seems to be more restricted to inland mature shade-tolerant

hardwood forests while *L. pulmonaria* and *L. scrobiculata* are found in shade-tolerant hardwood as well as coastal forests.

Nephroma

Nephroma bellum was the most common species of this genus, occurring in 5 protected areas with relatively low abundance. *Nephroma laevigatum* occurred at three protected areas and *N. helveticum* occurred at only two. Both *N. laevigatum* and *N. helveticum* had abundance of only 1 at each site. All three species were found on sugar maple and red maple in shade-tolerant hardwood forest dominated by sugar maple, yellow birch with some beech, red maple and red spruce or on red maple in balsam fir-white spruce dominated coastal forest.

All three species were considered not common by Selva (1999) in Cape Breton while Gowan and Brodo (1988) considered both *N. bellum* and *N. helveticum* as rare in New Brunswick. Gowan and Brodo (1988) had no record of *N. laevigatum* in their study site in New Brunswick. *Nephroma bellum* and *N. helveticum* have been recorded in eastern Cape Breton by Sneddon (unpublished data). All three species were reported for Thomas Raddall Provincial Park while *N. laevigatum* and *N. helveticum* were reported for Kejimkujik National Park during the Tuckerman Workshop in 1998 (Richardson pers. comm.). All three species occur at low abundance at few sites and are considered uncommon in Nova Scotia.

Pannaria

The only species in the genus *Pannaria*, in this study, was *P. conoplea,* found at Tangier Grand Lake and Terence Bay Wilderness Areas. Abundance was very low at Tangier Grand Lake Wilderness Area, where only one thallus was found. Terence Bay Wilderness Area had higher abundance with numerous thalli found on several trees. All thalli occurred on red maple, in balsam fir dominated forest with some black spruce and scattered red maple.

Pannaria conoplea is rare across North America (Brodo et al. 2001) including New Brunswick (Gowan and Brodo 1988) and Maine (Hinds and Hinds 2004). No previously published records are known for this species in Nova Scotia, however a few unpublished records exists for Cumberland County (Maass pers. comm.), Thomas Raddall Provincial Park and Kejimkujik National Park in south west Nova Scotia (Richardson pers. comm.).

Parmeliella

Parmeliella triptophylla was found in seven protected areas with abundances ranging from 1 to 3. *Parmeliella triptophylla* was found on red maple in Tangier Grand Lake and Terence Bay Wilderness Areas in forests dominated by balsam fir and with scattered red maple and black spruce. It was found on both red maple and sugar maple in shade-tolerant hardwood forests in other protected areas.

Brodo et al (2001) suggest *P. triptophylla* is "frequent in cool humid coniferous forest" which is consistent with its "common" status by both Selva (1999) in Cape Breton and Gowan and Brodo (1988) in New Brunswick. There are no records for this species in other Nova Scotian study sites. *Parmeliella triptophylla* seems to be a common but often overlooked species in Nova Scotia.

Pseudocyphellaria

One specimen of *P. perpetua* was found at each of Terence Bay and Tangier Grand Lake Wilderness Areas. These were both large thalli occurring on red maple in a forest dominated by balsam fir with scattered red maple and black spruce. *Pseudocyphellaria crocata* was also found at these same Wilderness Areas as well as 4 other protected areas. Coverage of *P. crocata* on tree trunks was low (<10% of the bole) at all sites but was inconsistent in the number of trees on which it occurred.

Pseudocyphellaria crocata is rare in Cape Breton (Selva 1999) and New Brunswick (Gowan and Brodo 1988). *Pseudocyphellaria crocata* was found in central Nova Scotia by Seaward et al. (1997). Since *P. perpetua* has only recently been distinguished as a new species (Miadlikowska et al. 2002), there are no published records of its occurrence in Nova Scotia. Some other Nova Scotia collections were made during the Tuckerman Lichen Workshop in 1998 (Richardson pers. comm.) and by Dr. W. Maass (pers. comm.). Some overlap in morphological features that supposedly distinguish these two species was noted and therefore these identifications may be uncertain.

Sticta

Sticta fuliginosa was found at Portapique River Wilderness Area on a sugar maple in a floodplain shade-tolerant hardwood forest made up of sugar maple and white ash. At Terence Bay Wilderness Area, *S. fuliginosa* was found on a red maple in a forest dominated by balsam fir with scattered red maple and black spruce.

Sticta fuliginosa is rare in New Brunswick (Gowan and Brodo 1988) and Maine with no recent records in that state (Hinds and Hinds 2004). The only other known locations for this species in the province are in Chignecto Provincial Park (Maass pers. comm..), Halifax County, found by the lead author and Thomas Raddall Provincial Park (Richardson pers. comm.). This species is very rare in Nova Scotia known from only a few locations.

DISCUSSION

Epiphytic cyanolichens, like many other groups of organisms, appear to have a typical distribution in that there are a few species that are very abundant, but most species are uncommon or rare. Species of the genus *Lobaria* were all very common together with *Collema subflaccidum*, *Leptogium cyanescens* and *Parmeliella triptophylla*. Uncommon species included *Collema furfuraceum, Collema nigrescens, Nephroma bellum* and *Pseudocyphellaria crocata.* Rare species were *Coccocarpia palmicola, Degelia plumbea, Erioderma pedicellatum, Leptogium corticola, Leptogium laceroides, Leptogium saturninum, Nephroma laevigatum, Nephroma helveticum, Pannaria conoplea, Pseudocyphellaria perpetua* and *Sticta fuliginosa*.

Rare and uncommon epiphytic cyanolichens seem to reflect several patterns of rarity. Within a geographic region, rare species can follow one of three patterns: 1. High abundance at a few locations; 2. low abundance occurring at a large number of locations; and 3. low abundance at few locations (Rabinowitz 1981). Those cyanolichens listed above as "rare", all occur at low abundance in only a few protected areas. Uncommon cyanolichens, *Collema furfuraceum* and *Nephroma bellum*, tend to have low abundance at a frequent number of sites. *Collema nigrescens* and *Pseudocyphellaria crocata* were inconsistent in their distribution pattern with high abundance at some sites and low abundance at others. It is possible that marginal habitat was surveyed where *C. nigrescens* and *P. crocata* abundance is low.

Some cyanolichens may be rare because they are at the limit of their climatic range in Nova Scotia. Brown et al. (1995) suggest that some organisms have highest abundance at the centre of their range and as distance from this centre increases conditions become less favourable and abundance decreases. *Coccocarpia palmicola, Collema furfuraceum, C. nigrescens* and *Leptogium corticola* are at the northern extent of their range in Nova Scotia (Brodo et al.2001). *Erioderma pedicellatum*, one of the rarest lichens, is at the southern extent of its range in Nova Scotia (Maass and Yetman 2002).

Other cyanolichens in Nova Scotia may be rare because they occupy specialized niches or rare habitats (Hunter 2002, Benayas et al. 1999). For example, nine species found in this study are thought to be restricted to old growth forest (Rose 1976, Leisca et al 1991, Selva 1994). Protected Areas with old growth or near old growth forest include Boggy Lake, Economy River, Portapique River and Eigg Mountain-James River Wilderness Areas and Bornish Hills Nature Reserve (Cameron 2004). Coastal forest found in Canso Coastal Barrens and Tangier Grand Lake Wilderness Areas may not be old growth forest but likely have a long continuity of forest cover.

Some cyanolichens seem to be restricted to humid coastal forest and thus niche specialists in Nova Scotia. Humid coastal forest in Nova Scotia consists of a narrow band, several kilometres wide, along the Atlantic coast (Davis and Browne 1999). Precipitation is high (1400 to 1500 mm per year) with much of that falling as rain. Fog is frequent and the temperature is often above freezing in winter. Proximity to the coast may also mean that air is laden with dissolved salt, thus requiring salt tolerance for organisms living in the coastal zone. Some of the rarest cyanolichens in this study, and in North America, seem to be restricted to these forests. These species include *C. palmicola, E. pedicellatum, L. corticola* and *Pannaria conoplea.* However, *L. saturninum* and *S. fuliginosa* occur in humid old growth forest as well. Maass and Yetman (2002) termed such forests humid sub-oceanic lichen forests.

This study did not assess the species richness of cyanolichens in the province. The species accumulation curve revealed that, with only 20 sites sampled, not all epiphytic cyanolichens have been found. Other studies suggest that there are at least 19 other epiphytic cyanolichens which probably occur in the region but were not recorded in this study (Gowan and Brodo 1988, Selva 1999).

Despite the small number of sites surveyed, the study was successful in documenting some of the rarest lichens in the region. Knowing the locations of rarities and the lichen rich areas can help in managing protected areas. Identifying important protected areas for lichens enable better planning for conservation and recovery of endangered lichens. Furthermore, abundance measures indicate rarity, distribution patterns, and can be used for long-term monitoring.

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