Forest lichens of Nova Scotia: creating access to baseline collections data

Final report to Nova Scotia Habitat Conservation Fund
Stephen R. Clayden, Botany and Mycology Section, New Brunswick Museum

Project Goal

Contribute to the conservation of forest lichens and their habitats in Nova Scotia by organizing the extensive collections made by Wolfgang Maass between 1964 and 2004, digitizing their associated data, and making the collections and data readily available.

Background

The New Brunswick Museum (NBM) formally acquired the botanical collections of Dr. Wolfgang Maass (WM) in December 2015, shortly before he passed away in April 2016 at age 86. A biographical sketch by his Nova Scotia colleagues David Richardson and Robert Cameron has been published in the journal *Symbiosis* (2016, vol. 69, pp. 199–203). WM's collections consist of all the bryophyte and lichen material that was present in his home at Chebucto Head, NS, as of November 2009. With his and his family's agreement, his collections were transferred at that time to the NBM for safekeeping. He had previously deposited many of his early collections of mosses, especially *Sphagnum* species, in other herbaria. In 1994, the University Museum of Bergen, Norway, acquired several hundred of his Newfoundland lichen collections (Tor Tønsberg, personal communication). As accepted by the NBM, WM's collections include approximately 14,000 packets of bryophytes and lichens. Most of this material originates from his own field work, a smaller portion from other collectors who sent him specimens for identification or as gifts. His own earliest collections were made in the 1950s during his student years in Germany and the Nordic countries. Following graduate studies in plant physiology and biochemistry at the University of Tübingen, he came to Canada on a postdoctoral fellowship in 1960. He was employed from 1962 to 1987 at the National Research Council (Atlantic Regional Laboratory) in Halifax.

Up to the late 1970s, WM pursued research in two distinct areas: the taxonomy and distribution of *Sphagnum* mosses, and the natural product chemistry of lichens. Perhaps through his growing awareness of the sensitivity of lichens to environmental quality and change, he shifted his focus around this time to field studies of forest-inhabiting lichens in Atlantic Canada. From 1980 to 1985, most of this work was carried out together with Barbara L. Hoisington. His 1980 paper on the Boreal Felt Lichen, "*Erioderma pedicellatum* in North America: a case study of a rare and endangered lichen," published in the *Proceedings of the Nova Scotian Institute of Science*, was a pioneering study of its kind. It was the first "status report" on a lichen of conservation concern in northeastern North America. It anticipated reports on other such lichens that were commissioned by the Committee on the Status of Endangered Wildlife in Canada.

WM explored many areas of Atlantic Canada remote from settlements and main roads at a time when few others were studying lichens in the region. He made especially numerous collections and observations in fog-influenced coastal areas and forested wetlands, and of tree-inhabiting cyanolichens (those with a cyanobacterium as the main photosynthetic component). For many areas and habitats, these collections and their associated data are an important contemporary record of lichen diversity and relative abundance. They provide a baseline against which subsequent changes can be assessed, whether in species' abundance and distribution, or in the integrity of their habitats. However, only a small portion of the collections data has been published or otherwise made available, and the specimens have not been physically organized or accessible.

Previous work on the Maass collections at the NBM has focused on the material from the other three Atlantic Provinces. The present project aimed to organize and digitize the Nova Scotia collections, which consist of approximately 6,000 specimen packets.

Project Objectives

1. Physically organize WM's collections of lichens from Nova Scotia, and ensure that they are available for examination by staff and visitors at the NBM Collections and Research Centre in Saint John, NB.

2. Create digital (spreadsheet) records for these collections and their associated locality, habitat, and other data; make these records available to the Nova Scotia Department of Natural Resources, the Atlantic Canada Conservation Data Centre, and others (on request).

3. Structure the specimen records for eventual uploading to the on-line NBM collections database.

4. Prepare a report summarizing the makeup of the collections, including the representation of species, counties, habitats, and substrates.

5. Promote the project, the existence of the collections, and the availability of the data associated with them—during and after the project.

Results

1. **Physical organization of collections**. The collections are in the original folded paper packets, each bearing handwritten information on the species' name(s), locality, habitat, substrate, collector(s), and date. A unique collection number is also recorded on most packets. These "numbers" are alphanumeric codes assigned by Maass and (or) Hoisington, each following his or her own system. Sorting the collections by date and collection number brought together material

from single localities and habitats, facilitating data entry and consistency. All specimens are organized in trays housed in steel herbarium cabinets.

When originally received at the New Brunswick Museum in 2009, the collections were frozen following a standard protocol in order to kill any insects that might have been present. The specimen packets, being made from acidic office-grade paper, had turned yellow where they were exposed to light over years of storage on open shelving or tables in WM's home. To ensure their preservation, the specimens now need to be transferred to new archival-quality packets in which the original labels and any other notation are carefully retained. This was noted in the project proposal, but the labour-intensive task of preparing and labeling new packets will require substantial additional resources and has not yet been initiated. Some packets were also damaged by water or chemical reagents, obscuring part or all of their handwritten label information. The water-damaged packets also have some mould-development on the lichens. It is very unlikely that the moulds are still viable, and the specimens have been retained.

2. **Data entry, editing, and analysis**. Data from a total of 5,623 packets of Nova Scotia lichens were entered into a spreadsheet. Species nomenclature was brought up to date following the most recent checklist of North American lichens (https://www.ndsu.edu/pubweb/~esslinge/chcklst/chcklst7.htm#M) and several hundred identifications were reviewed and revised by Frances Anderson, Stephen Clayden, and Kendra Driscoll. The resulting electronic file (Appendix 1) forms part of this report. It has not been printed, as the document would be several hundred pages in length; it is also being continuously expanded and corrected.

WM's collection numbers (e.g. 84G-23c) convey the following information: the first two numbers are an abbreviation of the year ("84" for 1984); the letter following the year designates the month ("A" for January, "B" for February, etc.); the number after the hyphen (here "23") designates a distinct collection locality, numbered in sequence ("1,", "2," etc.) for that month and year; the final lower case letter (here "c") designates a distinct specimen packet from that locality, (lettered "a" through "z", then "aa", "bb", etc.). In some cases, especially from the 1960s and 1970s, only the year or month-and-year were recorded. In others, only the collection numbers were noted on the packets, not the corresponding locality and ecological data. The missing information could usually be deduced from other packets, but this has not yet been possible in all cases. It appears that WM did not maintain field books in which this information might have been recorded.

Summaries of the geographical distribution of the collections by county and a checklist of the species identified to date are given in Table 1 and Appendix 2. Consistent with WM's interest in lichens with "oceanic" distributions, the best-represented counties are those along the Atlantic coast, from Shelburne to Guysborough. Nearly half of the packets contain two or more named

Table 1. Summary of geographical distribution of collections.

County	No. specimen packets	No. records of associated species	Total no. species-records
Antigonish	44	72	116
Kings	141	119	260
Cape Breton	136	174	310
Pictou	95	174	269
Inverness	146	229	375
Victoria	195	247	442
Annapolis	142	284	426
Richmond	229	325	554
Yarmouth	264	346	610
Hants	215	353	568
Colchester	271	429	700
Cumberland	279	451	730
Shelburne	348	543	891
Queens	379	651	1,030
Lunenburg	410	676	1,086
Digby	480	705	1,185
Guysborough	417	862	1,279
Halifax	1432	1876	3,308
All counties	5,623	8,516	14,139

species; 16% have 5 or more, and some as many as 17 species. Thus, in addition to the species listed in the spreadsheet in the "Scientific Name" field, the packets (and data set) contain 8,516 additional records, giving a total of more than 14,000 species occurrence-records for the province. In many cases, however, the collections are identified to genus only. This is true of most of the crustose lichens (with the exception of *Thelotrema* species—see below), and of many specimens belonging to the macrolichen genera *Bryoria*, *Cladonia*, and *Usnea*.

The multi-species packets generally include a "focal" lichen and others occurring with it in the same microhabitat, often a single tree-trunk. Examples of such focal species or species-complexes, and the number of packets in which they are the main collection, are: *Anzia colpodes* (73), *Cetrelia olivetorum* s.l. (99), *Coccocarpia palmicola* (187), *Erioderma mollissimum* (32),

Erioderma pedicellatum (49*), Fuscopannaria ahlneri* group (76), *Hypogymnia* (*Cavernularia*) *hultenii* (37), *Hypogymnia krogiae* (48), *Hypogymnia vittata* (28), *Hypotrachyna afrorevoluta + H. revoluta* (31), *Hypotrachyna* (*Everniastrum*) *catawbiensis* (43), *Leptogium cyanescens* (43), *Leptogium laceroides* (20), *Lobaria pulmonaria* (84), *Lobaria scrobiculata* (986), *Moelleropsis nebulosa* ssp. *frullaniae*, (30), *Mycoblastus caesius* (31), *Nephroma helveticum* (26), *Nephroma laevigatum* (101), *Normandina pulchella* (79), *Pannaria conoplea* (125), *Pannaria lurida* (20), *Pannaria rubiginosa* (101), *Parmeliella triptophylla* (40), *Parmotrema crinitum* (37), *Pectenia* (*Degelia*) *plumbea* (83), *Platismatia norvegica* (15), *Protopannaria pezizoides* (29), *Pseudocyphellaria crocata* s.l. (60), *Sphaerophorus globosus* (32), *Sticta fuliginosa* s.l. (60), *Thelotrema lepadinum* (418), *Thelotrema suecicum* (175), *Usnea longissima* (166), and *Usnea strigosa* (25). The actual number of specimens of these lichens is much higher. *Coccocarpia palmicola*, for example, is listed as the focal species on 187 packets, but it is also present as an associated species in 86 others, for a total 273 specimen-records for Nova Scotia. (Searching for species-records in the "associated species" field in the data set will be more straightforward when the spreadsheet is uploaded to a database program.)

For several species, the location and habitat data from the collections were cited in research publications by WM. He authored or co-authored papers on *Erioderma pedicellatum*, *E. mollissimum*, *Hypogymnia* (*Cavernularia*) *hultenii*, *Pannaria lurida*, and *Moelleropsis nebulosa* subsp. *frullaniae*, a new subspecies which he discovered in *Erioderma* habitats in Nova Scotia and Newfoundland. (A list of these papers is provided in Appendix 3.) Several additional publications were evidently planned on other species. WM's and Barbara Hoisington's many collections of *Coccocarpia palmicola* and *Lobaria scrobiculata*, for example, were apparently intended to document the range of woody plant species (trees and shrubs) on which these lichens occur across their ranges in Atlantic Canada. WM prepared rough distribution maps showing this data, but did not publish them. Copies are present in the files accompanying his collections at the New Brunswick Museum.

Several status reports commissioned by COSEWIC in the past 15 years have targeted lichens that were of special interest to WM, or that are well-represented among his collections. These include *Anzia colpodes*, *Erioderma pedicellatum*, *E. mollissimum*, *Fuscopannaria leucosticta* (report currently in preparation), *Pannaria lurida*, *Pectenia* (*Degelia*) *plumbea*, and *Pseudevernia cladonia*. For some of these species, WM's occurrence records were not fully available at the time the reports were written. Updated versions will need to incorporate this "new" information.

Several other provincially or regionally rare lichens for which WM made careful and extensive searches have not yet been the subject of COSEWIC or other recent status assessments. Among these are, for example, *Hypogymnia* (*Cavernularia*) *hultenii* and *Sticta limbata*. The importance of the collections in documenting the occurrence and habitats of such species is particularly evident in the case of *H. hultenii*. This small but distinctive oceanic species is quite frequent in Newfoundland. In Nova Scotia, it was first found by WM in 1979, and subsequently shown by him to occur in humid coniferous forests in a narrow coastal zone from Lunenburg County to Cape Breton County, with an outlier on Brier Island (Maass 1981). WM and Barbara Hoisington made at least 37 collections of *H. hultenii* at approximately 20 localities in Nova Scotia. However, the most recent of these dates from 1983; *H. hultenii* has not been observed or

collected in the province since that year. (There are many recent records for Newfoundland.) It is not known whether the lack of post-1983 records signals a decline of the species in Nova Scotia, or whether it has been overlooked owing to its small size and specialized habitat. Whatever the case, efforts should be made to determine its current status.

Although WM's collecting focused on foliose and fruticose species (macrolichens), he was also interested in selected crustose genera. For example, he made 116 and 225 collections, respectively, of *Lecanora* and *Pertusaria* s.l. (as "focal" lichens). Relatively few of these collections were identified to species, however, and it appears that none was examined for microscopic or chemical characters. Another crustose lichen that attracted his notice was *Mycoblastus caesius*—though he incorrectly identified his numerous collections of it. It is an oceanic species with a distinctive blue-grey thallus and secondary product chemistry.

The crustose genus that WM collected most intensively was *Thelotrema*. This is represented in Nova Scotia (and Atlantic Canada) by three species—*T. lepadinum T. subtile*, and *T. suecicum*—commonly known as the "barnacle lichens." There are more than 600 specimens of these lichens among his and Barbara Hoisington's Nova Scotia collections, not including many packets in which *Thelotrema* is present as an associate of other species. This material formed the basis of an unpublished manuscript, dated 1984, prepared by WM together with Hinrich Harries of Mount Allison University. Stephen Clayden is now revising the manuscript with the goal of seeing it published under WM's and Harries's names. *Thelotrema lepadinum* is a well-known oceanic species in northeastern North America; *T. suecicum* is reported to be rare in the region, but WM's and other unpublished data indicate that it has been overlooked in its specialized microhabitat: the bases of trees and shrubs with smooth, acidic bark, in boggy or otherwise humid forests. *Thelotrema subtile* has not yet been reported north of southern New England; WM's collections confirm its occurrence in swampy hardwood forests in southern interior Nova Scotia, where it occurs mainly on white ash (*Fraxinus americana*). It might prove to be a species of conservation concern.

From about 1979 onward, WM recorded detailed locality information on most of his collections using the odometer on his vehicle and noting distances to the nearest 0.1 km (100 m) from well-defined road junctions or other reference points. These notes, in combination with his descriptions of habitats, make it possible to determine the latitudes and longitudes of many of his collection localities with surprising precision. The "Ruler/Path" function in Google Earth was used for this purpose, paying careful attention to the correspondence between WM's descriptions of topography and vegetation on the one hand, and the available satellite imagery on the other. Although plotting the records in this way is time-consuming, its utility can be seen in the preliminary distribution maps prepared for *Thelotrema lepadinum* (Figure 1) and *T. suecicum* (Figure 2) in Atlantic Canada. These yet-to-be published maps are based on WM's and other records at the New Brunswick Museum. The latitudes and longitudes of the collections, derived from Google Earth, were added to the spreadsheet attached to this report. When this approach is extended to his records of other species, it should be possible to relocate many of his collection localities, including those of conservation-priority lichens and lichen-habitats.

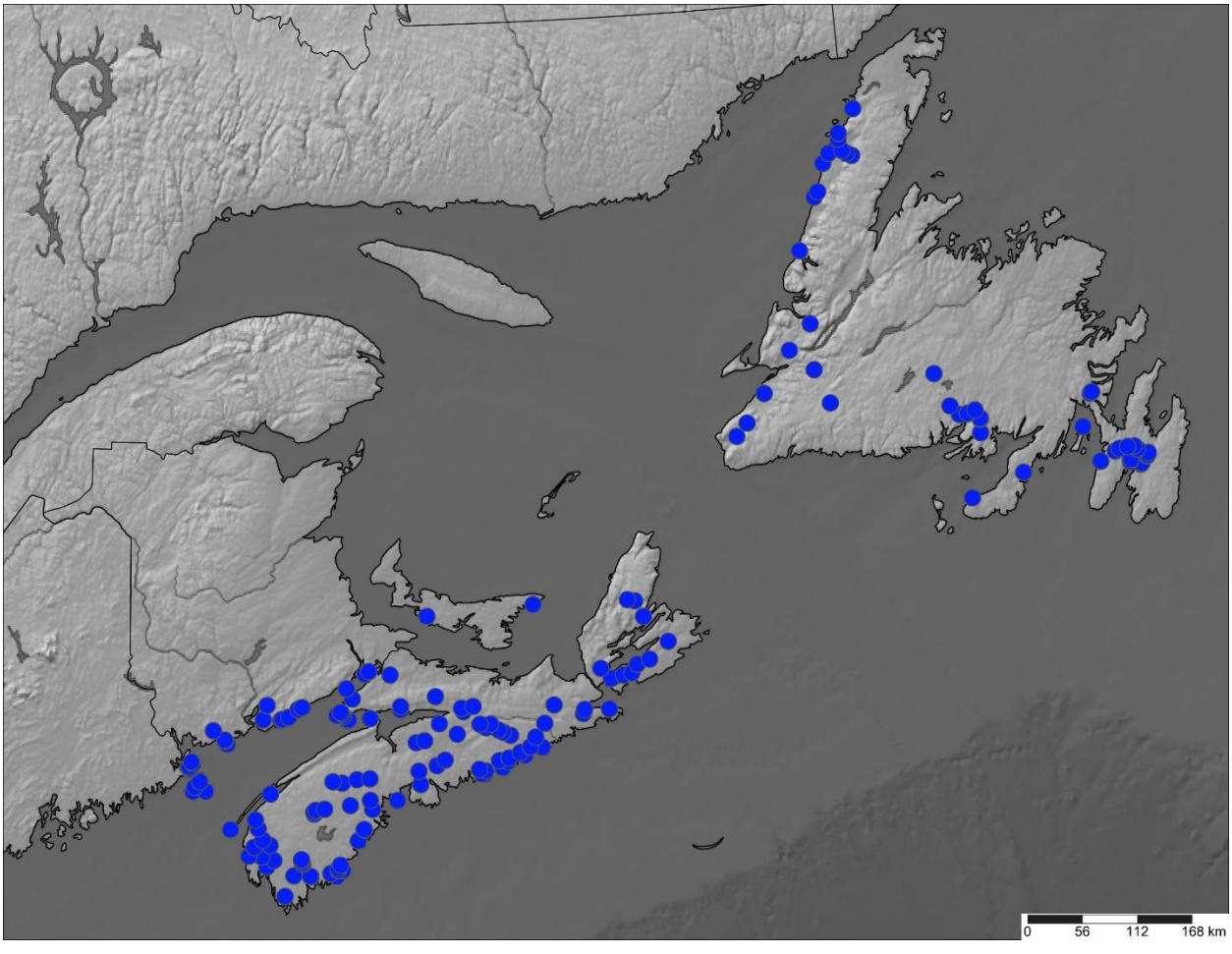

Figure 1. Distribution of *Thelotrema lepadinum* in Atlantic Canada, based largely on collections made by Wolfgang Maass. Occurrences plotted from latitudes and longitudes determined on Google Earth from detailed locality descriptions on specimen packets.

Achievements and lessons learned vis-à-vis project goal and objectives

The project has met its objective of creating access to a large, previously unavailable data set on the occurrence and habitats of forest-inhabiting lichens in Nova Scotia. About 7%, or 400 of the c. 6,000 lichen collections made by Wolfgang Maass in the province, have not yet been processed. The collections have been physically organized and made available for consultation and study. A great deal of work remains, however, to complete their identification, geo-referencing, re-packeting, and labeling. Many species of known or potential conservation priority are represented among them. The data set provides historical baseline information that will make it possible to assess changes in the distributions, habitats, and population status of these lichens in the province. Whether this information in turn contributes concretely to the conservation of lichens and their habitats in Nova Scotia—the goal of the project—will become evident only in time (years to decades).

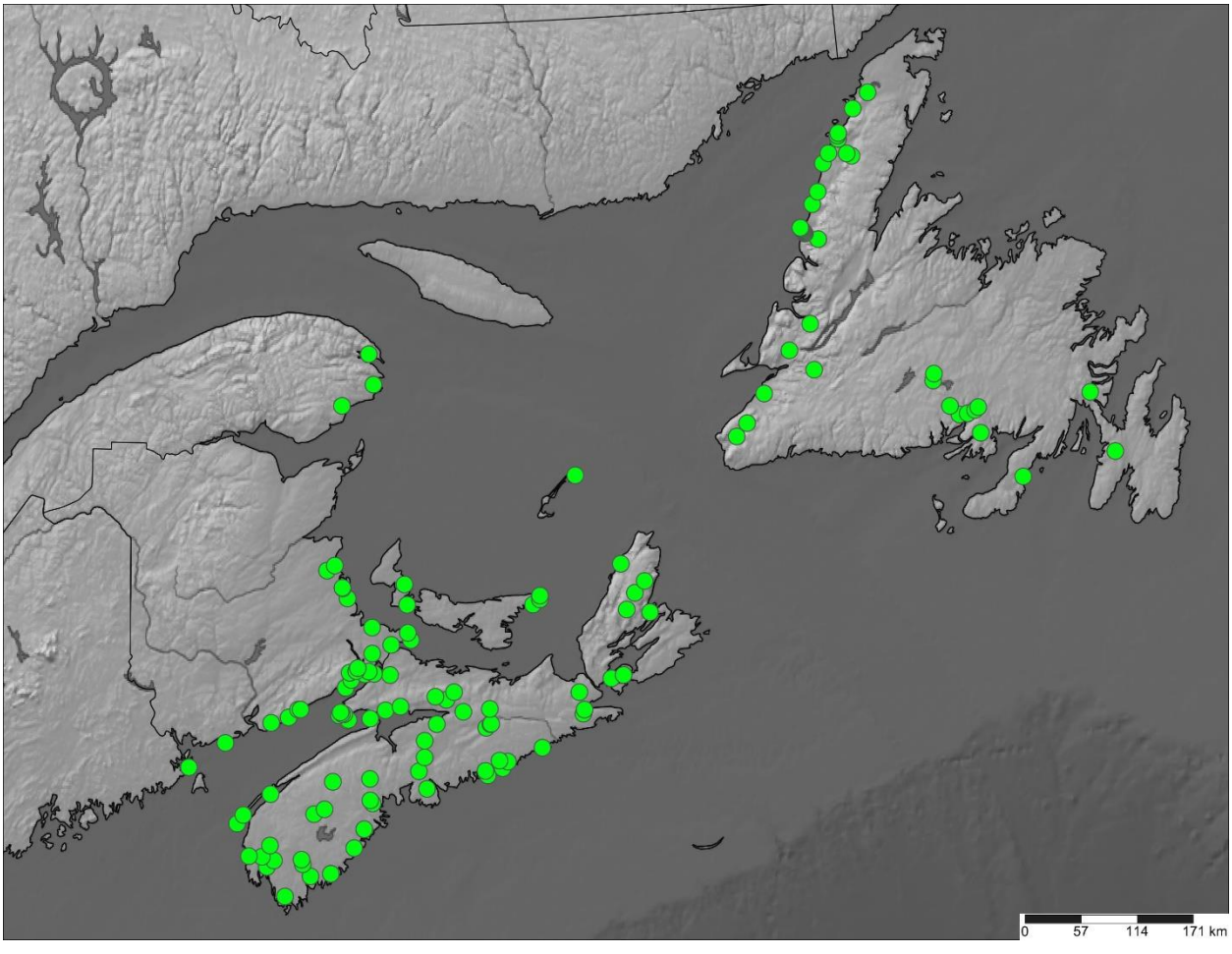

Figure 2. Distribution of *Thelotrema suecicum* in Atlantic Canada, based largely on collections made by Wolfgang Maass. Occurrences plotted from latitudes and longitudes determined on Google Earth from detailed locality descriptions on specimen packets. The known distribution is similar but not identical to that of *T. lepadinum*. There are no records of *T. lepadinum* from the east coast of New Brunswick, the Gaspé peninsula, or the Magdalen Islands.

Study of the material has yielded (and will continue to yield) many new species-records that WM did not note or anticipate. For example, there are parasitic and other "lichenicolous" fungi present on some of the lichens. A number of these were detected and identified by Kendra Driscoll in the course of digitizing the specimen data. *Phoma lobariae*, on a collection of *Lobaria quercizans* from swampy woods near the West Branch North River in the Cobequid Mountains north of Truro (Colchester County), is only the fourth record of this species in North America (the others are from Alaska, Maine, and Quebec).

To date, the promotion of this project has been informal. Numerous lichen specialists, government biologists, and others in and outside Nova Scotia and Atlantic Canada have been made aware that Wolfgang Maass's Nova Scotia and other lichen collections are now housed at

the New Brunswick Museum—and that the organization and digitization of the NS records has been supported by the Nova Scotia Habitat Conservation Fund.

Financial information

Total value of the project: $25,600
Nova Scotia Habitat Conservation Fund: $8,000
Matching funding: $8,000 (New Brunswick Museum Creative Futures Fund)
In-kind support: $9,600 (New Brunswick Museum staff and volunteer time)

Recommendations for future work

1. Upload the spreadsheet records of WM's lichen collections to the New Brunswick Museum's collections database and to the on-line Consortium of North American Lichen Herbaria (www.lichenportal.org).

2. Encourage the use and study of these collections, as well as the identification of material now named only to genus, by publishing notices in professional newsletters and other forums.

3. Continue geo-referencing of collection localities to enable the mapping, assessment, and rediscovery of sensitive species and habitats, and to facilitate their protection.

4. Ensure the long-term physical integrity and scientific value of the collections by transferring them to clearly labelled, archival quality packets.

5. Carry out targeted searches for *Hypogymnia hultenii* in Nova Scotia. Although WM's collections data suggest that this species was not rare in the late 1970s and early 1980s in humid coniferous forests along the central and eastern Atlantic coast, it has not been found in the province since that time.

Acknowledgements

The New Brunswick Museum is grateful to the Nova Scotia Habitat Conservation Fund for its support of our efforts to organize and provide access to Wolfgang Maass's collections and their associated data. We thank Frances Anderson and Kendra Driscoll for their expert review and revision of many specimen identifications. We also appreciate the careful data entry and editing carried out by Chelsey Chafe, Barbara Clayden, Kendra Driscoll, and Lean McIntosh.

Appendix 1. Collections of Nova Scotia lichens made by Wolfgang Maass (MS Excel spreadsheet—not printed). Note: Most of WM's collections dating from 1980 to 1985 were made together with Barbara L. Hoisington.

Appendix 2. Lichens identified among Nova Scotia collections made by Wolfgang Maass.

Abrothallus sp.
Acarospora sp.
Ahtiana aurescens (Tuck.) A. Thell & Randlane
Alectoria sarmentosa (Ach.) Ach.
Anaptychia palmulata (Michx.) Vain.
Anzia colpodes (Ach.) Stizenb.
Arctoparmelia centrifuga (L.) Hale
Arthonia sp.
Arthothelium sp.
Aspicilia sp.
Bacidia sp.
Bacidia schweinitzii (Fr. ex E. Michener) A. Schneid.
Biatora helvola Körb. ex Hellb. (s. lat.)
Bilimbia sabuletorum (Schreb.) Arnold
Bryoria sp.
Bryoria americana (Motyka) Holien
Bryoria capillaris (Ach.) Brodo & D. Hawksw.
Bryoria furcellata (Fr.) Brodo & D. Hawksw.
Bryoria fuscescens (Gyeln.) Brodo & D. Hawksw.
Bryoria fuscescens var. positiva (Gyeln.) Brodo & D. Hawksw.
Bryoria nadvornikiana (Gyeln.) Brodo & D. Hawksw.
Bryoria nitidula (Th. Fr.) Brodo & D. Hawksw.
Bryoria salazinica Brodo & D. Hawksw.
Bryoria trichodes (Michx.) Brodo & D. Hawksw.
Buellia sp.
Buellia disciformis (Fr.) Mudd
Buellia stillingiana J. Steiner
Calicium sp.
Caloplaca sp.
Caloplaca flavorubescens (Huds.) J. R. Laundon
Caloplaca holocarpa (Ach.) A. E. Wade
Candelariella sp.
Catillaria sp.?
Cetrelia chicitae (W. L. Culb.) W. L. Culb. & C. F. Culb.
Cetrelia olivetorum (Nyl.) W. L. Culb. & C. F. Culb.
Chaenotheca sp.
Chrysothrix candelaris (L.) J. R. Laundon
Cladonia arbuscula (Wallr.) Flot.
Cladonia botrytes (K. G. Hagen) Willd.
Cladonia cenotea (Ach.) Schaer.
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.
Cladonia coniocraea (Flörke) Spreng.
Cladonia cristatella Tuck.
Cladonia fimbriata (L.) Fr.
Cladonia gracilis group
Cladonia grayi G. Merr. ex Sandst.
Cladonia maxima (Asahina) Ahti
Cladonia merochlorophaea Asahina
Cladonia multiformis G. Merr.
Cladonia ochrochlora Flörke
Cladonia pleurota (Flörke) Schaer.
Cladonia pyxidata (L.) Hoffm.
Cladonia rangiferina (L.) F. H. Wigg.
Cladonia rei Schaer.
Cladonia scabriuscula (Delise) Nyl.
Cladonia squamosa Hoffm.
Cladonia stellaris (Opiz) Pouzar & Vezda
Cladonia terrae-novae Ahti
Cladonia uncialis (L.) F. H. Wigg.
Cladonia verticillata (Hoffm.) Schaer.
Coccocarpia palmicola (Spreng.) Arv. & D. J. Galloway
Collema furfuraceum (Arnold) Du Rietz
Collema nigrescens (Huds.) DC.
Collema subflaccidum Degel.
Dermatocarpon luridum (With.) J. R. Laundon
Dibaeis baeomyces (L. f.) Rambold & Hertel
Erioderma mollissimum (Samp.) Du Rietz
Erioderma pedicellatum (Hue) P. M. Jørg.
Evernia mesomorpha Nyl.
Evernia prunastri (L.) Ach.

Flavoparmelia caperata (L.) Hale
Fuscopannaria ahlneri (P. M. Jørg.) P. M. Jørg.
Fuscopannaria leucosticta (Tuck.) P. M. Jørg.
Fuscopannaria sorediata P. M. Jørg.
Graphis elegans (Borrer ex Sm.) Ach.
Graphis scripta (L.) Ach.
Heterodermia neglecta Lendemer, R. C. Harris & E. A. Tripp
Heterodermia speciosa (Wulfen) Trevis.
Heterodermia squamulosa (Degel.) W. L. Culb.
Hypocenomyce friesii (Ach.) P. James & Gotth. Schneid.
Hypocenomyce scalaris (Ach. ex Lilj.) M. Choisy ?
Hypogymnia hultenii (Degel.) Krog
Hypogymnia krogiae Ohlsson
Hypogymnia physodes (L.) Nyl.
Hypogymnia tubulosa (Schaer.) Hav.
Hypogymnia vittata (Ach.) Parrique
Hypotrachyna afrorevoluta (Krog & Swinscow) Krog & Swinscow
Hypotrachyna catawbiensis (Degel.) Divakar, A. Crespo, Sipman, Elix & Lumbsch
Hypotrachyna revoluta (Flörke) Hale
Icmadophila ericetorum (L.) Zahlbr.
Imshaugia aleurites (Ach.) S. L. F. Mey.
Lasallia papulosa (Ach.) Llano
Lecanora allophana Nyl.
Lecanora caesiorubella Ach.
Lecanora cinereofusca H. Magn.
Lecanora conizaeoides Nyl. ex Cromb.
Lecanora fuscescens (Sommerf.) Nyl.
Lecanora glabrata (Ach.) Malme
Lecanora hybocarpa (Tuck.) Brodo
Lecanora miculata Ach.
Lecanora muralis (Schreb.) Rabenh.
Lecanora subpallens Zahlbr.
Lecanora symmicta (Ach.) Ach.
Lecanora thysanophora R. C. Harris
Lecanora xylophila Hue
Lepra amara (Ach.) Hafellner
Lepra ophthalmiza (Nyl.) Hafellner
Lepraria incana (L.) Ach. ?
Leptogium acadiense J. W. Hinds, F. L. Anderson & Lendemer
Leptogium corticola (Taylor) Tuck.
Leptogium cyanescens (Rabenh.) Körb.
Leptogium laceroides B. de Lesd.
Leptogium milligranum Sierk
Lichenomphalia hudsoniana (H. S. Jenn.) Redhead, Lutzoni, Moncalvo & Vilgalys
Lobaria pulmonaria (L.) Hoffm.
Lobaria quercizans Michx.
Lobaria scrobiculata (Scop.) DC.
Lopadium disciforme (Flot.) Kullh.
Loxospora cismonica (Beltr.) Hafellner
Loxospora ochrophaea (Tuck.) R. C. Harris
Melanelia stygia (L.) Essl.
Melanelixia fuliginosa (Fr. ex Duby) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch
Melanelixia subaurifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch
Menegazzia terebrata (Hoffm.) A. Massal.
Micarea sp.
Micarea peliocarpa (Anzi) Coppins & R. Sant.
Moelleropsis nebulosa ssp. frullaniae Maass
Mycobilimbia sp.
Mycoblastus caesius (Coppins & P. James) Tønsberg
Mycoblastus sanguinarius (L.) Norman s.l.
Myelochroa aurulenta (Tuck.) Elix & Hale
Myelochroa galbina (Ach.) Elix & Hale
Nephroma arcticum (L.) Torss.
Nephroma bellum (Spreng.) Tuck.
Nephroma helveticum Ach.
Nephroma laevigatum Ach.
Nephroma parile (Ach.) Ach.
Nephroma resupinatum (L.) Ach.
Normandina pulchella (Borrer) Nyl.
Ochrolechia androgyna (Hoffm.) Arnold s.l.
Ochrolechia frigida (Sw.) Lynge
Ochrolechia pseudopallescens Brodo
Ochrolechia trochophora (Vain.) Oshio
Ophioparma ventosa (L.) Norman
Pannaria conoplea (Ach.) Bory
Pannaria lurida (Mont.) Nyl.
Pannaria rubiginosa (Ach.) Bory
Parmelia fertilis Müll. Arg.
Parmelia omphalodes (L.) Ach.
Parmelia saxatilis (L.) Ach.
Parmelia squarrosa Hale
Parmelia sulcata Taylor
Parmeliella parvula P. M. Jørg.
Parmeliella triptophylla (Ach.) Müll. Arg.
Parmeliopsis ambigua (Wulfen) Nyl.
Parmeliopsis hyperopta (Ach.) Arnold

Parmotrema crinitum (Ach.) M. Choisy
Parmotrema perlatum (Huds.) M. Choisy
Pectenia plumbea (Lightf.) P. M. Jørg., L. Lindblom, Wedin & S. Ekman
Peltigera aphthosa (L.) Willd.
Peltigera canina (L.) Willd.
Peltigera collina (Ach.) Schrad.
Peltigera degenii Gyeln.
Peltigera didactyla (With.) J. R. Laundon
Peltigera elisabethae Gyeln.
Peltigera evansiana Gyeln.
Peltigera horizontalis (Huds.) Baumg.
Peltigera hymenina (Ach.) Delise
Peltigera leucophlebia (Nyl.) Gyeln.
Peltigera malacea (Ach.) Funck
Peltigera membranacea (Ach.) Nyl.
Peltigera neopolydactyla (Gyeln.) Gyeln.
Peltigera polydactylon (Neck.) Hoffm.
Peltigera praetextata (Flörke ex Sommerf.) Zopf
Peltigera rufescens (Weiss) Humb.
Peltigera scabrosa Th. Fr.
Pertusaria macounii (I. M. Lamb) Dibben
Phaeographis dendritica (Ach.) Müll. Arg.
Phaeophyscia pusilloides (Zahlbr.) Essl.
Phaeophyscia rubropulchra (Degel.) Essl.
Phlyctis sp.
Physcia adscendens (Fr.) H. Olivier
Physcia aipolia (Ehrh. ex Humb.) Fürnr.
Physcia millegrana Degel.
Physcia phaea (Tuck.) J. W. Thomson
Physcia stellaris (L.) Nyl.
Physconia detersa (Nyl.) Poelt (s. lat.)
Platismatia glauca (L.) W. L. Culb. & C. F. Culb.
Platismatia norvegica (Lynge) W. L. Culb. & C. F. Culb.
Platismatia tuckermanii (Oakes) W. L. Culb. & C. F. Culb.
Porpidia albocaerulescens (Wulfen) Hertel & Knoph
Protopannaria pezizoides (Weber) P. M. Jørg. & S. Ekman
Protoparmelia badia (Hoffm.) Hafellner
Pseudevernia cladonia (Tuck.) Hale & W. L. Culb.
Pseudocyphellaria crocata (L.) Vain.
Psoroma hypnorum (Vahl) Gray
Punctelia appalachensis (W. L. Culb.) Krog
Punctelia rudecta (Ach.) Krog
Pycnothelia papillaria Dufour
Pyrenula pseudobufonia (Rehm) R. C. Harris
Pyxine sorediata (Ach.) Mont.
Ramalina americana Hale
Ramalina dilacerata (Hoffm.) Hoffm.
Ramalina farinacea (L.) Ach.
Ramalina roesleri (Hochst. ex Schaer.) Hue
Ramalina thrausta (Ach.) Nyl.
Rinodina ascociscana (Tuck.) Tuck.
Ropalospora chlorantha (Tuck.) S. Ekman
Scoliciosporum chlorococcum (Stenh.) Vezda
Solorina saccata (L.) Ach.
Sphaerophorus fragilis (L.) Pers.
Sphaerophorus globosus (Huds.) Vain.
Stenocybe sp.
Stereocaulon sp.
Sticta fuliginosa (Hoffm.) Ach.
Sticta limbata (Sm.) Ach.
Stictis urceolatum (Ach.) Gilenstam
Thelotrema lepadinum (Ach.) Ach.
Thelotrema subtile Tuck.
Thelotrema suecicum (H. Magn.) P. James
Trapeliopsis granulosa (Hoffm.) Lumbsch
Tuckermanopsis americana (Spreng.) Hale
Tuckermanopsis ciliaris (Ach.) Gyeln.
Tuckermanopsis orbata (Nyl.) M. J. Lai
Umbilicaria mammulata (Ach.) Tuck.
Usnea cornuta Körb.
Usnea dasopoga (Ach.) Nyl.
Usnea flammea Stirt.
Usnea fulvoreagens (Räsänen) Räsänen
Usnea longissima Ach.
Usnea merrillii Motyka
Usnea strigosa (Ach.) A. Eaton
Usnea subfloridana Stirt.
Usnea trichodea Ach.
Usnocetraria oakesiana (Tuck.) M. J. Lai & J. C. Wei
Viridothelium virens (Tuck. ex Michener) Lücking, M. P. Nelsen & Aptroot
Vulpicida pinastri (Scop.) J.-E. Mattsson & M. J. Lai
Xanthoparmelia conspersa (Ehrh. ex Ach.) Hale
Xanthoparmelia viriduloumbrina (Gyeln.) Lendemer
Xanthoria elegans (Link) Th. Fr.
Xanthoria parietina (L.) Th. Fr.
Xanthoria polycarpa (Hoffm.) Rieber
Xylographa opegraphella Nyl. ex Rothr.

Appendix 3. Publications on the lichens of Atlantic Canada authored by Wolfgang Maass and colleagues.

Maass, W. S. G. 1980. *Erioderma pedicellatum* in North America: a case study of a rare and endangered lichen. Proceedings of the Nova Scotian Institute of Science 30: 69–87.

Maass, W. S. G. 1981. New observations on the distribution and ecology of *Cavernularia hultenii* in eastern North America. Proceedings of the Nova Scotian Institute of Science 31: 193–206.

Hoisington, B. L. & Maass, W. S. G. 1982. *Cavernularia hultenii* in northernmost Newfoundland and southern Labrador. Bryologist 85: 122–125.

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

Maass, W. S. G. 1986. *Moelleropsis* (Lecanorales) as a component of *Erioderma* habitats in Atlantic Canada. Proceedings of Nova Scotia Institute of Science 37: 21–36.

Maass, W. S. G., Hoisington, B. L. and Harries, H. 1986. *Pannaria lurida* in Atlantic Canada. Proceedings of the Nova Scotian Institute of Science 36: 131–135.

Maass, W. S. G. and Yetman, D. J. 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. 50 pages.