

## Lichens and allied fungi of Sandbar Lake Provincial Park, Ontario

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Dorval, H.R., and R.T. McMullin. 2019. Lichens and allied fungi of Sandbar Lake Provincial Park, Ontario. *Canadian Field-Naturalist* 133(3): 206–215. <https://doi.org/10.22621/cfn.v133i3.2209>

### Abstract

Sandbar Lake Provincial Park (Sandbar Lake) covers 8053 ha in the boreal forest in northwestern Ontario. Within the park boundary are natural forests representative of those in the region, as well as forests that are heavily disturbed from resource extraction activities, which are prevalent in northwestern Ontario. The lichen biota in this part of the boreal forest is known to be rich and abundant, but lichen diversity is also known to be negatively impacted by disturbances (e.g., timber harvesting, mining, and climate change). Therefore, lichens can be used to monitor the effects of these disturbances, but baseline data are required. Here, we present the results of the first detailed inventory of the lichens and allied fungi of Sandbar Lake. We report 139 species in 69 genera from 16 sites that represent all macrohabitats present in the park. Seven species have a provincial conservation status rank from S1 to S3 (critically imperilled to vulnerable), and one species, *Arthrosporium populorum*, has previously been collected only once in northwestern Ontario. Our results fill biogeographic gaps for many species and allow lichens to be used as biomonitors during further study at Sandbar Lake. We show that Sandbar Lake has important conservation value, and our data provide an opportunity for further study in an area with no previous research on lichens.

Key words: Sandbar Lake Provincial Park; lichens; fungi; boreal forest; Great Lakes–St. Lawrence forest; conservation; biogeography; bioindicators; protected areas

### Introduction

Provincial parks in Ontario are designed to maintain and preserve natural and cultural integrity while allowing for recreational and educational opportunities for the public and scientific communities (Ontario 2015). They are regulated under the *Provincial Parks and Conservation Reserves Act* and, since 1954, have been managed by Ontario Parks, a branch of the Ontario Ministry of Natural Resources and Forestry. Between 1920 and 1954, they fell under the Department of Lands and Forests. The first provincial parks in Ontario were created from land that was considered unsuitable for agriculture and settlement. However, now parks are also established to provide opportunities for outdoor recreation and the resulting economic benefits. Parks allow the public and researchers to gain knowledge of the natural heritage of Ontario; they also protect the biodiversity, ecosystems, and provincially significant elements within their boundaries (Ontario 2006). Currently, more than 7 420 816 ha in Ontario have been incorporated into 335 provincial parks, accounting for 7% of the land area in the province (Ontario 2017).

Sandbar Lake Provincial Park was established

in 1970 (Ontario Parks 2012). It was initially classified as a recreation park but was changed to its current classification as a natural environment park in 1986 (Ontario Parks 2012). This designation dictates that the management goals include maintenance of ecosystem representativeness and natural and cultural heritage, while allowing for recreational, educational, and research activities (Ontario Parks 2012). The park area includes Sandbar Lake, sand beaches, and conifer-dominated forests. Since it was established, two additions to the park have doubled its size to over 8000 ha (Ontario Parks 2012). Sandbar Lake Provincial Park is in a region northwest of Lake Superior that is known for rich lichen diversity (Crowe 1994; Ahti and Crowe 1995) and as a hotspot for lichen diversity in North America (Brodo *et al.* 2001). However, the lichens of the Sandbar Lake area have not been documented previously.

The history of lichen collecting in Ontario has been summarized by McMullin and Lewis (2013). Of the 1083 species known from the province (McMullin *et al.* 2015, 2018), at least 455 occur in the region northwest of Lake Superior (Crowe 1994; Ahti and Crowe 1995). Despite the known diversity, the only

A contribution towards the cost of this publication has been provided by the Thomas Manning Memorial Fund of the Ottawa Field-Naturalists' Club.

focussed studies within this region of Ontario have been in Slate Islands National Park (C. Wetmore unpubl. data accessed through the Consortium of North American Lichen Herbaria [CNALH]) and Voyageur National Park in Minnesota, USA (Wetmore 1981).

The aim of our study was to document the lichens and allied fungi in Sandbar Lake Provincial Park. Our objectives were to examine all major ecosystems in the park, create a checklist of lichens and allied fungi traditionally treated with lichens, compare our results with those from two other provincial parks in Ontario, and provide provincial conservation status ranks for each species. Our results will provide an increased understanding of the biodiversity in the park and a baseline that can be used to detect changes to the lichen community from disturbances, such as climate change, acid rain, or land use changes in or near the park (McMullin *et al.* 2017).

### Study Area

Sandbar Lake Provincial Park is located in northwestern Ontario, ~4 km northeast of the town of Ignace and ~250 km northwest of Thunder Bay (Figure 1), along Highway 599. This protected area covers 8053 ha. When the park was established in 1970, its area was 3157 ha. In 1986, 1926 ha were added and, in 2003, Ontario's Living Legacy Land Use Strategy facilitated a second addition of 3720 ha on the north side of the park (Ontario Parks 2012). The latter comprises mainly wetland generated through paludification, where organic matter accumulation, especially *Sphagnum* spp., contributes to increased soil moisture (Lavoie *et al.* 2005; Ontario Parks 2012). This process results in reduced soil temperature, a reduction and overall change in tree and vascular plant cover, and shifts in nutrient availability, microbial activity, and decomposition rates (Lavoie *et al.* 2005).

This wetland is designated a nature reserve zone, which is a classification used to enhance protection of features represented within provincial parks that are considered unique within the region and the province (Ontario Parks 2012). Minimal to no development is permitted within these zones, but research may be permitted. Sandbar Lake Provincial Park contains five nature reserve zones, all of which were examined for lichens during this study. Natural environment zones are areas intended for limited development to generate and maintain low-intensity recreational activities. Development permitted in these zones includes the provision of signage for trail navigation and the maintenance of interpretive facilities. Two natural environment zones covering 6872 ha are present in Sandbar Lake Provincial Park (Ontario Parks 2012). Historical zones were also established in the park to

mark and protect culturally and historically significant areas, including those that have historically been occupied by humans and human-made structures (Ontario Parks 2012). Sandbar Lake Provincial Park has four historical zones, each delineated based on human occupation during the Laurel Period (2200–1600 years B.P.) and the Blackduck Period (1200 years B.P. to European contact; Ontario Parks 2012). All nature reserve, natural environment, and historical zones within Sandbar Lake Provincial Park are illustrated in Figure 1.

The park provides opportunities for outdoor recreation, including hiking, canoeing, and seasonal camping at 75 campsites. All campsites and hiking trails are located in the campground area in the south-eastern corner of the park adjacent to Highway 599. Use of the campground area and recreational fishing in Sandbar Lake accounts for the vast majority of park use by visitors; the remainder of the park is visited only infrequently.

Sandbar Lake Provincial Park is located within the transition zone between the boreal and Great Lakes–St. Lawrence forests (Ontario Parks 2012). The park comprises mostly conifer-dominated forests; however, mixed-wood forests, wetlands, exposed bedrock outcrops, and outwash plain ecosystem types are also represented (Ontario Parks 2012). Timber harvesting, sporadic fires, and windthrow events, which occurred mainly during the early 20th century, are largely responsible for shaping the vegetation communities currently in the park (Ontario Parks 2012). In recent decades, timber harvesting and mining operations have surrounded the park boundary (Ontario Parks 2012).

### Methods

#### Sampling

Fieldwork was conducted in the fall of 2017. Collections were made throughout the park in all major ecosystems, nature reserves, and natural ecosystem zones over 12 days. Floristic habitat sampling, completed through the intensive study of large areas, was used to evaluate species presence (Newmaster *et al.* 2005). This sampling technique was used at 16 sites, shown with corresponding geographic coordinates and habitat descriptions in Table 1. As many microhabitats as possible were examined in each site: e.g., a variety of tree species, rocks, forest floor. Most sites were visited on only one occasion; however, sites I and II, Campground and Red Pine (*Pinus resinosa* Aiton) forest, were visited more than once. All collections have been deposited at the National Herbarium of Canada (CANL) at the Canadian Museum of Nature Natural Heritage Campus in Gatineau, Quebec.

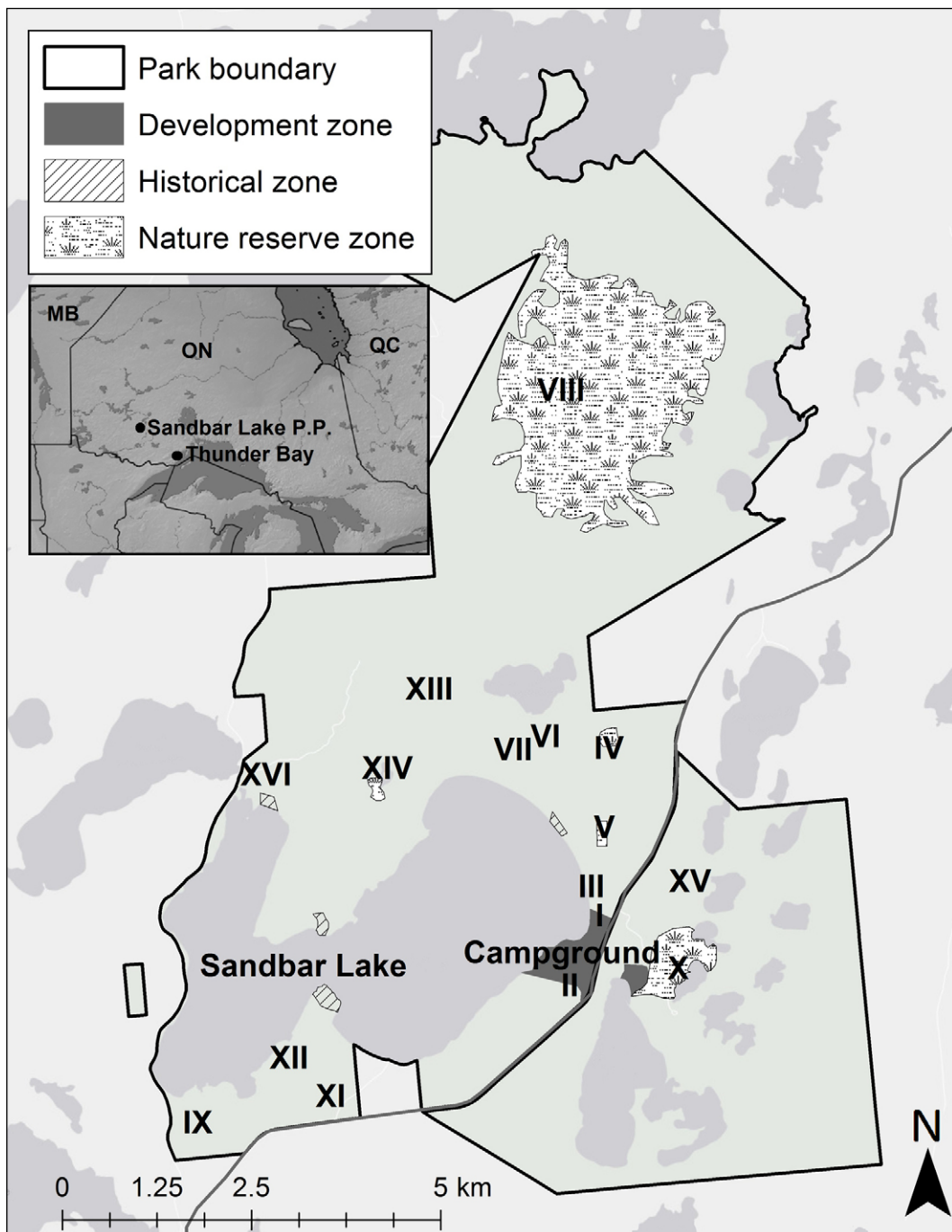


FIGURE 1. Sandbar Lake Provincial Park, showing designated zones and sampling sites.

#### Identification

All specimens were identified using standard techniques outlined by Brodo *et al.* (2001), including the use of microscopy and chemical spot tests. When neces-

sary, an ultraviolet light chamber was used for additional chemical examination. Thin-layer chromatography was also used in further chemical analysis, following Orange and White (2001) using solvents A, B', and C.

TABLE 1. Location and description of collection sites.

| Site | Location                     | Latitude (°N) | Longitude (°W) | Habitat description  |
|------|------------------------------|---------------|----------------|--|
| I    | Campground                   | 49.46517      | 91.55536       | Campsites near Sandbar Lake with small, dense patches of forest between them, connected by gravel roadways.  |
| II   | Red Pine forest              | 49.46503      | 91.55407       | Red Pine ( <i>Pinus resinosa</i> )-dominated forest naturally regenerated after fire, with young Balsam Fir ( <i>Abies balsamea</i> ) in the understorey, adjacent to the campground.                        |
| III  | Beach forest                 | 49.47220      | 91.54784       | Mixed-wood forest, dominated by Balsam Fir and Balsam Poplar ( <i>Populus balsamifera</i> ), adjacent to sandy beach along the eastern shoreline of Sandbar Lake.  |
| IV   | Mixed-wood forest*           | 49.48950      | 91.53708       | Deciduous-dominated mixed-wood forest with abundant fallen logs and herbaceous groundcover.  |
| V    | Jack Pine forest*            | 49.47955      | 91.54389       | Jack Pine ( <i>Pinus banksiana</i> )-dominated forest with exposed bedrock, young Black Spruce ( <i>Picea mariana</i> ) understorey, and lichens and mosses forming large thick mats.                        |
| VI   | Boulder cave                 | 49.48659      | 91.54849       | Caves formed by large boulders leaning against a bedrock cliff, with high humidity and limited light exposure.   |
| VII  | Cliff and exposed bedrock    | 49.48638      | 91.55068       | Exposed bedrock and steep cliffs with mixed-wood forest surrounding the base.  |
| VIII | Treed fen*                   | 49.52254      | 91.55263       | Large, humid, lowland area resulting from paludification, with sporadic Tamarack ( <i>Larix laricina</i> ) and Black Spruce, with sphagnum moss groundcover and a high diversity of wetland vascular plants. |
| IX   | Forest at South Agimak River | 49.47526      | 91.52035       | Dense, late-successional, mixed-wood forest with little understorey vegetation, near the South Agimak River and associated wetland.  |
| X    | Silhouette trail*            | 49.46295      | 91.53601       | Mixed-wood forest along Silhouette trail/roadway, with a vegetative community resulting from past resource extraction.   |
| XI   | Clearing at Flayers Road     | 49.45061      | 91.59702       | Treeless clearing along gravel road (Flayers Road) surrounded by Jack Pine, with sandy soil, fallen logs, and exposed bedrock.   |
| XII  | Flayers Road fen             | 49.45850      | 91.60091       | Fen, near Flayers Road, dominated by Tamarack and Black Spruce, with moss covering the ground and some pools of standing water.  |
| XIII | Forest north of Sandbar Lake | 49.49306      | 91.56565       | Mixed-wood forest with highly variable structure and age, located between the northeastern shoreline and 1 km north of Sandbar Lake.   |
| XIV  | Shoreline of Bog Lake*       | 49.48997      | 91.58136       | Sedge mat with abundant Tamarack and Black Spruce, few shrubs, and many dead standing trees, surrounding the small lake.   |
| XV   | Ontario rangers road         | 49.47526      | 91.52035       | Road re-colonized by forest dominated by young Balsam Fir, between two lakes to the north and south of the road.   |
| XVI  | North Agimak River           | 49.49087      | 91.60870       | River with exposed and mossy boulders, surrounded by dense mixed-wood forest.  |

\*Indicates the sampling sites in each of the park's five nature reserve zones.

#### Sorensen–Dice coefficient of similarity

To compare the lichen community at Sandbar Lake Provincial Park with two other locations in Ontario, we used the Sorensen–Dice coefficient of similarity (Dice 1945; Sorensen 1948). This coefficient is calculated as follows:

$$2A/(2A + B + C)$$

where A is the total number of species at Sandbar Lake Provincial Park and another location (e.g., location 2), B is the number of species at Sandbar Lake Provincial Park that are absent from location 2, and

C is the number of species at location 2 that are absent from Sandbar Lake Provincial Park (Dice 1945; Sorensen 1948).

The two locations included for comparison, Awenda Provincial Park (McMullin and Lendemer 2016) and Sandbanks Provincial Park (McMullin and Lewis 2014), are study sites with comparable search efforts nearest to Sandbar Lake Provincial Park.

#### Conservation status

We report the conservation status (S ranks) for each species recorded in the park. The Ontario Na-

tural History Information Centre (NHIC) assigns these non-legal provincial conservation status ranks to species in Ontario, based on guidelines set out by NatureServe (2018). If adequate information is known about the presence of a species in the province, then a rank between 1 and 5 is assigned. An S rank of 1 denotes a species that is considered critically imperilled, 2 means imperilled, 3 is vulnerable, 4 is apparently secure, and 5 is secure. Other ranks include NR meaning not ranked, U meaning unrankable (because of lack of information), and ? meaning the rank is uncertain. Species with a rank of S1 to S3 are provincially tracked. Observations of these species in the province are considered remarkable and are reported to the NHIC. Species with a rank above S3 or are unranked are not provincially tracked and are considered to be fairly common within the province.

## Results

We located 139 species in 69 genera at Sandbar Lake Provincial Park (see Annotated species list): 54 (39%) species are crustose, 52 (37%) are foliose, and 33 (24%) are fruticose. For 122 species (88%), green algae are the primary photobiont; for 13 (9%), cyanobacteria are the primary photobiont; and four (3%) are non-lichenized allied fungi.

### Sorensen–Dice coefficient of similarity

Sorensen–Dice coefficients of similarity were determined for each of the two other provincial parks and Sandbar Lake Provincial Park. The lichen community at Sandbar Lake Provincial Park is more similar to that of Sandbanks Provincial Park (coefficient value of 0.65) than to that of Awenda Provincial Park (coefficient value of 0.49). The number of species ( $n = 139$ ) at Sandbar Lake Provincial Park was also more similar to the number found at Sandbanks ( $n = 122$ ) than Awenda ( $n = 203$ ). Sandbar Lake Provincial Park is considerably larger than both other provincial parks in this comparison (Table 2).

### Conservation status

Of the 139 species discovered at Sandbar Lake Provincial Park, 125 have been assigned conservation status ranks. Seven of these species have a conservation status rank between S1 and S3 (critically imperilled, imperilled, vulnerable) and are provincially

tracked. One species is listed as S1S2: *Arthrosporum populorum* A. Massl.; two are S2: *Bacidia laurocerasi* (Delise ex Duby) Zahlbr. and *Ochrolechia pseudopallescens* Brodo; two are S2S3: *Calicium parvum* Tibell and *Chaenothecopsis pusilla* (Ach.) A.F.W. Schmidt; and two are S3: *Cetrelia chicitae* (W.L. Culb.) W.L. Culb. & C.F. Culb. and *Melanelixia glabrata* (Lamy) Sandler & Arup. The non-tracked species include 19 that are S4, seven that are S4?, 27 that are S4S5, 65 that are S5, nine that are not ranked, and five that are unrankable.

### Annotated species list

This list is organized alphabetically by genus and species, and taxonomic authorities follow the 23rd version of the North American Lichen Checklist (Esslinger 2018), as does most of the nomenclature. Any differences between this list and Esslinger's reflects the opinion of the authors. Substrate follows species name and taxonomic authorities. Roman numerals indicate the collection site (Table 1). Provincial conservation status rank follows the collection site. Non-lichenized fungi typically treated with lichens are preceded by a dagger (†).

- Acarospora fuscata* (Schrad.) Arnold—Saxicolous. VII. S5
- Amandinea punctata* (Hoffm.) Coppins & Scheid.—Corticolous on Balsam Fir (*Abies balsamea* (L.) Miller). I. S5.
- Arthonia* sp.—Corticolous on a snag. I. SNR.
- Arthrosporum populorum* A. Massl.—Corticolous on a fallen Trembling Aspen (*Populus tremuloides* Michaux). XIII. S1S2.
- Athallia pyracea* (Ach.) Arup, Frödén & Søchting—Corticolous on a fallen *P. tremuloides*. XIII. SU.
- Bacidia laurocerasi* (Delise ex Duby) Zahlbr.—Corticolous. II. S2.
- Baeomyces rufus* (Huds.) Rebert.—Terricolous on sandy soil. IX. S4S5.
- Biatora pycnidia* Printzen & Tønsberg—Corticolous on *A. balsamea* and Black Spruce (*Picea mariana* (Miller) Britton, Sterns & Poggenburgh). IV, XV. SNR.
- Biatora vernalis* (L.) Fr.—Bryicolous. I. S5.
- Bryoria* sp.—Corticolous on *P. mariana* and dead *P. mariana*. I, XII, VIII. SNR.

**TABLE 2.** Sorensen–Dice coefficient of similarity between Sandbar Lake Provincial Park community and two other park communities in Ontario.

| Provincial park | Approximate distance from Sandbar Lake Provincial Park | Area (ha) | No. of species | Sorensen–Dice coefficient |
|-----------------|--|-----------|----------------|---------------------------|
| Sandbar Lake    | 0  | 8053      | 139            | 1                         |
| Awenda          | 1018 km southeast                                      | 2915      | 203            | 0.49                      |
| Sandbanks       | 1254 km southeast                                      | 1551      | 122            | 0.65                      |

- Bryoria furcellata* (Fr.) Brodo & D. Hawksw.—Corticolous on *P. mariana* and Jack Pine (*Pinus banksiana* Lambert). I, III, IX, XIII, XIV. S5.
- Bryoria fuscescens* (Gyeln.) Brodo & D. Hawksw.—Corticolous on *A. balsamea*. XII. S5.
- Bryoria kockiana* Velmala, Myllys & Goward—Corticolous on *A. balsamea* and White Spruce (*Picea glauca* (Moench) Voss. I. S4.
- Bryoria trichodes* subsp. *trichodes* (Michx.) Brodo & D. Hawksw.—Corticolous on *P. mariana*. XII, XIV. S5.
- Buellia erubescens* Arnold—Corticolous on *A. balsamea* and Paper Birch (*Betula papyrifera* Marshall). I, X, XV. S5.
- Calicium parvum* Tibell—Corticolous on *P. resinosa*. II. S2S3.
- Calicium trabinellum* (Ach.) Ach.—Lignicolous on a snag. X. S4S5.
- Caloplaca arenaria* (Pers.) Müll. Arg.—Saxicolous. VII. S5.
- Caloplaca cerina* (Ehrh. ex Hedwig) Th. Fr.—Corticolous on a fallen *P. tremuloides*. XIII. S5.
- Caloplaca chrysophthalma* Degel.—Corticolous on a fallen *P. tremuloides*. I, IV. S4?
- Candelariella lutella* (Vainio) Räsänen—Corticolous on *Alnus* sp. and on a fallen *P. tremuloides*. I, XIII. SNR.
- Candelariella vitellina* (Hoffm.) Müll.—Saxicolous. VII. S5.
- Carbonicola anthracophila* (Nyl.) Bendiksby & Timdal—Lignicolous on burned wood. II. S4?
- Cetrelia chicitae* (W.L. Culb.) W.L. Culb. & C.F. Culb.—Saxicolous. XVI. S3?
- Chaenotheca brunneola* (Ach.) Müll. Arg.—Lignicolous on a snag. II. S4.
- Chaenotheca chrysocephala* Turner ex Ach.) Th. Fr.—Corticolous on *P. mariana*. XIII. S4.
- Chaenotheca ferruginea* (Turner ex Sm.) Mig.—Corticolous on a charred conifer and *P. resinosa*. II, X. S4.
- †*Chaenothecopsis nana* Tibell—Corticolous on *P. mariana*. XIII. SU.
- †*Chaenothecopsis pusilla* (Ach.) A.F.W. Schmidt—Corticolous on *P. resinosa*. II. S2S3.
- Chrysothrix caesia* (Flot.) Körb—Corticolous on *B. papyrifera*. I. S5.
- Cladonia botrytes* (K.G. Hagen) Willd.—Lignicolous on dead *P. mariana*. VIII. S5.
- Cladonia cenotea* (Ach.) Schaerer—Lignicolous on rotting wood. II. S5.
- Cladonia cornuta* (L.) Hoffm.—Terricolous. XI. S4S5.
- Cladonia cristatella* Tuck.—Lignicolous on a rotted stump; saxicolous; terricolous. I, V. S5.
- Cladonia deformis* (L.) Hoffm.—Terricolous on thin soil. V. S5.
- Cladonia digitata* (L.) Hoffm.—Lignicolous on rotting wood and a stump. I, II. S4S5.
- Cladonia macilenta* var. *macilenta* Hoffm.—Terricolous. XI. S5.
- Cladonia merochlorophaea* Asah.—Terricolous. I. S4.
- Cladonia mitis* Sandst.—Saxicolous. V. S5.
- Cladonia ochrochlora* Flörke—Lignicolous on rotting wood; terricolous. II, XI. S5.
- Cladonia parasitica* (Hoffm.) Hoffm.—Lignicolous on a log. II. S4.
- Cladonia phyllophora* Hoffm.—Terricolous. V, XI. S5.
- Cladonia pyxidata* (L.) Hoffm.—Terricolous. I. S5.
- Cladonia rangiferina* (L.) F.H. Wigg.—Saxicolous on bedrock. V. S5.
- Cladonia stellaris* (Opiz) Pouzar & Vězda—Saxicolous on bedrock. V. S5.
- Cladonia uncialis* (L.) F.H. Wigg.—Terricolous. V. S5.
- Cladonia verticillata* (Hoffm.) Schaer.—Terricolous. XI. S4S5.
- Dermaatocarpon luridum* (With.) J.R. Laundon—Saxicolous. XVI. S5.
- Dimelaena oreina* (Ach.) Norman—Saxicolous. VII. S4.
- Evernia mesomorpha* Nyl.—Corticolous on *A. balsamea*, *P. mariana*, and a snag. I, II, III. S5.
- Flavoparmelia caperata* (L.) Hale—Corticolous on *B. papyrifera*; saxicolous. I, VI. S5.
- Flavopunctelia flaventior* (Stirt.) Hale—Corticolous on *A. balsamea*. I. S5.
- Fuscidea arboricola* Coppins & Tønsberg—Corticolous on *A. balsamea*. XV. SU.
- Heterodermia speciosa* (Wulfen) Trevisan—Bryicolous. I. S4S5.
- Hypogymnia incurvoides* Rass.—Corticolous on *P. mariana*. XIV. S4.
- Hypogymnia physodes* (L.) Nyl.—Corticolous on *A. balsamea* and *Picea* sp. I, II, IV, XII, XV. S5.
- Hypogymnia tubulosa* (Schaer.) Hav.—Corticolous on *A. balsamea* and *Picea* sp. I, XIII. S4?
- Imshaugia aleurites* (Ach.) S.F. Meyer—Corticolous on a burned snag and dead Eastern White Cedar (*Thuja occidentalis* L.). II, VIII. S5.
- Imshaugia placrodia* (Ach.) S.F. Meyer—Corticolous on a *P. mariana* log. IX. S4S5.
- Julella fallaciosa* (Arnold) R.C. Harris—Corticolous on *B. papyrifera*. I. S4?
- Lasallia papulosa* (Ach.) Llano—Saxicolous. VI. S5.
- Lecanora albella* var. *rubescens* (Imshaug & Brodo)—Corticolous on *B. papyrifera*. XIII. SNR.
- Lecanora allophana* (Ach.) Nyl.—Corticolous on a snag. I. S5.
- Lecanora allophana* f. *sorediata* Vain.—Corticolous on *B. papyrifera* and *P. tremuloides*. I, IX. S5.

- Lecanora circumborealis* Brodo & Vitik.—Corticolous on Tamarack (*Larix laricina* (Du Roi) K. Koch). VIII. S5.
- Lecanora polytropa* (Ehrh.) Rabenh.—Saxicolous. VII. S5.
- Lecanora pulicaris* (Pers.) Ach.—Corticolous on *B. papyrifera*; lignicolous on a *Pinus* sp. cone. I, XIII. S5.
- Lecanora symmicta* (Ach.) Ach.—Corticolous on *B. papyrifera* and Eastern White Pine (*Pinus strobus* L.). I, X. S5.
- Lecanora thysanophora* R.C. Harris—Corticolous on *A. balsamea* and a deciduous tree. XIII. S4S5.
- Lepra trachythallina* (Erichsen) Lendemer & R.C. Harris—Corticolous on *T. occidentalis*. IV. S4.
- Lepraria finkii* (B. de Lesd.) R.C. Harris—Corticolous on *T. occidentalis*; saxicolous. VI, XVI. S5.
- Leptogium cyanescens* (Rabenh.) Körb.—Saxicolous on a mossy boulder. I, XVI. S5.
- Leptorhaphis epidermidis* (Ach.) Th. Fr.—Corticolous on *B. papyrifera*. IX. S4.
- Lobaria pulmonaria* (L.) Hoffm.—Corticolous on *P. tremuloides*. VII. S4.
- Melanelixia glabrata* (Lamy) Sandler & Arup—Corticolous on dead *P. strobus*. XIV. S3.
- Melanelixia subaurifera* (Nyl.) O. Blanco *et al.*—Corticolous on *B. papyrifera*; saxicolous. I, X. S5.
- Melanohalea exasperata* (Nyl.) O. Blanco *et al.*—Corticolous on *Alnus* sp. I. S4S5.
- Mycobilimbia berengeriana* (A. Massal.) Hafellner & V. Wirth—Terricolous. I. S4S5.
- Mycoblastus sanguinarius* (L.) Norman—Corticolous on *P. mariana*. VIII. S4S5.
- Mycocalicium subtile* (Pers.) Szatala—Lignicolous on a snag. I, II. S4S5.
- Myelochroa glabina* (Ach.) Elix & Hale—Corticolous on *B. papyrifera*. I. S4S5.
- Nephroma helveticum* Ach.—Saxicolous. XVI. S4S5.
- Nephroma parile* (Ach.) Ach.—Saxicolous on a mossy rock; terricolous. I, XVI. S4S5.
- Nephroma resupinatum* (L.) Ach.—Corticolous on Mountain Maple (*Acer spicatum* Lamarck); saxicolous on a mossy rock; terricolous. I, XIII. S4.
- Ochrolechia arborea* (Kreyer) Almb.—Corticolous on *B. papyrifera* and *P. mariana*. I, XIV. S4S5.
- Ochrolechia pseudopallescens* Brodo—Corticolous on *P. mariana* and dead *P. mariana*. VIII, XIV. S2.
- Parmelia squarrosa* Hale—Corticolous on *B. papyrifera*. I, XIII. S5.
- Parmelia sulcata* Taylor—Corticolous on *B. papyrifera* and on a snag. II, X. S5.
- Parmeliopsis capitata* R.C. Harris ex J.W. Hinds & P.L. Hinds—Corticolous on a conifer, *L. laricina*, *P. mariana*, and dead *P. strobus*. I, V, VIII, XII. S5.
- Parmeliopsis hyperopta* (Ach.) Arnold—Corticolous on dead *P. strobus* and a snag. I, V. S5.
- Peltigera aphthosa* (L.) Willd.—Terricolous on mossy soil. II. S5.
- Peltigera canina* (L.) Willd.—Lignicolous on a rotted log; terricolous on the base of a rock. I, IV. S5.
- Peltigera elisabethae* Gyeln.—Terricolous on sandy soil. I, III, IV. S5.
- Peltigera evansiana* Gyeln.—Bryicolous on a mossy boulder. XVI. S4.
- Peltigera extenuata* (Nyl. ex Vainio) Lojka—Saxicolous and terricolous. I, XIII, XVI. S4?
- Peltigera horizontalis* (Huds.) Baumg.—Lignicolous on a rotted log; saxicolous; terricolous on the base of a rock. I, IV, XIII. S5.
- Peltigera malacea* (Ach.) Funck—Terricolous. X. S4S5.
- Peltigera neckeri* Hepp ex Müll. Arg.—Saxicolous. XI. S5.
- Peltigera polydactylon* (Neck.) Hoffm.—Saxicolous. I. S5.
- Peltigera rufescens* (Weiss) Humb.—Terricolous. I. S5.
- Pertusaria rubefacta* Erichsen—Corticolous on *A. spicatum*. XIII. S4?
- Phaeophyscia adiastrata* (Essl.) Essl.—Saxicolous. I, XVI. S4.
- Phaeophyscia hirtella* Essl.—Corticolous on *P. tremuloides*. I. S4.
- Phaeophyscia pusilloides* (Zahlbr.) Essl.—Bryicolous; corticolous on *A. spicatum* and *P. tremuloides*. I, XIII. S5.
- Physcia adscendens* (Fr.) H.Olivier—Corticolous on *Alnus* sp.; saxicolous. I. S5.
- Physcia caesia* (Hoffm.) Hampe ex Fürnr.—Saxicolous. I. S4S5.
- Physcia millegrana* Degel.—Saxicolous. I. S5.
- Plasmatia tuckermanii* (Oakes) W.L. Culb. & C.F. Culb.—Corticolous. XII. S4S5.
- Polysporina simplex* (Taylor) Vězda—Saxicolous. VII. S4S5.
- Porpidia crustulata* (Ach.) Hertel & Knoph—Saxicolous. XIII. S5.
- Protoparmelia hypotremella* Herk, Spier & V. Wirth—Corticolous on dead *T. occidentalis*. VIII. SNR.
- Punctelia rudecta* (Ach.) Krog.—Corticolous on *A. balsamea*. I. S5.
- Pyxine soledata* (Ach.) Mont.—Saxicolous. VI. S5.
- Ramalina dilacerata* (Hoffm.) Hoffm.—Corticolous on *Picea* sp. I, XIII. S4.
- Ramalina intermedia* (Delise ex Nyl.) Nyl.—Saxicolous on a boulder. VII. S5.
- Rhizocarpon concentricum* (Davies) Beltr.—Saxicolous. VII. SNR.
- Rhizocarpon timidii* Ihlen & Fryday—Saxicolous. VII. SNR.

- Rinodina freyi* H. Magn.—Corticolous on a fallen *P. tremuloides*. XIII. S4S5.
- Scoliosporium chlorococcum* (Stenh.) Vězda—Lignicolous on a *Pinus* sp. cone. I. S5.
- †*Sphinctrina anglica* Nyl.—Lichenicolous on *P. hypotremella* on *T. occidentalis*. VIII. S4.
- †*Stenocybe pullatula* (Ach.) Stein—Corticolous on *Alnus* sp. I. SU.
- Stereocaulon dactylophyllum* Flörke—Saxicolous. I. S4.
- Stereocaulon grande* (H.Magn.) H. Magn.—Saxicolous. XVI. S4.
- Stereocaulon tomentosum* Fr.—Terricolous on mossy soil and on sandy soil. IX, X, XI, XVI. S4S5.
- Trapeliopsis granulosa* (Hoffm.) Lumbsch—Terricolous on sandy soil. III. S5.
- Tuckermanopsis americana* (Sprengel) Hale—Corticolous on *B. papyrifera* and on a snag. II, XIII. S5.
- Tuckermanopsis sepincola* (Ehrh.) Ach.—Corticolous on *L. laricina*. VIII. S5.
- Umbilicaria deusta* (L.) Baumg.—Saxicolous. VII. S5.
- Umbilicaria mammulata* (Ach.) Tuck.—Saxicolous. III, VI. S4S5.
- Umbilicaria muehlenbergii* (Ach.) Tuck.—Saxicolous on a boulder. V, VII. S4S5.
- Usnea cavernosa* Tuck.—Corticolous on *A. balsamea* and on *P. mariana*. I, III, VIII, XII. S4S5.
- Usnea dasopoga* (Ach.) Nyl.—Corticolous on a conifer. XII. S5.
- Usnea hirta* (L.) Weber ex F.H. Wigg.—Corticolous on a snag. II. S5.
- Usnea lapponica* Vain.—Corticolous on a snag. II. S4?
- Usnea subfloridana* Stirt.—Corticolous on dead *P. mariana*. VIII. S4S5.
- Vulpicida pinastri* (Scop.) J.-E. Mattson & M.J. Lai—Corticolous on burned wood and on *P. mariana*; lignicolous on rotting wood. II, V, VIII, XV, XIV. S5.
- Xanthomendoza hasseana* (Räsänen) Schøting, Kärnefelt & S.Y. Kondr.—Corticolous on *P. tremuloides*. XIII. S5.
- Xanthoparmelia plittii* (Gyeln.) Hale—Saxicolous. VII. S4S5.
- Xanthoparmelia viriduloumbrina* (Gyeln.) Lendemer—Saxicolous. VII, XVI. SU.

## Discussion

Sandbar Lake Provincial Park hosts a rich diversity of lichens, including many species that are rare in the region and province. For example, *A. populorum*, of which we made a single collection, is only known from nine collections in Ontario, of which only one is in northwestern Ontario (MIN 879779). This spe-

cies is almost exclusively collected from the bark of Trembling Aspen, as it has been from Sandbar Lake Provincial Park. Although it is provincially tracked, this species is inconspicuous and may be overlooked in the province. Three species, *B. laurocerasi*, *C. parvum*, and *O. pseudopallescens*, are also considered rare or very rare in southern Ontario (Wong and Brodo 1992). Within the province, *B. laurocerasi* has been collected mainly from the area directly surrounding the Great Lakes. Given the distance of this provincial park from this location (~200 km northwest), this observation is notable. Similarly, *C. chicitae* is only known from near Lake Superior in Ontario (Brodo *et al.* 2001). Geographic patterns found in previous reports of these species are likely affected by past collection efforts being almost exclusively in the area surrounding the Great Lakes, solidifying the need for further study in inland areas of northwestern Ontario. Overall, the species composition of the community found at Sandbar Lake Provincial Park reflects the boreal forest in the region; representative species include *P. aphthosa*, *V. pinastri*, and 17 species in the genus *Cladonia* (Brodo *et al.* 2001). The most common species in Sandbar Lake Provincial Park were *B. furcellata* and *P. canina*, which we collected six times each, at two and six collection sites, respectively. Both species are reported frequently from the province, as well.

Although the northwest region of Ontario is known for a high diversity of lichens, previously, only one study has been geographically focussed (an intensive study within a relatively small, delineated boundary such as within a provincial park of a few hundred ha as opposed to within the entire province or not in a delineated area) in the region, on the Slate Islands (C. Wetmore unpubl. data accessed through CNALH). Focussed studies in areas with delineated boundaries, such as ours, are important for establishing baseline data. Lichens are effective indicators of climate change and ecological integrity and, with a sound baseline, can be used to monitor changes in the local environment over time (McMullin *et al.* 2017).

Coefficients generated through a Sorensen–Dice comparison showed a low level of similarity between the lichen community at Sandbar Lake Provincial Park and two other provincial parks in Ontario. Given the distance and difference in climate and forest types among the parks, this result was not surprising. Awenda and Sandbanks Provincial Parks are over 1000 km southeast of Sandbar Lake Provincial Park and both border large freshwater bodies (Georgian Bay and Lake Ontario). Sandbar Lake is located within the boreal forest region, while Awenda and Sandbanks are in the Great Lakes–St. Lawrence forest region, which has a higher diversity of decidu-



ous trees. Both Awenda and Sandbanks Provincial Parks are smaller than our study area. Although the size of Sandbar Lake Provincial Park would likely relate to higher diversity of lichen species, access to most parts of this park are limited, with few roads and trails outside the campground. Access by trails and roads is also limited in some areas of Sandbanks; however, the small size of the park may make it easier to sample a greater proportion of its area. In contrast, Awenda has trail networks that can be used to access most portions of the park. Nonetheless, these parks were selected because they were the nearest areas with similar search efforts (McMullin and Lewis 2014; McMullin and Lendemer 2016).

Sandbar Lake Provincial Park is surrounded by resource extraction operations, especially timber harvesting. The park, therefore, provides protection for important habitats in the area. Expansions to the park have also facilitated increased ecosystem representativeness, and over time there is potential for mature or old-growth forests to develop—a habitat that is rare in this region (Ontario Parks 2012). Much of the current area of Sandbar Lake has experienced a variety of disturbances in recent history, including natural processes, such as wildfire, and anthropogenic ones, such as industrial-scale timber harvesting (Ontario Parks 2012). Forest management practices in northern Ontario have been shown to have direct effects on lichen community composition (e.g., herbicide contact, loss of microhabitats) and indirect effects (e.g., light exposure, tree species presence, changes in structural diversity, changes to available moisture; McMullin *et al.* 2013). As a result, previous disturbances in the park will have influenced the lichen biota present now. Our baseline data provide the first foundation that can be used to acknowledge and monitor future changes to the lichen community. Our results can also be used to compare with lichen communities on lands outside the park to better understand the effects on lichen biodiversity of resource extraction in the region.

### Author Contributions

Writing – Original Draft Preparation: H.R.D. and R.T.M.; Writing – Review & Editing: R.T.M. and H.R.D.; Conceptualization: R.T.M.; Formal Analysis: H.R.D.; Investigation: H.R.D. and R.T.M.; Methodology: H.R.D. and R.T.M.; Project Administration: H.R.D. and R.T.M.; Resources: H.R.D. and R.T.M.

### Acknowledgements

We thank the Ministry of Natural Resources and Forestry, Ontario Parks, and the staff of Sandbar Lake Provincial Park for allowing this study to take place and for providing accommodations and natural heritage information to ensure that fieldwork could be

conducted with the greatest efficiency.

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Received 7 January 2019

Accepted 14 October 2019

#### SUPPLEMENTARY MATERIAL:

**Appendix S1.** Collection details of specimens.