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Cover Photograph: The Rouge River and Rouge River Valley in Rouge National Urban Park in the Greater Toronto Area of southern Ontario. Photograph © R. Troy McMullin.

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Abstract - Rouge National Urban Park is in the eastern region of the Greater Toronto Area (GTA) of southern Ontario. It was established in 2015 and is Canada's first national urban park. To better understand the biodiversity in the park, we conducted a survey of the lichens and allied fungi and discovered 124 species in 69 genera. Three species are reported for the first time from Canada: *Arthonia* cf. *granosa, Verrucaria dolosa,* and *V. phloeophila.* Two additional species are reported for the first time in Ontario: *Halecania* sp. and *Verrucaria praetermissa.* Thirty-three species are new to the GTA. Four species have a provincial rank of S3 (vulnerable). Ten species are considered rare in Ontario. Most of the rare species occur in the narrow southern portion of the park that is heavily forested with deep ravines, flood plains, and old-growth forests. Our results show the importance of protected natural areas in urban landscapes for biodiversity, even for taxa that are sensitive to disturbance, such as species of lichens and their related fungi.

Introduction

Rouge National Urban Park (RNUP), in the eastern region of the Greater Toronto Area (GTA), is Canada's first and only national urban park. Recorded human history in the park area dates back at least 10,000 years and includes the first farmers from Indigenous communities who started growing corn and other crops around 700 AD (PCA 2019, 2021). Increased human disturbances to the landscape as a result of the Euro-Canadian settlement and the proliferation of industrial agriculture, timber harvesting, and milling in the Rouge Valley dates back to the 18th century (PCA 2019, 2021). Disturbances intensified in the 20th century, and much of the Rouge Park landscape was further altered by housing developments, aggregate mineral extraction, the construction of service and transportation corridors, the introduction of numerous invasive alien plant species and feral animals, altered hydrological and fire regimes, unmanaged and increasing park visitation, dumping, and the creation of several unofficial trails through sensitive habitats, with most of these issues predating Parks Canada's presence (PCA 2021). Despite these disturbances, the park still contains a rich biodiversity, including 971 species of vascular plants, 112 breeding birds, 24 mammals, and 19 herpetofauna (TRCA 2015). The 2013 Ontario BioBlitz (a 24-hour survey) also took place in the area that is now RNUP, and 54 lichen species were reported (McMullin et al. 2018).

Lichens are stable composite organisms that are comprised primarily of a mycobiont (fungus) and a photobiont (an alga, cyanobacterium, or both) (Brodo et al. 2001). Many lichen species are sensitive to disturbance and, consequently, are typically studied outside of urban centers in Canada, in less disturbed habitats where diversity tends to be higher (e.g., Bell-Doyon et al. 2021, Brodo et al. 2013, Paquette et al. 2019). A lichen study in three southern Ontario cities

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(Hamilton, Niagara Falls, and Owen Sound) confirmed this narrative and showed a negative correlation between urbanization and lichen diversity (McMullin et al. 2016). One of the main reasons for the lower diversity in urban areas is the presence of pollutants in the atmosphere and precipitation, from which lichens obtain minerals and nutrients (Richardson 1975, Richardson and Cameron 2004). They have a range of tolerances to air pollution and, as a result, sensitive species have been used extensively to monitor air quality (Cameron et al. 2007, Henderson 2000, Richardson 1992). Lichens are also used to monitor ecological integrity. Due to the narrow environmental conditions required by particular species, they can be used as indicators of subtle changes (Allen and Lendemer 2016, McMullin et al. 2017).

Despite the sensitivity of many species, natural environments in urban areas still provide suitable habitat for many lichens (e.g., Allen and Howe 2016; Allen and Lendemer 2021; McMullin et al. 2014; Tumur and Richardson 2017, 2019). For example, old-growth forests in deep ravines, like those in the southern part of RNUP, could host relic populations in a landscape where few old-growth forests remain (Bohdan 2014, Henry and Quinby 2010). The species inhabiting old-growth forests can also become established in maturing stands nearby more easily as dispersal limitations are reduced (e.g., Hilmo and Såstad 2001). In addition, the habitat in urban parks is important for recolonization as air quality improves. Ontario's air quality has steadily improved since 1988 (Ministry of the Environment 2014). Therefore, lichens may recolonize suitable habitats in the GTA as they have done in the European cities of London and Paris when air quality improved (Rose and Hawksworth 1981, Seaward and Letrouit-Galinou 1991). However, to track whether recolonization is occurring or to monitor increases or declines in populations, baseline data are requuired. Knowing what species are present, where they are located, and identifying which are rare or sensitive are also essential for developing management strategies (Reid and Miller 1989, Powell et al. 2000).

The aim of our study is to document the lichen and allied fungi biota in RNUP. Our objectives were to survey the major ecosystem types, examine as many meso- and micro-habitats as possible, provide a summary of the lichen and allied fungi species discovered, and highlight rare species and their location in the park. The results can help to illustrate the importance of natural space in urban areas for biodiversity, even for taxa that are sensitive to disturbance such as species of lichens and their related fungi.

Methods

Study Area

Parks Canada, an agency of the Government of Canada, began working towards the establishment of RNUP in 2011 with municipal and provincial governments, Indigenous partners, and stakeholders (PCA 2019). The park was officially created in May 2015, and once it is fully developed, it will cover 19546 acres (49.15 miles^2) (PCA 2019), making it the largest protected urban area in North America.

Rouge National Urban Park is located in the eastern portion of the GTA, Canada's largest metropolitan area (with 6,417,516 people), and overlaps the cities of Markham, Pickering, Toronto, and the Township of Uxbridge (Fig. 1, PCA 2019, Statistics Canada 2017). The park is centered on the Rouge River and its tributaries, but it also includes portions of the Duffins Creek and Petticoat Creek watersheds (PCA 2021, TRCA 2015). It stretches north from Lake Ontario about 14 miles to the Oak Ridges Moraine. This area has been exposed since the Late Wisconsin glacier retreated about 12,000 years ago (Barnett et al. 1998). The bedrock in the park is mostly shale (PCA 2019, Sharpe 1980). The ecosystems include forests, meadows, ravines, and inland and coastal wetlands, along with small remnants of rare habitats such as oak savannah and some of the northern-most remnants of Carolinian woodlands in Ontario

(PCA 2021, TRCA 2015). The northern section of the park has scattered wetland and forested pockets with corridors intertwined, but it is mostly used for agriculture — approximately 50% of the total park area is actively farmed (PCA 2019). The southern section of the park is at the northern limit of the Carolinian Life Zone and it contains mature forested ravine complexes

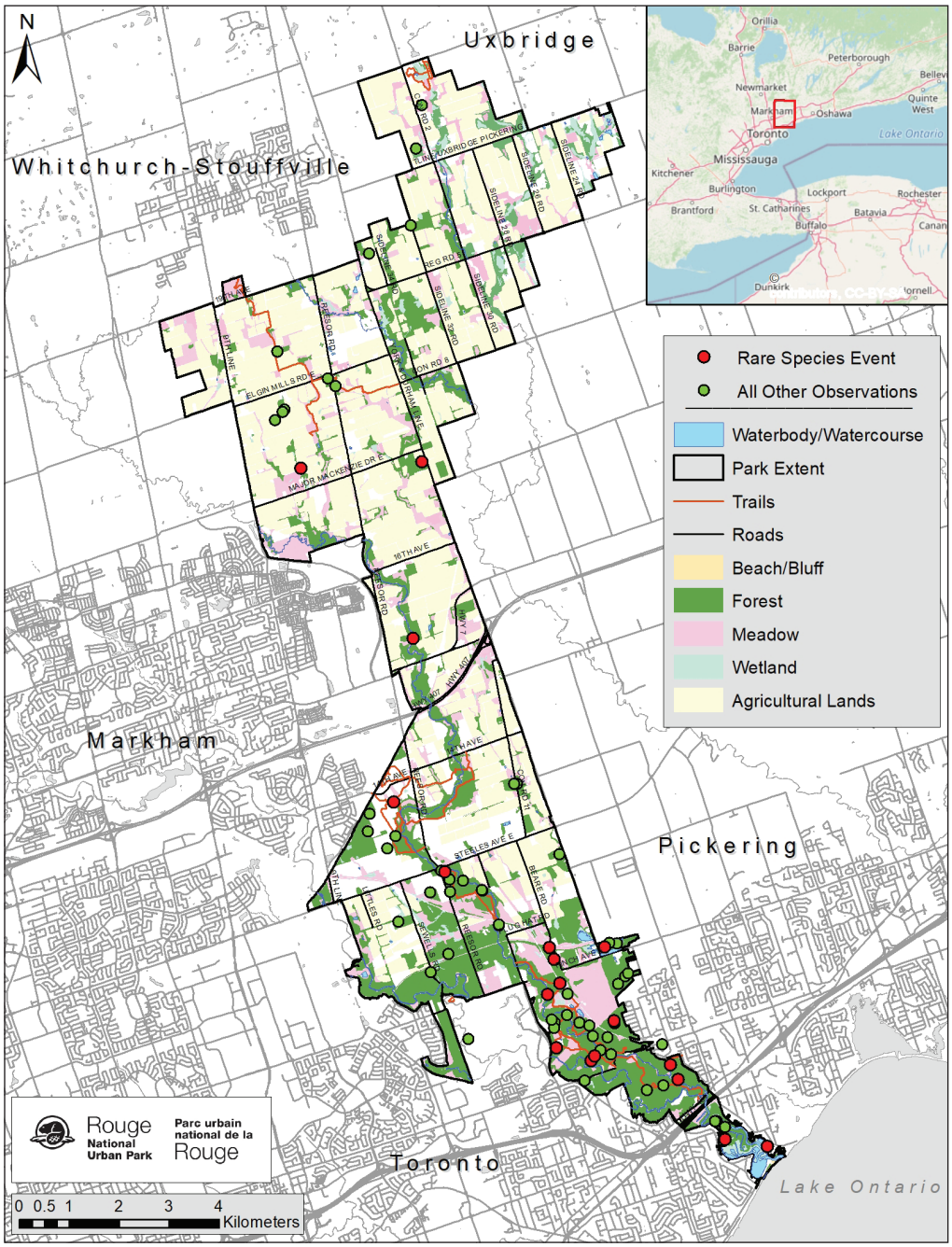

Figure 1. Rouge National Urban Park land cover and collection sites for all lichens and allied fungi. Red dots = rare species, which are defined in Table 2. Green dots = all other collection sites.

with steep valley slopes, bluffs, expansive floodplains, and the largest coastal wetland in Toronto, the Rouge Marsh (PCA 2019, 2021; TRCA 2015). The park is between 43.78974°N and -79.12129°W in the south, 43.99500°N and -79.19948°W in the north, 43.79476°N, -79.11678°W in the east, and 43.94834°N, -79.26816°W in the west. The mean annual temperature in the region is 48.92°F with a mean monthly low of 25.34°F in January and a high of 72.14°F in July, and the mean annual precipitation is 32.72 inches, with rainfall constituting 86% of the total (Government of Canada 2017). Most of the rain falls in May, August, and September, while most of the snow falls between December and March (Government of Canada 2017). The minimum and maximum elevations are 242.78 feet and 1082.68 feet above sea level (Ontario Ministry of Natural Resources and Forestry 2022). Air quality has been improving in Ontario in recent decades, and there has been considerable improvement since 2008, as well as fewer smog advisories (Government of Ontario 2014). Nitrogen oxides, sulphur dioxide, carbon monoxide, and fine particulate matter have decreased in concentration and emission by over 10% between 2006 and 2015, while ozone increased 3% (Government of Ontario 2015).

Sampling

Our survey of the lichens and allied fungi of RNUP was conducted from October 25–27, 2020. We also include the results from the Ontario BioBlitz on September 15, 2013. Using land cover maps, we selected a wide variety of natural habitat types to assess (Figs. 1 & 2, Table 1). Our survey methods followed Newmaster et al. (2005), who showed that examining large areas (referred to as floristic habitat sampling) captures cryptogam diversity more effectively than using smaller representative plots. Using floristic habitat sampling, we surveyed as many ecosystems in the park as possible. All observed restricted mesohabitats (e.g., streams, rock outcrops) were examined in each ecosystem. We attempted to assess as many microhabitats (e.g., snags, different tree species and rock types) as possible at each location. This method was described by Selva (2003) as an "intelligent meander."

Identification

Our specimens were identified using light microscopy (compound and stereomicroscopes) and chemical spot tests with paraphenylenediamine in ethyl alcohol, 50% nitric acid, sodium hypochlorite, 10% and 20% potassium hydroxide, and Lugol's iodine following Brodo et al. (2001). We further examined chemistry using a longwave ultraviolet light chamber (365 nm). Specimens that we could not reliably identify by morphology, spot tests, or ultraviolet light were analyzed for secondary metabolites using thin-layer chromatography (TLC) in solvents A, B′, and C following Culberson and Kristinsson (1970) and Orange et al. (2001). We captured images with a Leica DVM6 digital microscope (Figs. 3A, C; 4A, C, E). Maps were produced with ArcGIS v. 10.8.1 (Figs. 1; 2; 3B, D; 4B, D, F). Our specimens are housed at the Biodiversity Institute of Ontario Herbarium (OAC) at the University of Guelph and at the national herbarium at the Canadian Museum of Nature (CANL).

Conservation Status

Provincial conservation status ranks (S-ranks) are non-legal designations, which are set in Ontario by the Natural History Information Centre based on guidelines developed by NatureServe (2021). Species with distributions and frequencies that are well understood receive a rank between 1 and 5. Ranks are defined as follows: 1 = critically imperilled, 2 = imperilled, 3 = vulnerable, 4 = apparently secure, 5 = secure, NR = not ranked, U = unrankable (due to a lack of information), and ? = rank uncertain.

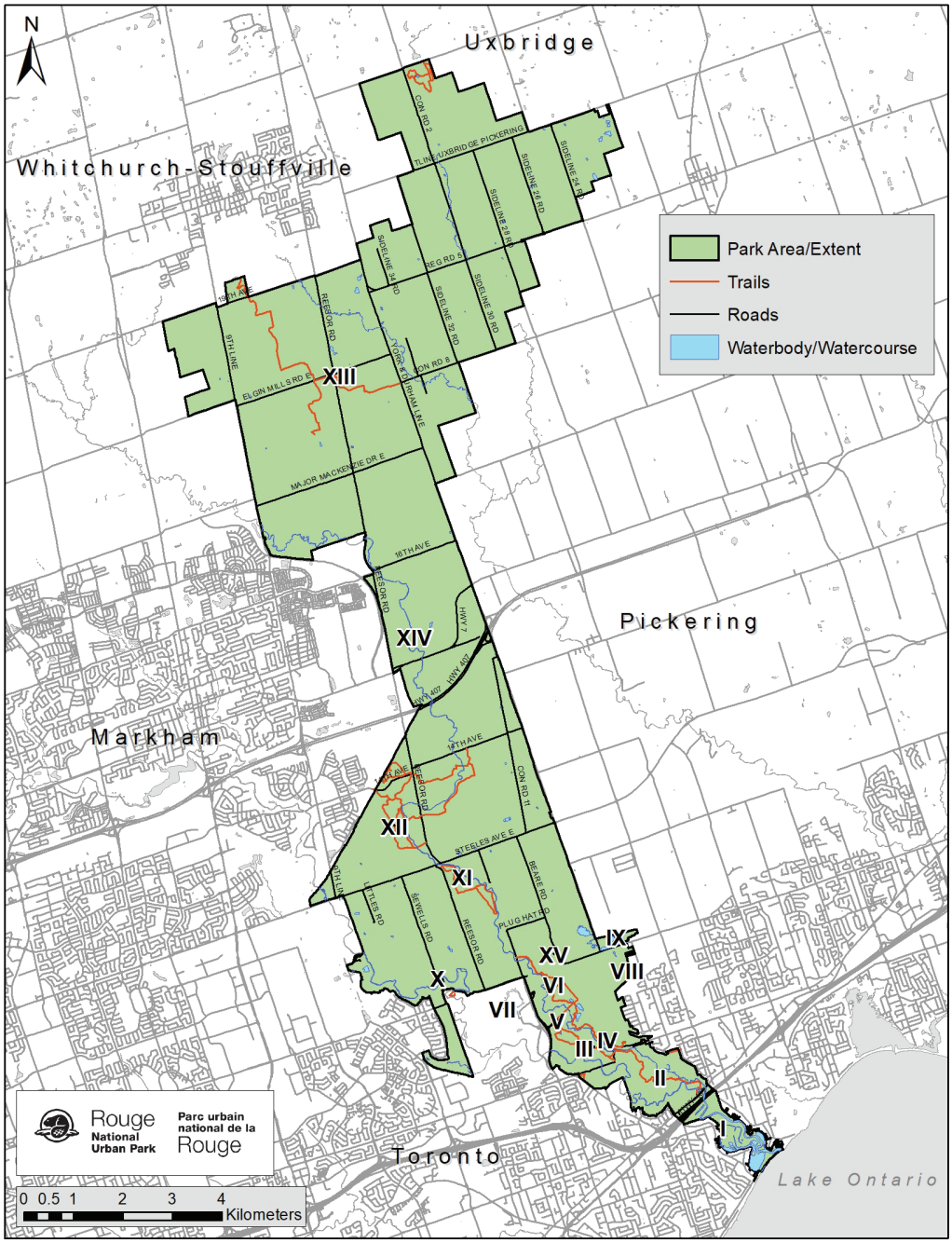

Figure 2. Major collection areas for lichens and allied fungi in Rouge National Urban Park. Roman numerals correspond with collections in the annotated species list and the habitat descriptions in Table 1.

Table 1. Site coordinates and habitat descriptions for localities examined. Roman numerals correspond with those in Figure 1 and the Annotated Species List.

Site No.	Location	Latitude	Longitude	Habitat
I	Ravine S of Hwy 401	43.79912	-79.129787	Mature and old-growth mixed-wood deciduous dominated forest in a river flood plain in a deep ravine. Tree cover includes American Beech, Eastern Hemlock, Maple, and Willow.
II	Trails between Glen Rouge Campground and Twyn Rivers Dr	43.80868	-79.14520	Mature American Beech, Eastern Hemlock, Sugar Maple, and Yellow Birch forest. Located atop a ravine.
III	Vista Trail	43.81425	-79.16157	Mature Sugar Maple/Red Oak forest on a ravine slope.
IV	Orchard Trail	43.81568	-79.15846	Mature American Beech, Eastern Hemlock, and Sugar Maple forest. Some patches of Freeman Maple/Green Ash Swamp. Also, some cultural woodlands with Manitoba Maple.
V	Rouge Valley Conservation Centre vicinity	43.81931,	-79.17069	Mature and young mixed-wood forest. Collections of exposed trees or trees at forest edge. Tree cover includes Maple, Russian Olive, Staghorn Sumac, White Ash, and White Pine.
VI	Cedar Trail and the Beare Wetlands Loop	43.82598	-79.17140	Wetlands with standing water and scattered trees. Most collections in the ravine between the two trails with mature mixed-wood forest that include American Beech, Eastern Hemlock, Eastern White Cedar, Maple, and Yellow Birch.
VII	Toronto Zoo – Canadian Domain	43.82175	-79.18433	Large scattered trees including Maple and Trembling Aspen.
VIII	Finch Ave and Woodview Ave Cedar Swamp	43.82818	-79.15288	Mature and old-growth Freeman Maple/Green Ash Swamp with a notable flood regime. Second-growth Freeman Maple/Green Ash forest south of Finch Avenue. Some patches of Eastern White Cedar swamp.
IX	Scarborough Pickering Townline and 11th Concession	43.83439	-79.15556	Mature and old-growth American Beech, Red Oak, and Sugar Maple forest. Some patches of Freeman Maple/ Green Ash swamp.
X	Sewells Road and Old Finch Ave Vicinity	43.82761	-79.20059	Mature and old-growth mixed-wood forest in and atop a deep ravine. Tree cover includes Ironwood, Maple, and Oak.
XI	Woodlands Area	43.84600	-79.19386	Mature mixed-wood forests. Tree cover includes Ash, Black Maple, Eastern White Cedar, Red Oak, and Sugar Maple.
XII	Bob Hunter Memorial Park	43.85550	-79.21053	Mature mixed-wood deciduous dominated forest. Tree cover includes American Beech, Hawthorn, Ironwood, Maple, and Oak. Also, ornamental calcareous boulders and old exposed cedar fence posts.
XIII	Northern Woodlots	43.93796	-79.22211	Mature American Beech, Red Oak, and Sugar Maple forest. Some areas of Freeman Maple, Green Ash, and Eastern White Cedar swamp. Sporadic Black Cherry and Ironwood.
XIV	Little Rouge Creek off Hwy 7	43.89002	-79.20454	Mature and old-growth American Beech/Sugar Maple forest on a ravine slope. Also, floodplain forest with Eastern White Cedar, Freeman Maple, Green Ash, and Yellow Birch. Located adjacent to Little Rouge River.
XV	Plug Hat Rd and Beare Rd	43.83147	-79.17113	Mature American Basswood, Black Cherry, Red Oak, Sugar Maple, and Trembling Aspen forest. Located along a small creek and adjacent to Little Rouge River.

Results

From 374 specimens, 124 species in 69 genera are reported. One hundred and twelve species are lichens and 12 are allied fungi, 2 of which are lichenicolous. Of the lichenized species, 65 (58%) are microlichens (crustose) and 47 (42%) are macrolichens (33 foliose, 14 fruticose). One hundred and eight (96%) species of lichens have green algae as their primary photobiont and 4 species (4%) have cyanobacteria as their primary photobiont. Seven species (6%) are calicioids (1 lichenized and 6 allied fungi).

Three species are reported for the first time from Canada: *Arthonia* cf, *granosa, Verrucaria dolosa,* and *V. phloeophila* (Figs. 3 & 4, Table 2). Two additional species are reported for the first time in Ontario: *Halecania* sp. and *Verrucaria praetermissa* (Figs. 3 & 4, Table 2). Thirty three species are reported for the first time from the Greater Toronto Area: *Agonimia* sp., *Anisomeridium polypori, Arthonia granosa, Aspicilia laevata, Bacidina chloroticula, B. egenula, Caloplaca microphyllina, Chaenotheca brunneola, Chaenothecopsis perforata, C. savonica, Cladonia ignatii, Halecania* sp., *Inoderma byssaceum, Ionaspis alba, Lecania crytella, Lecanora strobilina,*

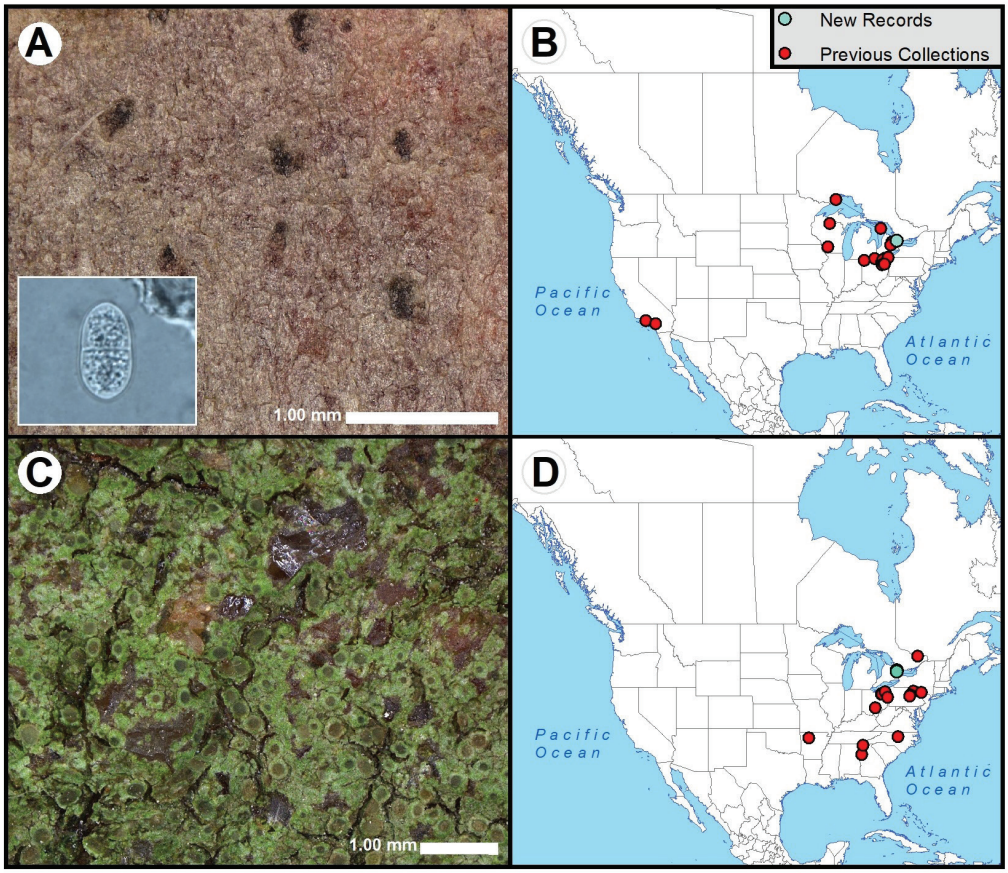

Figure 3. A–B, Reported for the first time from Canada. C–D, Reported for the first time from Ontario. A, *Arthonia* cf. *granosa* thallus and apothecia (*Wegenschimmel 166*, CANL). Inset showing the two-celled ascospores with equal sized cells. B, North American distribution of *A.* cf. *granosa.* C, *Halecania* sp. thallus and apothecia (*McMullin 22418*, CANL). D, North American distribution of *Halecania* sp. In maps, cyan dots = new records, red dots = previous collections.

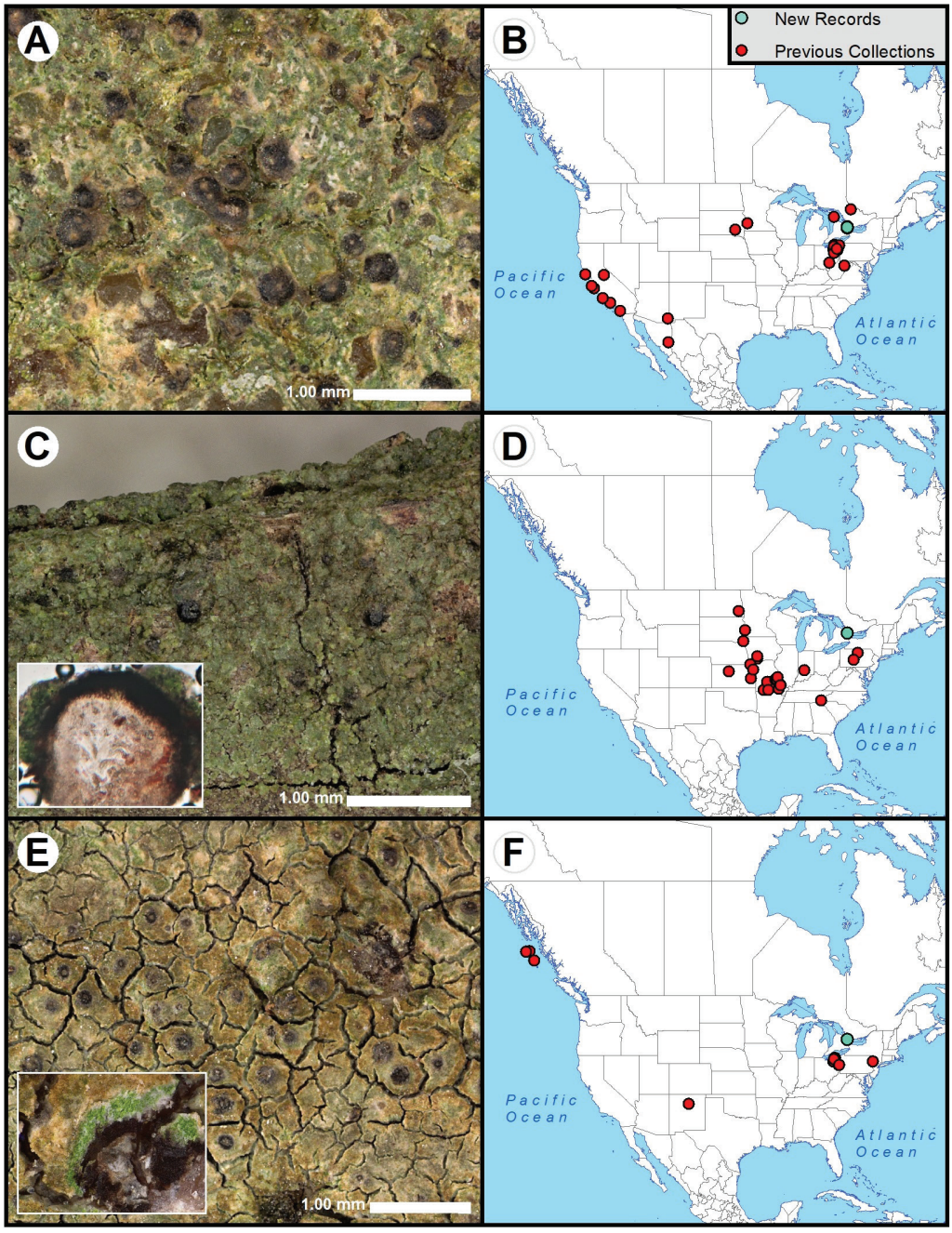

Figure 4. A–D, Reported for the first time from Canada. E–F, Reported for the first time from Ontario. A, *Verrucaria dolosa* thallus and perithecia (*McMullin 22419*, CANL). B, North American distribution of *V. dolosa.* C, *Verrucaria phloeophila* thallus and perithecia (*Wegenschimmel 177*, CANL). Inset showing the dark exciple that is indistinguishable from the involucrellum. D, North American distribution of *V. phloeophila.* E, *Verrucaria praetermissa* thallus and perithecia (*Wegenschimmel 173*, CANL). Inset showing the continuous dark basal area. In maps, cyan dots = new records, red dots = previous collections.

Lepraria caesiella, Multiclavula mucida, Physconia leucoleiptes, Placynthiella icmalea, Polyozosia dispersa, Punctelia bolliana, Ramalina intermedia, Rinodina tephraspis, Ropalospora viridis, Strigula stigmatella, Trapeliopsis flexuosa, Verrucaria dolosa, V. muralis, V. nigrescens, V. phloeophila, V. praetermissa, and *Xanthomendoza weberi.*

Ten species are considered rare in Ontario based on provincial ranks (S1-S3) or are non-ranked species with a small number of collections in the province (see Table 2 for additional details): *Bacidina chloroticula, B. egenula, Halecania* sp., *Inoderma byssaceum, Phaeophyscia kairamoi, Verrucaria dolosa, V. praetermissa, V. phloeophila, Viridothelium virens,* and *Xanthomendoza weberi.*

Table 2. Ten lichen and allied fungi species discovered in Rouge National Urban Park that are considered rare in Ontario based on provincial ranks (S1-S3) or are non-ranked species with a small number of collections in the province.

Species	Provincial Rank	Notes
Bacidina chloroticula	SNR	Three previous collections are known from Ontario - *Brodo et al. 31686* (CANL), *Macoun 2801* (CANL) (det. S. Ekman), and *Wong et al. 2712* (CANL) (det. S. Ekman). The latter two collections were reported by Ekman (1996).
Bacidina egenula	SNR	Known from six previous collections in Ontario. Two from the Ottawa region (*Brodo et al. 30406*, CANL; *Robitaille 149.4*, CANL, det. S. Ekman; Ekman 1996), one from Guelph (*McMullin 7101,* OAC; McMullin et al. 2014), two from the Bruce Peninsula (*Lay 08-0276*, NY; *Lewis 240*, CANL; Brodo et al. 2013), and one from the Kingston area (*McMullin 22427*, CANL).
Halecania sp.	SNR	First known collection in ON and second known collection in Canada *(Brodo et al. 2021).*
Inoderma byssaceum	S3	-
Phaeophyscia kairamoi	S3	-
Verrucaria dolosa	SNR	Reported for the first time from Canada. Three previous collections are known: one from British Columbia (*Björk s.n.*, Ways of Enlichenment- Lichen Photogallery — www.waysofenlichenment.net), and two from Ontario on the Bruce Peninsula (*Brodo 32132*, CANL) and in Algonquin Provincial Park (*Brodo 33065B*, CANL).
Verrucaria praetermissa	SNR	First known collection in Ontario.
Verrucaria phloeophila	SNR	First known collection in Canada.
Viridothelium virens	S3	-
Xanthomendoza weberi	S3	-

Annotated Species List

- The list is arranged alphabetically by genus and species.
- Species authors are cited following Brummitt and Powell (1992) or the 23rd edition of the North American Lichen Checklist (Esslinger 2019).
- Nomenclature follows the 23rd edition of the North American Lichen Checklist (Esslinger 2019). Any deviance from Esslinger's list represents the opinion of the authors.
- Collection numbers follow the names of each collector.
- Collection numbers followed by (^{TLC}) were analysed with thin-layer chromatography.
- Roman numerals correspond to collection sites in Table 1 and they are illustrated in Figure 2.
- Provincial conservation status ranks (S-ranks) are included for each species (S1-S5, SNR, or SU).

† = non-lichenized fungi traditionally treated with lichens.
* = reported for the first time from the Greater Toronto Area.
** = reported for the first time from Ontario.
*** = reported for the first time from Canada.

Acarospora fuscata (Ach.) Arnold — Saxicolous. *McMullin 12529* (IV). S5.

Acrocordia cavata (Ach.) R.C. Harris — Corticolous on *Fraxinus* sp. (Ash). *McMullin 22368* (I). S4.

***Agonimia spp**. Corticolous on *Acer* x *freemanii* A.E. Murray (Freeman Maple) and *Fagus grandifolia* Ehrh. (American Beech). Bryicolous over tree bark, lignicolous on stump. *Wegenschimmel 153* (IV), *155* (II), *228* (II), *245* (XIII), *272* (IV), *308* (II), *314* (XV). SNR. Notes: These specimens do not appear to match any known species of *Agonimia*. Most of the collections are sterile with scattered roundish areoles that are strongly convex. One of those specimens, *Wegenschimmel 272*, was fertile and had the large (53–67 × 21–23 µm) heavily muriform ascospores characteristic of the genus. All of the specimens appear to be the same taxon except for two. *Wegenschimmel 153* is sorediate, but no other known species in the genus is known to be sorediate, and *Wegenschimmel 228* is sterile and has a granular thallus. It is possible that the latter two specimens belong to other genera, but we are placing them here due to their minute size, colour, and general gestalt that is consistent with other species of *Agonimia*.

Alyxoria varia (Pers.) Ertz & Tehler — Corticolous on *American Beech, Carya cordiformis* (Wangenh.) K.Koch (Bitternut Hickory), and *Quercus macrocarpa* Michx. (Bur Oak). *Maloles 49* (II), *McMullin 22385* (I), *Wegenschimmel 158* (VIII), *226* (IX), *247* (IV), *255* (XIV), *269* (IX), *280* (XIII). S4.

Amandinea punctata (Hoffm.) Coppins & Scheid — Corticolous on *Acer nigrum* F.Michx. (Black Maple), *A. Saccharum* Marshall (Sugar Maple), and Freeman Maple. *McMullin 12535* (XI), *Wegenschimmel 258* (XIII), *299* (XV). S5.

***Anisomeridium polypori (Ellis & Everh.) M.E. Barr** — Corticolous on Bur Oak, *Fraxinus pennsylvanica* Marshall (Green Ash), and *Quercus rubra* L. (Red Oak). *McMullin 22382* (I). S4.

†**Arthonia hypobela Nyl.** — Corticolous on *Pinus strobus* L. (Eastern White Pine). *McMullin 12570* (V). S4S5.

***†**Arthonia cf. granosa B. de Lesd.** — Corticolous on Red Oak. *Wegenschimmel 166* (IV). SNR. Notes: We have observed and collected this taxon frequently in southern Ontario. It is consistent with the description of *A. granosa* from Europe in lacking algae, making the host bark paler, having circular to ellipsoidal ascomata that are epruinose, ascospores that are 2-celled and 15–25 ×8–15 µm (see inset of Fig. 3A), an epispore that is KI-, and ascomatal gel that is I+ red and KI+ blue (Fig. 3A, Sundin 1999). However, European material is described with pycnidia present (Sundin 1999), which all specimens that we have seen lack. Therefore, it is being placed in *A.* cf. *granosa* for now, but further study may reveal the North American material to be a distinct species.

Arthonia helvola (Nyl.) Nyl. — Corticolous on *Betula alleghaniensis* Britt. (Yellow Birch). *McMullin 12557* (III), *22403* (XIII), *Wegenschimmel 183* (II). S4.

Arthonia radiata (Pers.) Ach. — Corticolous on Ash and Freeman Maple. *Maloles 41* (IV), *McMullin 22387* (XIII), *22400* (I), *Wegenschimmel 267* (IV). S5.

***Arthothelium ruanum (A. Massal.) Körb.** — Corticolous on Bitternut Hickory, Green Ash, Sugar Maple, and *Tilia americana* L. (American Basswood). *Wegenschimmel 163* (XV), *194* (IV), *263* (VIII), *311* (II). S4.

***Arthrosporum populorum A. Massal.** — Corticolous on Ash. *McMullin 22392* (XIII). S1S2.

***Aspicila laevata (Ach.) Arnold** — Saxicolous. *McMullin 22414*[TLC] (I). S4. TLC: stictic acid.

Bacidia schweinitzii (Fr. ex Tuck.) A. Schneid. — Corticolous on Bur Oak. *Wegenschimmel 191* (II). S5.

***Bacidina chloroticula (Nyl.) Vězda & Poelt** — Corticolous on Base of American Beech. *Wegenschimmel 189* (III). SNR.

***Bacidina egenula (Nyl.) Vězda** — Saxicolous on concrete. *McMullin 22424* (XII), *Wegenschimmel 171* (I). SNR.

***Bacidina sp.** — Saxicolous (non-calcareous). *Wegenschimmel 161* (XIII). SNR. Notes: This taxon has minute apothecia ([0.2-]0.3–0.6[-0.7] mm in diameter) with pale brown pigmentation, a granular thallus, and acicular ascospores. It is inconspicuous in the field.

Bilimbia sabuletorum (Schreb.) Arnold — Bryicolous, corticolous on *Thuja occidentalis* L. (Eastern White Cedar). *McMullin 22362* (VI), *Wegenschimmel 249* (XIII), *257* (XIV). S5.

Caloplaca arenaria (Pers.) Müll. Arg. — Saxicolous (non-calcareous). *McMullin 22413* (VI). S5.

Caloplaca cerina (Hedw.) Th. Fr. — Corticolous on Maple and Aspen. *McMullin 22377* (XIII), *Wegenschimmel* (XIII). S5.

Caloplaca feracissima H. Magn. — Saxicolous on granite and concrete. *McMullin 12552* (III), *Wegenschimmel 294* (III). S5.

Caloplaca flavovirescens (Wulfen) Dalla Torre & Sarnth. — Saxicolous (calcareous). *McMullin 22425* (XII). S4.

***Caloplaca microphyllina (Tuck.) Hasse** — Lignicolous on an old fence post. *McMullin 22363* (XII). S5.

Caloplaca pyracea (Ach.) Zwackh — Corticolous on *Populus tremuloides* Michx. (Trembling Aspen). *McMullin 12542* (VII). S5.

Candelaria concolor (Dicks.) Arnold — Corticolous on American Beech, *Fraxinus Americana* L. (White Ash), *Rhus typhina* L. (Staghorn Sumac), and Sugar Maple. *Maloles 23* (XV), *McMullin 12545* (VII), *22367* (XIII), *Wegenschimmel 209* (VIII), *220* (XIV), *224* (IX), *252* (XV). S5.

Candelariella aurella (Hoffm.) Zahlbr. — Saxicolous on concrete. *McMullin 12554* (III). S5.

Candelariella effloresces R.C. Harris & W.R. Buck — Corticolous on an Eastern White Cedar snag. *McMullin 12522* (IV), *22360* (XIII). S5.

Catillaria nigroclavata (Nyl.) J. Stein. — Corticolous on *Elaeagnus angustifolia* L. (Russian Olive), Freeman Maple, and a fallen conifer branch. *McMullin 12569* (V), *22416* (XIII), *Wegenschimmel 214* (XIV). S4S5.

***Chaenotheca brunneola (Ach.) Müll. Arg.** — Lignicolous on a Freeman Maple snag. *Maloles 66* (VIII). S4.

†Chaenothecopsis debilis (Sm.) Tibell — Lignicolous on Freeman Maple and Red Oak snags. *Maloles 24* (I), *35* (III), *51* (II), *67* (VIII), *McMullin 22398* (I). S4.

***†Chaenothecopsis perforata Rikkinen & Tuovila** — Resinicolous on Staghorn Sumac. *McMullin 22365* (V). SNR.

***†Chaenothecopsis savonica (Räsänen) Tibell** — Lignicolous on an Eastern White Cedar stump. *Maloles 72* (VIII). S4.

†Chaenothecopsis sp. — Lignicolous on a Freeman Maple snag. *Wegenschimmel 318* (XIII). SNR. Notes: Ascospores 2-celled, 6–7 × 2.5–3 µm, light brown with a distinct septum. Stalk and capitulum lacking secondary compounds. Stalk <0.6 mm tall. Not associated with lichens or free-living algae.

Chrysothrix caesia (Flot.) Ertz & Tehler — Corticolous on Freeman Maple, Red Oak, Russian Olive, White Pine, Yellow Birch. *McMullin 12563* (V), *Wegenschimmel 284* (IX), *284* (XV), *324* (XIII). S5.

Cladonia chlorophaea (Flörke ex Sommerf.) Spreng. — Bryicolous over a log. *Wegenschimmel 168*[TLC] (IV). S5. TLC: fumarprotocetraric acid.

Cladonia coniocraea (Flörke) Spreng. — Corticolous on Maple. *McMullin 12518* (IV), *22417* (X). S5.

Cladonia conista (Nyl.) Robbins — Terricolous. *McMullin 12568*[TLC] (IV). SU. TLC: bourgeanic and fumarprotocetraric acids.

Cladonia cristatella Tuck. — Lignicolous on a log. *McMullin 12531* (IV). S5.

Cladonia decorticata (Flörke) Spreng. — Lignicolous on a log. *McMullin 12519* (IV). S4?

Cladonia fimbriata (L.) Fr. — Lignicolous on a log and corticolous on Freeman Maple. *Maloles 64* (VIII), *Wegenschimmel 278*[TLC] (IX), *239* (VIII). S5. TLC: fumarprotocetraric acid.

***Cladonia ignatii Ahti** — Bryicolous. *McMullin 22372* (X). SNR.

Cladonia incrassata Flörke — Bryicolous and lignicolous on a stump. *Wegenschimmel 170* (VIII), *259* (VIII). S4?

Cladonia macilenta var. bacillaris (Ach.) Schaer. — Lignicolous on a log. *McMullin 12516* (IV). S5.

Cladonia pocillum (Ach.) O.J. Rich. — Terricolous. *McMullin 12526* (IV). S5.

Cladonia pyxidata (L.) Hoffm. — Lignicolous on a log. *McMullin 12515* (IV). S5.

Coenogonium pineti (Ach.) Lücking & Lumbsch — Lignicolous, bryicolous on a stump, and corticolous on a log. *McMullin 12555* (III), *Wegenschimmel 169* (VIII). S4?

***Cresponea chloroconia (Tuck.) Egea & Torrente** — Corticolous on Bur Oak. *Maloles 26* (I), *47* (II), *Wegenschimmel 301* (II). S4.

Dictyocatenulata alba Finley & E.F. Morris — Corticolous on Bur Oak and Yellow Birch. *McMullin 12558* (III), *22404* (XIII), *Wegenschimmel 234* (II). SU.

Evernia mesomorpha Nyl. — Corticolous on Bur Oak. *Wegenschimmel 157* (VIII). S5.

Flavoparmelia caperata (L.) Hale — Corticolous on Freeman Maple and Sugar Maple. *Maloles 56* (II), *McMullin 12534* (XI), *22359* (XIII), *Wegenschimmel 222* (IX), *297* (I), *322* (XIII). S5.

Flavopunctelia soredica (Nyl.) Hale — Corticolous on Freeman Maple and Sugar Maple. *Maloles 16* (XV), *60* (VIII). S4.

Graphis scripta (L.) Ach. — Corticolous on American Beech and *Betula papyrifera* Marshall (White Birch). *Maloles 57* (II), *McMullin 22384* (I), *Wegenschimmel 248* (XIII), *261* (IX), *262* (VIII), *270* (IX), *279* (XIII), *290* (VIII). S5.

****Halecania sp.** — Saxicolous (non-calcareous). *McMullin 22418*[TLC] (VI), *Wegenschimmel 159*[TLC] (XIII), *192* (IV). SNR. TLC: argopsin. Notes: the ascospores are 2-celled, hyaline, and 11.5–15 × 4–5 µm. Asci tips are Catillaria-type. On boulders in a creek valley. Although this taxon is undescribed, it is known from throughout eastern North America (e.g., Harris and Ladd 2005, Brodo et al. 2021). There is only one other record of this taxon in Canada, which is from Quebec (Fig. 3D, Brodo et al. 2021).

Hyperphyscia adglutinata (Flörke) H. Mayrhofer & Poelt — Corticolous on Bur Oak and a *Juglans cinerea* L. (Butternut) snag. *Maloles 44* (II), *McMullin 12564* (V), *22388* (XIII), *Wegenschimmel 217* (XIV). S4.

†Illosporiopsis christiansenii (B.L. Brady & D. Hawks.) D. Hawks. — Lichenicolous on *Physcia adscendens* and *P. stellaris*. *Maloles 22* (XV), *29* (I), *McMullin 22379* (XIII), *Wegenschimmel 307* (XIV). S3.

***Inoderma byssaceum (Weigel) Gray** — Corticolous on Bur Oak. *Wegenschimmel 155* (VIII). S3.

***Ionaspis alba Lutzoni** — Saxicolous (non-calcareous). *Wegenschimmel 165* (XIII). S4.

†Julella fallaciosa (Stizenb. ex Arnold) R.C. Harris — Corticolous on Sugar Maple and White Birch. *McMullin 12521* (IV), *22390* (XIII), *Wegenschimmel 198* (IX), *219* (XIV). S5.

Lecania croatica (Zahlbr.) Kotlov — Corticolous on American Beech, *Prunus serotina* Ehrh. (Black Cherry), Sugar Maple, and *Ulmus Americana* L. (White Elm). *McMullin 22366* (XIII), *22386* (I), *Wegenschimmel 221* (IX), *250* (VIII), *251* (XIII), *273* (III), *286* (XV), *293* (III), *312* (XV). S5.

***Lecania cyrtella (Ach.) Th. Fr.** — Corticolous on Green Ash. *Wegenschimmel 160* (VIII). SNR.

Lecania naegelii (Hepp) Diederich & van den Boom — Corticolous on American Basswood, American Beech, Freeman Maple, Sugar Maple, and Trembling Aspen. *McMullin 12548* (VI), *Wegenschimmel 227* (VIII), *264* (VIII), *271* (IX), *274* (IV), *282* (I), *320* (XV). S4.

Lecanora allophana f. sorediata Vain. — Corticolous on Maple and Oak. *McMullin 22349*[TLC], *22349*[TLC] (XI). SNR. TLC: atranorin and two unknown fatty acids that char with sulphuric acid and heating.

Lecanora sambuci (Pers.) Nyl.—Corticolous on Trembling Aspen. *McMullin 12546* (VII). SNR.

***Lecanora strobilina Ach.**—Lignicolous on an Eastern White Cedar snag. *Wegenschimmel 187* (VIII), *295* (VIII). S4S5.

Lecanora symmicta (Ach.) Ach.—Corticolous on Maple. *McMullin 22364* (VIII). S5.

Lecanora thysanophora R.C. Harris—Corticolous on Green Ash, Red Oak, and Sugar Maple. *McMullin 12532* (XI), *22358* (VIII), *Wegenschimmel 232* (IX), *256* (XIV), *289* (XV). S5.

***Lepraria caesiella R.C. Harris**—Corticolous on *Abies balsamea* (L.) Mill. (Balsam Fir) and *Tsuga canadensis* (L.) Carrière (Eastern Hemlock). *Maloles 43* (IV), *McMullin 22342* [TLC], *22348* [TLC] (VIII), *Wegenschimmel 316* (XIV). S4S5. TLC: atranorin, pallidic acid, and zeorin.

Lepraria finkii (B. de Lesd.) R.C. Harris—Terricolous, lignicolous on hardwood and corticolous on the base of Eastern White Cedar and *Picea glauca* (Moench) Voss (White Spruce). *McMullin 22340* [TLC] (I), *22352* [TLC] (VI), *Wegenschimmel 207* (IV), *265* (VIII), *283* (IV), *288* (XV). S5. TLC: atranorin, stictic acid, and zeorin.

Melanelixia subaurifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawks., & Lumbsch—Corticolous on an Eastern White Cedar snag, *Malus* sp. (Crabapple), and *Rhamnus cathartica* L. (European Buckthorn). *McMullin 12520* (IV), *22381* (XIII), *Wegenschimmel 237* (XIV). S5.

***Multiclavula mucida (Pers.) R.H. Petersen**—Lignicolous on a rotting log (hardwood). *Maloles 62* (VIII), *McMullin 22389* (VIII), *Wegenschimmel 266* (VIII). S4?

Myelochroa aurulenta (Tuck.) Elix & Hale—Corticolous on Sugar Maple. *Maloles 46* (II). S5.

***Myriolecis dispersa (Pers.) Śliva, Zhao Xin, & Lumbsch**—Saxicolous (calcareous). *McMullin 12551* (III). S5. Notes: granules in the epihymenium not dissolving in nitric acid or potassium hydroxide.

Ochrolechia arborea (Kreyer) Almb.—Corticolous on hardwood snag. *McMullin 12539* (XI), *Wegenschimmel 296* (I). S4S5.

†Ovicuculispora parmeliae (Berk. & M.A. Curtis) Etayo—Lichenicolous on *Physcia* sp. *McMullin 22373* (VI). S4, S5.

Parmelia sulcata Taylor—Corticolous on Crabapple, Cherry, Freeman Maple, Staghorn Sumac, Sugar Maple, and White Ash. *Maloles 23* (XV), *McMullin 22402* (XIII), *12561* (V), *Wegenschimmel 230* (IX), *317* (XIII). S5.

Peltigera elisabethae Gyeln.—Terricolous. *McMullin 22409* (VIII). S5.

Peltigera evansiana Gyeln.—Terricolous. *Maloles 63* (VIII), *McMullin 22394* (VIII). S4.

Peltigera neckeri Hepp ex Müll. Arg.—Terricolous with moss. *Wegenschimmel 176* (VIII). S5.

Peltigera praetextata (Flörke ex Sommerf.) Zopf—Terricolous and bryicolous on hardwood log and stump. *Maloles 50* (II), *McMullin 12566* (IV), *22354* (VIII), *22395* (VIII), *Wegenschimmel 174* (VIII), *212* (VIII), *213* (XIV), *275* (IV). S5.

Pertusaria macounii (Lamb) Dibben—Corticolous on Bur Oak. *Wegenschimmel 181*[TLC] (II). S4. TLC: stictic acid complex, 2,7-dichloroxanthone, and unknowns.

†Phaeocalicium curtisii (Tuck.) Tibell—Corticolous on Staghorn Sumac. *McMullin 22356* (VII), *Wegenschimmel 190* (III). S5.

†Phaeocalicium polyporaeum (Nyl.) Tibell—Fungicolous on *Trichaptum biforme* (Fr.) Ryvarden (Violet-Toothed Polypore). *Maloles 53* (II), *59* (VIII), *McMullin 22378* (VIII), *Wegenschimmel 182* (II). S4?

Phaeophyscia ciliata (Hoffm.) Moberg—Corticolous on Maple. *McMullin 22361* (XIII). S4.

Phaeophyscia kairamoi (Vain.) Moberg—Corticolous on Black Maple. *McMullin 12537* (XI). S3?

Phaeophyscia orbicularis (Neck.) Moberg—Saxicolous (calcareous), corticolous on Ash and Sugar Maple. *McMullin 12549* (III), *22391* (XIII), *Wegenschimmel 210* (IX), *298* (XV). SNR.

Phaeophyscia pusilloides (Zahlbr.) Essl.—Corticolous on Freeman Maple, Sugar Maple, and White Ash. *Maloles 32* (III), *McMullin 12528* (IV), *22374* (XIII), *Wegenschimmel 201* (IX), *243* (XIII), *315* (XV). S5.

Phaeophyscia rubropulchra (Degel.) Essl.—Corticolous on Freeman Maple and Sugar Maple. *Maloles 30* (I), *70* (IX), *McMullin 12541* (XI), *22411* (X), *Wegenschimmel 231* (IX), *244* (XIV), *285* (XV), *309* (VIII), *313* (XV). S5.

Physcia adscendens H. Olivier—Corticolous on Cherry, Crabapple, Maple, and Staghorn Sumac. *Maloles 20* (XV), *McMullin 12547* (VII), *22371* (XIII), *22380* (XIII). S5.

Physcia aipolia (Ehrh. ex Humb.) Fürnr. — Corticolous on Black Maple, a Butternut snag, Green Ash, and Sugar Maple. *Maloles 34* (III), *71* (IX), *McMullin 22347*[TLC] (I), *Wegenschimmel 253* (XIV), *281* (IV), *323* (XIV). S5. TLC: unknown fatty acids running below norstictic acid.

Physcia millegrana Degel. — Corticolous on Cherry, Freeman Maple, Sugar Maple, and White Ash. *Maloles 18* (XV), *27* (I), *McMullin 12565* (V), *22370* (XIII), *Wegenschimmel 205* (VIII), *218* (XIV), *240* (IX), *242* (XIII), *287* (XV), *321* (XIII). S5.

Physcia stellaris (L.) Nyl. — Corticolous on Sugar Maple and White Ash. *Maloles 12* (XV), *McMullin 12562* (V). S5.

Physciella chloantha (Ach.) Essl. — Corticolous on an Ash snag, *Crataegus* sp. (Hawthorn), Sugar Maple, and White Ash. *McMullin 22396* (XII), *22401* (I), *22412* (XI), *Wegenschimmel 254* (XIV), *277* (XV), *302* (II). S4?

Physciella melanchra (Hue) Essl. — Corticolous on Sugar Maple and hardwood. *McMullin 22355* (XI), *12543* (VII), *Wegenschimmel 200* (IX), *206* (IV), *208* (VIII), *236* (IX), *292* (III), *306* (VIII). S4?

Physconia detersa (Nyl.) Poelt — Corticolous on Freeman Maple, Hawthorn, Sugar Maple, and White Birch. *Maloles 37* (III), *McMullin 22408* [TLC] (XII), *Wegenschimmel 235* (IX), *260* (XIII). S5. TLC: variolaric acid.

***Physconia enteroxantha (Nyl.) Poelt** — Corticolous on Freeman Maple and Black Maple. *McMullin 22344* [TLC] (XI), *Wegenschimmel 276* (IV), *246* [TLC] (XIII). S4? TLC: secalonic acid.

***Physconia leucoleiptes (Tuck.) Essl.** — Corticolous on Ash and a deciduous shrub. *McMullin 22346*[TLC] (I), *22345*[TLC] (I). S4. TLC: secalonic acid.

Placynthiella icmalea (Ach.) Coppins & P. James — Lignicolous on Eastern White Cedar. *Wegenschimmel 151*[TLC] (IV), *152*[TLC] (VIII). S4. TLC: gyrophoric acid.

***Porpidia albocaerulescens (Wulfen) Hertel & Knoph** — Saxicolous (non-calcareous). *Wegenschimmel 175* (III). S4S5.

Porpidia crustulata (Ach.) Hertel & Knoph — Saxicolous (non-calcareous). *McMullin 22341*[TLC] (XII). S5. TLC: stictic acid.

Protoblastenia rupestris (Scop.) J. Steiner — Saxicolous (calcareous). *McMullin 12527* (IV). S5.

Protoparmeliopsis muralis (Schreb.) M. Choisy — Saxicolous. *Wegenschimmel 180* (IX). S5.

***Punctelia bolliana (Müll.Arg.) Krog** — Corticolous on *Fraxinus pennsylvanica*. *Maloles 58* (VIII). S4, S5.

Punctelia rudecta (Ach.) Krog — Corticolous on Freeman Maple, Red Oak, and Sugar Maple. *Maloles 45* (II), *61* (VIII), *68* (IX), *McMullin 12533* (XI), *Wegenschimmel 223* (IX). S5.

***Ramalina intermedia (Delise ex Nyl.) Nyl**. — Lignicolous on Freeman Maple. *Maloles 65* (VIII). S5.

***Rinodina tephraspis (Tuck.) Herre** — Saxicolous (non-calcareous). *McMullin 22369* (VI). S4.

***Ropalospora viridis (Tønsberg) Tønsberg** — Corticolous on American Beech, Balsam Fir, and Maple. *Maloles 33* (III), *48* (II), *McMullin 22343*[TLC] (VIII), *22351*[TLC] (VIII), *22353* [TLC] (XI), *Wegenschimmel 197* (II), *211* (VIII). S4, S5. TLC: perlatolic acid.

Sarcogyne hypophaea (Nyl.) Arnold — Saxicolous (non-calcareous). *McMullin 12524* (IV), *Wegenschimmel 225* (IX), *291* (III), *319* (XIII). SU.

Sarcogyne regularis Körb. — Saxicolous (calcareous). *McMullin 12550* (III), *22422* (XII). S5.

***Strigula stigmatella (Ach.) R.C. Harris** — Bryicolous and saxicolous. *McMullin 22393* (VI). S4, S5.

Trapelia placodioides Coppins & P. James — Saxicolous (non-calcareous). *McMullin 12559* (III), *22397* (X), *Wegenschimmel 215* (XIII). S5.

***Trapeliopsis flexuosa (Fr.) Coppins & P. James** — Lignicolous on old fence post. *Wegenschimmel 172* (XIII). S4S5.

*****Verrucaria dolosa Hepp** — Saxicolous (non-calcareous). *McMullin 22419* (VI), *22420* (VI), *Wegenschimmel 185* (III), *186* (XIII), *199* (XIII), *300* (XV), *203* (XIV). SNR. Notes: Distinguished from similar species of *Verrucaria* on non-calcareous rocks by its thin thallus (25–50 µm thick) that is continuous (not forming areoles) and green to olive-brown ascospores that are 1-celled and 15–17.5 × 6.5–8.5 µm, and small (100–150[–180] µm wide) semi-immersed to prominent perithecia with a colourless excipulum (Fig. 4A, Krzewicka 2012). Although this species is reported for the first time in Canada, it is common in RNUP.

***Verrucaria muralis Ach.** — Saxicolous on concrete. *McMullin 22421* (XI), *22423* (XII). S5.

***Verrucaria nigrescens Pers.** — Saxicolous (calcareous). *Wegenschimmel 156* (VIII). S5.

**** Verrucaria phloeophila Breuss** — Corticolous on Eastern White Cedar. *Wegenschimmel 177* (XIV), *178* (XIII). SNR. Notes: This species is characterized by its corticolous substrate, an involucrellum that is indistinguishable from the dark exciple (see inset of Fig. 4C), a dark exciple throughout when perithecia are mature, and large ascospores (25–30 × 12–14 µm) (Fig. 4C, Lendemer and Breuss 2009).

****Verrucaria praetermissa (Trevis.) Anzi** — Saxicolous (non-calcareous). *Wegenschimmel 173* (XIV), *241* (XIII). SNR. Notes: Distinguished from other *Verrucaria* species on non-calcareous rocks by a well-developed thallus with a grey-brown matt upper surface, a continuous black basal layer (see inset of Fig. 4E), immersed perithecia that are not in mounds on the thallus, and ascospores that are 18–23 × 7–13 µm (Fig. 4E, Krzewicka 2012).

Viridothelium virens (Tuck. ex Michen.) Lücking — Corticolous on American Beech. *Maloles 36* (III), *54* (II), *McMullin 22405* (I), *Wegenschimmel 195* (IX), *303* (II). S3. Notes: specimens were all sterile.

Xanthomendoza fallax (Arnold) Søchting, Kärnefelt & S.Y. Kondr. — Corticolous on a Butternut Snag, Green Ash, and Sugar Maple. *Maloles 15* (XV), *McMullin 12544* (VII), *22399* (XIII), *Wegenschimmel 202* (IX), *204* (VIII), *216* (XIII). S5.

Xanthomendoza hasseana (Räsänen) Søchting — Corticolous on Maple. *McMullin 22376* (XIII). S5.

Xanthomendoza ulophyllodes (Räsänen) Søchting — Corticolous on Ash and Black Maple. *Maloles 69* (IX), *McMullin 12536* (XI), *22410* (X), *22415* (I). S4.

Xanthomendoza weberi (S.Y. Kondr. & Kärnefelt) L. Lindblom — Corticolous on Aspen. *Maloles 19* (XV). S3.

Xanthoparmelia cumberlandia (Gyeln.) Hale — Saxicolous (non-calcareous). *McMullin 12523* (IV). S5.

Xanthoria parietina (L.) Th. Fr. — Corticolous on Maple. *McMullin 22357* (XIII). SNR.

***†Zythia resinae (Fr.) P. Karst.** — Resinicolous on Spruce. *McMullin 12567* (IV). S4S5.

Discussion

The lichen and allied fungi biota in RNUP includes a high number of rare species (10). The overall number of species discovered in the park (124) was surprisingly high as well, considering the urban landscape surrounding the park and the many previous and current disturbances. However, with no base-line data, it is impossible to know how this community of species compares to historical ones. Now that there is a base-line, management strategies for rare species can be developed and changes in populations can be monitored.

Comparisons to lichen communities in other areas in southern Ontario are also difficult to make because of different ecosystems, disturbances, and sizes (see Table 3 for comparisons). For example, the Carden Alvar Natural Area is the closest location (54.5 miles north) with a comparable lichen and allied fungus survey (199 species) (McMullin 2019). Nonetheless, that area is composed entirely of an alvar ecosystem that does not exist in RNUP. It is also a larger area (31810 acres vs 19546 acres in RNUP), is far from an urban center, and it lacks Carolinian forests and deep ravine ecosystems (McMullin 2019). The Arboretum at the University of Guelph in the City of Guelph is the next closest park (55.5 miles west), and the only other urban park that has been surveyed in the province (McMullin et al. 2014). It contains 104 species, but it is smaller (408 acres) and the bedrock is calcareous, which many lichen species are restricted to (McMullin et al. 2014, Lendemer and Harris 2008). Sandbanks Provincial Park is 94 miles east of RNUP and is the only other coastal park on the north shore of Lake Ontario that has been surveyed (it contained 128 species) (McMullin and Lewis 2014). However, the park is largely a dune ecosystem and it has calcareous rock outcrops, which are unlike any of the ecosystems at RNUP. There appears to be no comparable areas in Ontario that have been

surveyed for lichens and allied fungi, so the effects of the urbanization cannot be inferred by the communities in other areas.

Previous collections of lichens and allied fungi have been made in the GTA. McMullin et al. (2018) summarized all known collections, most of which were made during four bioblitzes in different watersheds within the GTA. They compiled all historical records with those made during the bioblitzes and reported 180 species. We discovered an additional 33 species that had not previously been reported and increase the number of known lichens and allied fungi in the GTA to 213.

The old forest stands in and around the deep ravines at the southern end of the park contained the greatest number of rare species (see Fig. 1). The steep slopes of the ravines likely prevented large scale timber harvesting in the past, and the lichen and allied fungus communities were preserved except for species that were negatively affected by air pollution.

Rouge National Urban Park is Canada's only national urban park and, once fully developed, it will be the largest urban park in North America. The ecological integrity in the park has been affected considerably by past and current settlement and recreation activities. The park is surrounded by a dynamic urban environment, including residential, industrial, and commercial developments and infrastructure such as roads, highways, rail lines, hydro corridors, regional water mains, pipelines, and sewers that traverse all parts of the park and have the ability to greatly impact the ecological integrity of RNUP (PCA 2019, 2021). However, since the park was established in 2015, there have been at least 72 ecological restoration and farmland enhancement projects completed, in partnership with Toronto and Region Conservation Authority, Indigenous partners, and park farmers (PCA 2021). The results include the restoration of more than 173 acres of aquatic habitat, more than 67 acres of forest habitat, 5 acres of meadow habitat, and the planting of more than 126,000 native trees, perennials, shrubs and aquatic plants (PCA, 2021). Based on these restoration projects and the improved air quality in the GTA in recent decades (Ministry of the Environment 2014), we expect the lichen and allied fungus biota to increase in the park. Future monitoring of the rare species is recommended. Our study shows that, despite their sensitivities, many lichens and their related fungi can colonize and persist in urban environments when suitable habitat is available.

Table 3. Survey results from studies of lichens and allied fungi in southern Ontario parks with similar search effort to that of the study in Rouge National Urban Park.

Location	Approximate distance from RNUP (miles)	Area (acres)	Number of Species	Reference
Rouge Urban National Park	0	19546	124	-
Carden Alvar Natural Area	54.5	31810	199	McMullin 2019
Arboretum at the University of Guelph	55.5	408	104	McMullin et al. 2014
Copeland Forest Resource Management Area	57	4398	154	McMullin and Lendemer 2013
Awenda Provincial Park	80	7203	203	McMullin and Lendemer 2016
Sandbanks Provincial Park	94	3832	128	McMullin and Lewis 2014
Frontenac Provincial Park	138	12884	280	Lewis 2020

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Literature Cited

Allen, J.L., and N.M. Howe. 2016. Landfill Lichens: A checklist for Freshkills Park, Staten Island, New York. Opuscula Philolichenum 15:82–91.

Allen, J.L., and J.C. Lendemer. 2016. Climate change impacts on endemic, high-elevation lichens in a biodiversity hotspot. Biodiversity and Conservation 22:555–568.

Allen, J.L., and J.C. Lendemer. 2021. Urban Lichens: A field guide for Northeastern North America. Yale University Press, New Haven, CT, USA. 168 pp.

Barnett, P.J., D.R. Sharpe, H.A.J. Russell, T.A. Brennand, G. Gorrell, F. Kenny, and A. Pugin. 1998. On the origin of the Oak Ridges Moraine. Canadian Journal of Earth Sciences 35:1152–1167.

Bell-Doyon, P., S.B. Selva, and R.T. McMullin. 2021. Calicioid fungi and lichens from an unprotected intact boreal forest ecosystem in Québec. Écoscience 28:127–136.

Bohdan, A. 2014. The importance of passive protection to preservation of lichens — relics of the primeval forests in the Białowieża Forest. Przegląd Przyrodniczy 25:151–161.

Brodo, I.M., R.C. Harris, W. Buck, J. C. Lendemer, and C. Lewis. 2013. Lichens of the Bruce Peninsula, Ontario: Results from the 17th Tuckerman Workshop, 18–22 Sept. 2008. Opuscula Philolichenum 12:198–232.

Brodo, I.M., R.E. Lee, C. Freebury, P.Y. Wong, C.L. Lewis, and R.T. McMullin. 2021. Additions to the lichens and lichenicolous fungi of the Ottawa region in Ontario and Quebec, with reflections on a changing biota. Canadian Field Naturalist 135:1–27.

Brodo, I.M., S.D. Sharnoff, and S. Sharnoff. 2001. Lichens of North America. Yale University Press, New Haven, CT, USA. 795 pp.

Brummitt, R.K., and C.E. Powell (Eds.). 1992. Authors of Plant Names. Royal Botanical Gardens, Kew, Greater London, UK. 732 pp.

Cameron, R.P., T. Neily, and D.H.S. Richardson. 2007. Macrolichen indicators of air quality for Nova Scotia. Northeastern Naturalist 14:1–14.

Culberson, C.F., and H. Kristinsson. 1970. A standardized method for the identification of lichen products. Journal of Chromatography 46:85–93.

Ekman, S. 1996. The corticolous and lignicolous species of *Bacidia* and *Bacidina* in North America. Opera Botanica 127:1–148.

Esslinger, T.L. 2019. A cumulative checklist for the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada, Version 23. Opuscula Philolichenum 18:102–378.

Government of Canada. 2017. Canadian climate normal 1981–2010 station data — Toronto. Available online at https://tinyurl.com/hj4uggl. Accessed 12 Februrary 2021.

Government of Ontario. 2014. Smog advisory statistics. Available online at http://airqualityontario.com. Accessed 12 Frebruary 2021.

Government of Ontario. 2015. Air quality in Ontario: 2015 report. Government of Ontario, Toronto, ON, Canada. 37 pp.

Harris, R.C., and D. Ladd. 2005. Preliminary draft: Ozark lichens: Enumerating the lichens of the Ozark Highlands of Arkansas, Kansas, Illinois, Missouri, and Oklahoma. Prepared for the 14th Tuckerman Lichen Workshop, Eureka Springs, AR, USA. 249 pp.

Henderson, A. 2000. Literature on air pollution and lichens XLIX. The Lichenologist 32:89–102.

Henry, M., and P. Quinby. 2010. Ontario's Old-Growth Forests. Fitzhenry & Whiteside, Markham, ON, Canada. 232 pp.

Hilmo, O., and S.M. Såstad. 2001. Colonization of old-forest lichens in a young and an old boreal *Picea abies* forest: An experimental approach. Biological Conservation 102:251–259.

Krzewicka, B. 2012. A revision of *Verrucaria* s.l. (Verrucariaceae) in Poland. Polish Botanical Studies 27:1−141.

Lendemer, J.C., and O. Breuss. 2009. *Verrucaria thujae* (Verrucariaceae, Lichenized Ascomycetes), a new corticolous species from the Great Lakes Region of North America. Opuscula Philolichenum 7:13–16.

Lendemer, J.C,. and R.C. Harris. 2008. Keys to Lime Loving Lichens. Institute of Systematic Botany, The New York Botanical Garden, Bronx, NY, USA. 23 pp.

Lewis, C.J. 2020. Checklist of the lichens and allied fungi of Frontenac Provincial Park, Ontario. Rhodora 121:248–296.

McMullin, R.T. 2019. Lichens and allied fungi added to the list of rare species inhabiting the Carden Alvar Natural Area, Ontario. Natural Areas Journal 39:212–225.

McMullin, R.T., L.L. Bennett, O.J. Bjorgan, D.A. Bourque, C.J. Burke, M.A. Clarke, M.K. Gutgesell, P.L. Krawiec, R. Malyon, A. Mantione, A.T. Piotrowski, N.Y. Tam, A.C. Van Natto, Y.F. Wiersma, and S.G. Newmaster. 2016. Relationships between air pollution, population density, and lichen diversity in the Niagara Escarpment World Biosphere Reserve. The Lichenologist 48:593–605.

McMullin, R.T., K. Drotos, D. Ireland, and H. Dorval. 2018. Diversity and conservation status of lichens and allied fungi in the Greater Toronto Area: Results from four years of the Ontario BioBlitz. The Canadian Field Naturalist. 132:394–406.

McMullin, R.T., and J.C. Lendemer. 2013. Lichen biodiversity and conservation status in the Copeland Forest Resources Management Area: A lichen-rich second-growth forest in southern Ontario. Canadian Field-Naturalist 127: 240–254.

McMullin, R.T., and J.C. Lendemer. 2016. Lichens and allied fungi of Awenda Provincial Park, Ontario: Diversity and conservation status. American Midland Naturalist 176:1–19.

McMullin, R.T., and C.J. Lewis. 2014. The unusual lichens and allied fungi of Sandbanks Provincial Park, Ontario. Botany 92:85–92.

McMullin, R.T., J. Maloles, C. Earley, and S.G. Newmaster. 2014. The Arboretum at the University of Guelph, Ontario: An urban refuge for lichen biodiversity. North American Fungi 9:1–16.

McMullin, R.T., D. Ure, M. Smith, H. Clapp, and Y.F. Wiersma. 2017. Ten years of monitoring air quality and ecological integrity using field-identifiable lichens at Kejimkujik National Park and National Historic Site in Nova Scotia, Canada. Ecological Indicators 81:214–221.

NatureServe. 2021. Conservation Status Assessment. Available online at https://www.natureserve.org/conservation-tools/conservation-status-assessment. Accessed 12 Frebruary 2021.

Newmaster, S.G., R.J. Belland, A. Arsenault, D.H. Vitt, and T.R. Stephens. 2005. The ones we left behind: Comparing plot sampling and floristic habitat sampling for estimating bryophyte diversity. Diversity and Distributions 11:57–72.

Ministry of the Environment. 2014. Air Quality Ontario. Available online at http://www.airqualityontario.com/. Accessed 12 February 2021.

Ontario Ministry of Natural Resources and Forestry. 2022. Ontario Classified Point Cloud (Lidar-Derived). Available online at https://geohub.lio.gov.on.ca/maps/mnrf::ontario-classified-point-cloud-lidar-derived/about. Accessed 22 April 2022.

Orange, A., P.W. James, and F.J. White. 2001. Microchemical Methods for the Identification of Lichens. British Lichen Society, London, UK. 101 pp.

Paquette, H.A., N.B. Van Miltenburg, S.B. Selva, and R.T. McMullin. 2019. The calicioids of Forillon National Park, Quebec, Canada. Opuscula Philolichenum 18:58–73.

Parks Canada Agency (PCA). 2019. Rouge National Urban Park Management Plan. Available online at https://www.pc.gc.ca/en/pn-np/on/rouge/info/gestion-management/gestion-management-2019. Accessed 12 February 2021.

Parks Canada Agency (PCA). 2021. Multi-species Action Plan for Rouge National Urban Park of Canada [Proposed]. *Species at Risk Act* Action Plan Series. Parks Canada Agency, Ottawa, ON, Canada. 57 pp.

Powell, G.V.N., J. Barborak, and M. Rodriguez. 2000. Assessing representativeness of protected natural areas in Costa Rica for conserving biodiversity: A preliminary gap analysis. Biological Conservation 93:35–41.

Reid, W.V., and K.R. Miller. 1989. Keeping options alive: The scientific basis for conserving biodiversity. World Resources Institute, Washington, DC, USA. 128 pp.

Richardson, D.H.S. 1975. The Vanishing Lichens: Their History, Biology and Importance. David & Charles Publishers, Newton Abbot, Devonshire, UK. 231 pp.

Richardson, D.H.S. 1992. Pollution Monitoring with Lichens. Richmond Publishing, Slough, Berkshire, UK. 76 pp.

Richardson, D.H.S., and R.P. Cameron. 2004. Cyanolichens: Their response to pollution and possible management strategies for their conservation in northeastern North America. Northeastern Naturalist 11:1–22.

Rose, C.I., and D.L. Hawksworth. 1981. Lichen recolonization in London's cleaner air. Nature 289:289–929.

Seaward, M.R.D., and M.A. Letrouit-Galinou. 1991. Lichen recolonization of trees in the Jardin du Luxembourg, Paris. Lichenologist 23:181–186.

Selva, S.B. 2003. Using calicioid lichens and fungi to assess ecological continuity in the Acadian Forest Ecoregion of the Canadian Maritimes. Forestry Chronicle 79:550–558.

Sharpe, D.R. 1980. Quaternary geology of Toronto and surrounding area. Available online at http://www.geologyontario.mndm.gov.on.ca/mndmfiles/pub/data/records/P2204.html.

Accessed 1 July 2022.

Statistics Canada. 2017. 2016 Census of population. Available online at https://www150.statcan.gc.ca/n1/en/catalogue/98-316-X2016001. Accessed 1 July, 2022.

Sundin, R. 1999. Phylogenetic and taxonomic studies within *Arthonia* Ach. (Ascomycetes, Arthoniales). Ph.D. Dissertation. Stockholm University, Stockholm, Södermanland, Sweden. 162 pp.

Toronto and Region Conservation Authority (TRCA). 2015. Rouge National Urban Park — Terrestrial Biological Inventory and Assessment. Toronto and Region Conservation Authority, Toronto, ON, Canada. 167 pp.

Tumur, A., and D.H.S. Richardson. 2017. The lichen-forming fungi in the Halifax Public Gardens, Nova Scotia. Proceedings of the Nova Scotian Institute of Science 49:35–48.

Tumur, A., and D.H.S. Richardson. 2019. The Lichens of Point Pleasant Park, Halifax, Nova Scotia. Northeastern Naturalist 26 (1):63–80.