The CANADIAN FIELD-NATURALIST

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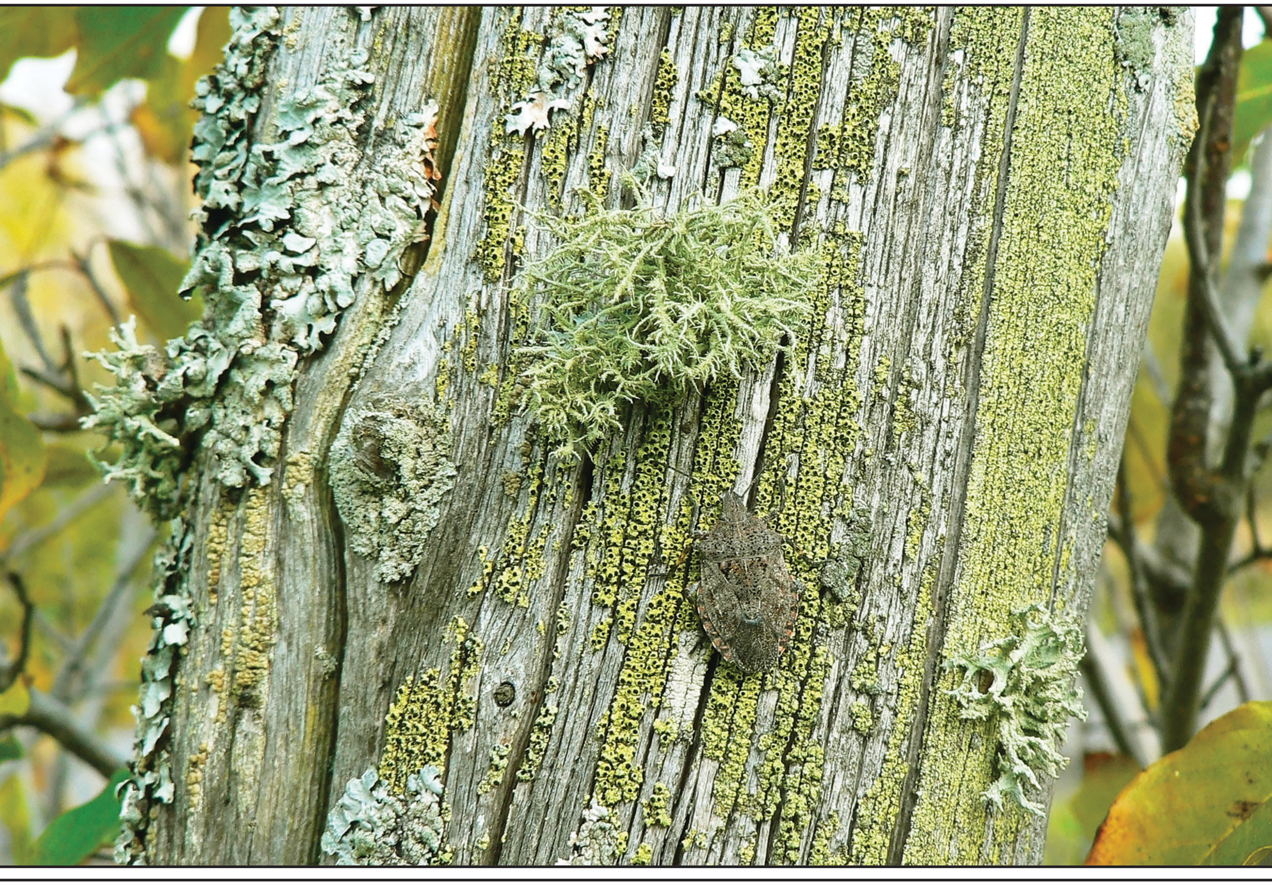

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Ottawa Field-Naturalists' Club
Club des naturalistes d'Ottawa

The Ottawa Field-Naturalists' Club

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The Canadian Field-Naturalist

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COVER: The crustose Yellow Soot Lichen (*Calicium tigillare*) covers this snag and makes a colourful resting place for a stink bug. This lichen is one of the 113 species whose name has changed since Brodo's *Lichens of the Ottawa Region, Second Edition* appeared in 1988. Patches of the foliose Hammered Shield Lichen (*Parmelia sulcata*) and fruticose Bristly Beard Lichen (*Usnea hirta*) also find this spot a good place to grow. See the article in this issue by Brodo *et al.*, pages 1–27. Photo: Colin Freebury, south of Ottawa International Airport, September 2006.

The Canadian Field-Naturalist

Additions to the lichens, allied fungi, and lichenicolous fungi of the Ottawa region in Ontario and Quebec, with reflections on a changing biota

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Abstract
The inventory of lichens, allied fungi, and their parasites in the Ottawa region has grown from 391 in 1988 to 543 today, almost entirely because of the discovery of species overlooked in previous years and the inclusion of fungal parasites. In addition, almost 140 names have changed with reclassifications and re-identifications. These changes are presented here together with a list of synonyms updating the 1988 list. Vouchers are cited for all new records, and notes are presented for many species neither described nor keyed out in easily accessible literature. Reference is made to the new, complete list of lichens and lichenicolous fungi available online. The new checklist includes one species new for North America (*Tremella christiansenii*); five species and one variety new for Canada (*Caloplaca parvula*, *Caloplaca reptans*, *Cladonia petrophila*, *Enchylium tenax* var. *ceranoides*, *Leprocaulon adhaerens*, and *Merismatium peregrinum*); four new for Ontario (*Caloplaca reptans*, *Kiliasia tristis*, *Lempholemma chalazanum*, and *Rinodina fimbriata*); and nine new for Quebec (*Arthonia helvola*, *Arthonia hypobela*, *Caloplaca parvula*, *Cladonia petrophila*, *Lempholemma chalazanum*, *Leprocaulon adhaerens*, *Merismatium peregrinum*, *Rimularia badioatra*, and *Tremella christiansenii*). Although the climate of the region is warming, especially with higher minimum temperatures in winter, the lichen biota has not increased as a result but, in fact, may be threatened by the effects of climate change on the health of the forests and the trees that support lichens. Air quality has improved in recent decades, allowing numerous lichens to again become established in urban areas. Local areas of especially rich lichen diversity can be found on both the Ontario and Quebec sides of the region, and some of these "hot-spots" are mentioned. Other factors influencing the decrease or increase of lichen cover are also discussed.

Key words: Eastern Canada; climate change; impoverishment of biota; urban lichens

Introduction
The lichen biota within a 50-km radius of the city of Ottawa (Figure 1) has received considerable attention since the days of John Macoun in the late 19th and early 20th centuries. In 1898, Macoun listed 152 species of lichens (Macoun 1898) and added 44 species eight years later (Macoun 1906) giving a total of 196 lichens. After Macoun, the next comprehensive listings were those of Brodo (1981), who reported 367 species, and Brodo (1988), with 391 species.

In the 30 years since publication of *Lichens of the Ottawa Region* (Brodo 1988), a tremendous amount of fieldwork has occurred, resulting in the discovery of 160 species beyond the nearly 400 previously known. The lichenology staff of the Canadian Museum of Nature (CMN; I.M.B., P.Y.W., R.T.M.) and their students (Sharon Gowan, Hayley Paquette, and François Lutzoni) have been exploring and collecting throughout the region, while amateur naturalists (R.E.L. and C.F.) have chosen to study smaller segments (Stony Swamp in the Greenbelt and Gatineau Park, respectively) in some depth. Visiting lichenologists from Ontario's Ministry of Natural Resources and Forestry (Sam Brinker and C.J.L.), other parts of North America (Stephen Clayden, Trevor Goward, Richard Harris, James Lendemer, Claude Roy, Steven Selva, and John Sheard), and Europe (Teuvo Ahti, André Aptroot, Ulf Arup, Stefan Ekman, David Hawksworth, Hannes

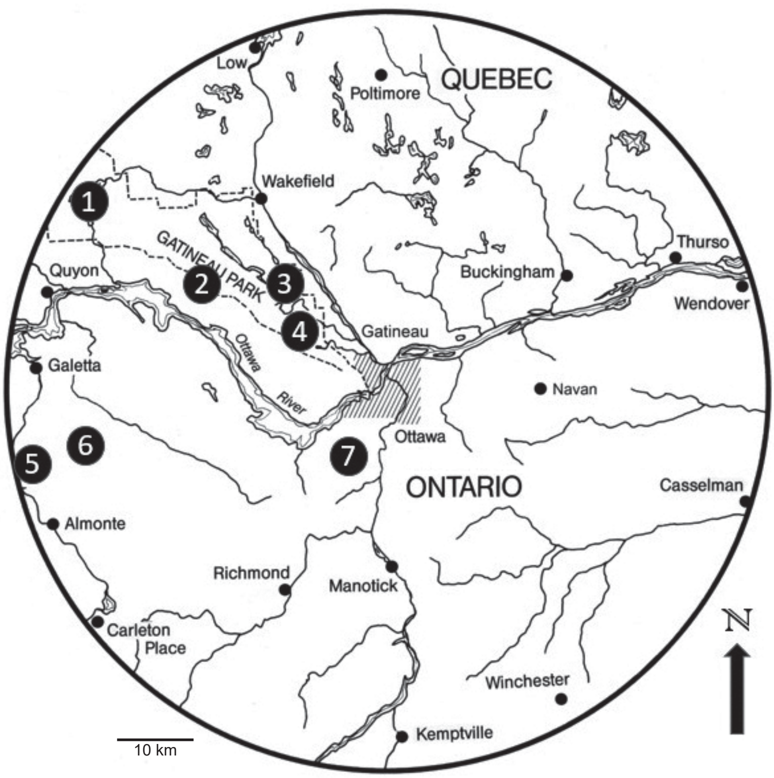

FIGURE 1. Ottawa Region, circumscribed as a circle with a 50-km radius from Parliament Hill, showing some important centres of lichen diversity ("hot-spots"). 1–4, Gatineau Park, Quebec. 1. Lac la Pêche; 2. Luskville Falls; 3. Lac Meech, MacDonald Bay; 4. King Mountain; 5. Blakeney Rapids Park, Mississippi Mills; 6. Burnt Lands Provincial Park, Almonte; 7. Ottawa Greenbelt, Stony Swamp (Macoun Club Study Area). Base map provided by Daniel Brunton and used with his permission.

Hertel, Ingvar Kärnefelt, Leif Tibell, and Tor Tønsberg) have brought fresh eyes and vast experience to joint forays with I.M.B. All have made discoveries of taxa new to the region augmenting our knowledge of the lichen biota, and many have re-identified existing specimens in the National Herbarium (CANL).

More than a third of the species listed in Brodo (1988; 139/391) have been either reclassified and therefore renamed by other lichenologists, or the specimens on which the reports were made have been re-identified, usually by the lichenology staff of CMN and visitors to CANL. Together with another 160 species discovered through fieldwork, including 13 fungi parasitic on lichens (which were not covered in Brodo [1988]), a total of 299 new names have to be considered by those interested in Ottawa area lichens. We document these changes here.

Study Area

The circle defining the "Ottawa region" was drawn by local naturalists in John Macoun's day with a 25-mile (40-km) radius from Parliament Hill (45°25′29″N, 75°41′59″W), later expanded to 30 miles (48 km; Brunton 1988). Since 1981, with the introduction of metric measurements in Canada, the radius has been set at 50 km, encompassing about 7850 km^2 (Figure 1). The circle is centred on an urban area home to about one million people. As in other large cities with significant air pollution, the core is essentially a "lichen desert" (Brodo *et al*. 2001: 89), with only a small selection of common corticolous lichens (e.g., Hammered Shield Lichen [*Parmelia sulcata* Taylor], Candleflame Lichen [*Candelaria concolor* (Dickson) Stein], and Star Rosette Lichen [*Physcia stellaris* (L.) Nyl.]) found in inner-city parks and along the lower parts of the Rideau Canal and Rideau River and adjacent Ottawa River. Species richness improves somewhat in the surrounding suburbs, but even here, routine maintenance and replacement of structures and renewal of tree plantings generally preclude establishment of well-developed lichen communities. These urban/suburban areas occupy less than a tenth of the circle. Outlying woodlands that support pollution-sensitive species cover more than a third of the area, with most of the remainder, almost half, being agricultural fields largely devoid of lichens. The status of the lichen biota vis-à-vis air quality and traffic in Ottawa was recently reviewed by Coffey and Fahrig (2012).

The region is bisected by the Ottawa River, which follows a geological divide and marks a political one. The land to the south (in the province of Ontario) is mostly underlain by flat-lying calcareous limestone of Paleozoic age, generally buried under beds of clay or sand. The often-exposed bedrock to the north (Quebec) is predominantly acidic granitic rock of the Precambrian Shield, which rises from the lower plain as an escarpment as much as 250 m high, with moderate relief behind it. Outlying exposures of both rock types occur on either side of the river, and glacially transported blocks of granite provide substrate for lichens restricted to acidic rocks in places well out onto the limestone plain.

In places, heavy late-glacial and post-glacial flows of water have stripped away the soft sediments altogether, leaving bedrock exposed. Flat-lying exposures of calcareous limestone now form a rare ecological formation known as an alvar, with examples that escaped industrial quarrying on both sides of the river.

Access to this diverse environment for the purpose of survey and collection has been facilitated by the establishment during the 20th century of substantial conservation areas as public lands, most notably by virtue of their size, Gatineau Park in Quebec and the Ottawa Greenbelt in Ontario. About two-thirds of the additional species reported here were found as a result of extended searches in these two areas.

The region experiences a humid continental climate, with hot, humid summers and very cold winters, classified as Dfb in the Köppen-Geiger climate classification system (Beck *et al.* 2018). With the current global warming trend (1981–2019), the mean annual temperature (as measured at the Environment and Climate Change Canada weather station on the Central Experimental Farm) was 6.6°C with average highs of 11.4°C and average lows of 1.9°C. The average high in July is 27°C and the average low in January is −14°C. Mean annual precipitation is about 920 mm, 750 mm as rain and 175 cm as snow. The record high and low temperatures, often of special biological significance (see Discussion below), are 38°C in July and −39°C in December, respectively (Wikipedia 2020 based on data compiled and summarized from Government of Canada [2020a]).

Methods

Additions to the lichen biota of the Ottawa region were recorded at CMN as they were discovered. All new records were reviewed and the vouchers re-examined. Standard laboratory methods for morphological and chemical studies were used in identifying the lichens, as summarized in Brodo *et al.* (2001). Permits to collect vouchers were obtained from the National Capital Commission by I.M.B., C.F., R.E.L., C.J.L., R.T.M., and P.Y.W., and the vouchers were deposited in CANL, except for collections made by visitors to the Ottawa region: Lendemer (NY [New York Botantical Garden, Bronx, New York]), Roy (QFA [Université Laval, Québec]), Selva (UMFK [University of Maine at Fort Kent, Fort Kent, Maine]), Sheard (hb. Sheard), Hertel (M [Staatliche Naturwissenschaftliche Sammlungen Bayerns, München, Germany]), Goward (UBC [University of British Columbia, Vancouver]), and Tønsberg (BG [University of Bergen, Bergen, Norway]; acronyms according to Thiers [2019]).

Results

Over the past 32 years, new fieldwork and herbarium study have uncovered an additional 135 species and one variety of lichens, 12 unlichenized fungi related to lichen fungi, and two species of uncertain or varying lichenization. A recent surge in interest in lichen parasites has prompted us to include lichenicolous fungi (11 species).

Many of the additions to the list reflect a shift in attention to microlichens. This was made possible by the availability of newer, more comprehensive and practical taxonomic keys. In the 1988 checklist, 168 (43% of the species) were foliose and fruticose (macrolichens), which, however, constitute 19% of the new discoveries, with crustose lichens accounting for about 75% and lichen parasites much of the remainder. This suggests that some upper limit is being approached among lichens that are easily seen, and most future additions are likely to be the more inconspicuous crusts.

A large number of these records have already been published or are listed online, e.g., Freebury (2011) for Gatineau Park species; Lee (2011), for the western greenbelt of Ottawa; and elsewhere in the region (e.g., Lewis and Brinker 2017). All these additions are listed in List I below. List II is made up of 19 additional lichen records resulting from the re-identification of species included in Brodo (1988). Among the new records for Ottawa, one species is also new for North America, five species and one variety are new for Canada, four are new for Ontario, and nine are new for Quebec; these are presented in List IV.

In addition to these new records for the Ottawa region, 18 lichens previously known only from the Quebec side are now reported from the Ontario side as well, and 15 species known only from the Ontario side are now also listed for Quebec. These can be found in List III.

Notes and comments on the species are made when appropriate in the compiled lists. The abbreviations ON and QU are included to indicate whether the species is known from the Ontario side of the Ottawa River or the Quebec side, respectively, as in Brodo (1988). One or two voucher specimens are briefly cited as well. (The abbreviation MCSA refers to the Macoun Club Study Area, between the Bells Corners and Bridlewood communities in west Ottawa.)

We are not introducing new or updated identification keys for the lichens of the region for several reasons. Of the 160 taxa listed as new records for the region (List I), 110 (69%) are included in the revised keys for the lichens of North America (Brodo 2016), and many of them are described and illustrated in Brodo *et al.* (2001), Hinds and Hinds (2007), or McMullin and Anderson (2014). Of the remaining 50 taxa not in those keys, 20 are either lichenicolous fungi, which are not covered in either the original Ottawa lichen inventory or in Brodo (2016), or are stubble lichens and fungi, the so-called calicioid species. The calicioids are almost all well covered in some recent, readily available articles (e.g., Selva and Tibell 1999; McMullin *et al.* 2018b; Gockman *et al.* 2020); most of the parasitic, lichenicolous fungi can be identified using the fairly comprehensive keys by Ihlen and Wedin (2008), which cover Swedish species. For these reasons, only brief notes will be included in the annotated lists, and only for the taxa not covered in the references above.

Annotated species lists

The additions and changes to the lichen biota of the Ottawa region are divided into five lists:

In **List I**, we present new records for the region.

List II gives the correct names of species whose earlier reports were based on misidentification, together with vouchers and the names under which they were originally reported.

List III presents all species for which we have new provincial records, e.g., species known only from the Quebec (QU) part of the region in 1988 but now known from the Ontario (ON) side as well, and *vice versa*. Here vouchers are given only for the newly reported provincial record.

List IV gives new reports for North America, Canada, and the provinces of Ontario and Quebec as a whole.

List V gives the current, accepted names for all species in Brodo (1988) whose names have changed since then owing to reclassification or other research. The entries in List II are repeated so that the disposition of all the changed names in Brodo (1988) are accounted for.

Collections by I.M.B., C.J.L., T.M., C.F., and P.Y.W. are deposited at CANL; those of Lendemer are at NY; those of R.E.L. are either in CANL or his private herbarium (hb. Lee; collection too small to be divided). For most species entries, only one or two specimens are cited per provincial record, even though many may have been collected.

Lichenicolous fungi and other non-lichenized fungi are designated by the following symbols:

* = lichenicolous fungi (parasites on living lichens)
+ = saprophytic fungi related to either lichens or lichenicolous fungi, on various substrates
# = fungi of uncertain status, e.g., those that are questionably or weakly lichen-forming; or algicolous/saprophytic; or parasitic when young but saprophytic or lichen-forming when mature; or lichenicolous lichens.

The complete up-to-date list of the 543 lichens and lichenicolous fungi of the Ottawa region has been posted on the website of the Ottawa Field-Naturalists' Club (https://ofnc.ca/wp-content/uploads/2021/02/Lichens-of-the-Ottawa-Region-revised-2021-02-28.pdf) and will be updated at least annually.

I. Species new for the Ottawa region

Acarospora americana H. Magn. ON: Ottawa, along Rideau River, Hog's Back, on granite, *Harris 12143* (NY); Ottawa, *Macoun 66*, 7 May 1897, CANL. The Harris specimen is cited in Knudsen *et al.* (2011) in a detailed discussion of the species with a full description and many excellent photos. The Macoun specimen is mentioned in Brodo *et al.* (2013).

Anaptychia crinalis (Schaer.) Vězda (syn. *A. setifera* Räsänen). ON: Ottawa, among mosses on rocks, with *Lempholemma polyanthes*, *Macoun 103*, 30 Aug. 1903, CANL 2693. With no modern collections of this charismatic lichen, the species is probably no longer present in the area.

Anisomeridium biforme (Borrer) R.C. Harris. QU: Aylmer, on ash (*Fraxinus*), *Brodo 29775*.

Arthonia fuliginosa (Schaer.) Flot. ON: Bells Corners (MCSA), on thin bark of small Black Ash (dead from Emerald Ash Borer attack), *Lee 2426*. This is a relatively rare species found mainly on Eastern White Cedar (*Thuja occidentalis* L.) in old cedar swamps and humid forests in the Great Lakes region (CNALH 2020). It was first reported for North America from Michigan by Wetmore (1988) and for Ontario by Crowe (1994) based on Wetmore's collections from the Slate Islands off the north shore of Lake Superior. It was later recorded from the Bruce Peninsula (Brodo *et al.* 2013). Harris (2015) includes *A. fuliginosa* in his key to *Arthonia* with an illustration of its ascospores (sub "*Arthonia* sp. #2"). In our material, the ascomata are irregular, forming star-shaped clusters, dark brown, usually pruinose, with a whitish thallus that can sometimes be rather well-developed, usually turned yellow with potassium hydroxide (KOH). The spores are 4–6-celled with the uppermost cell larger than the others, 16–23 × 6–8 µm (*n* = 18).

Arthonia helvola (Nyl.) Nyl. ON: Bells Corners, Stony Swamp, on base of Paper Birch (*Betula papyrifera* Marshall), *Brodo 32906*. QU: Gatineau Park, Trail 05 near Asticou, on Yellow Birch (*Betula alleghaniensis* Britton), *Lendemer 28299*, *Freebury 1449*; Keogan Cabin, on *B. alleghaniensis*, *McMullin 18784.* If the exposed roots of Yellow Birch in mature maple (*Acer*) forests are closely examined, there is a good chance of finding the tiny bright orange ascomata of *A. helvola*. The pigment is an anthraquinone that turns purple with KOH. The ascospores are often hard to find, but they are 3-celled, tapered, with the top cell slightly larger than the others, ~8–12 × 3–5 µm (Harris 1977). These are apparently the first published records of the species from Quebec. It was first reported for North America from Michigan and Ontario by Harris (1977) but seems to be fairly common in its preferred habitats in eastern North America (CNALH 2018).

+*Arthonia hypobela* Nyl. (syn. *A. caudata* Willey) ON: Bells Corners, Stony Swamp, on Eastern White Pine (*Pinus strobus* L.) twigs, *Brodo 32918*. QU: Gatineau Park, Church Hill, on *P. strobus*, *Freebury 1443*, det. Lendemer. This inconspicuous fungus is apparently restricted to the young, smooth bark of white pine appearing as tiny black dots on the dark bark. It is very common although rarely collected because it is so hard to see. The ascomata are black, round to irregular in shape, not pruinose, and produce comet-shaped, 4–8-celled ascospores that are 24–32(–37) × (4.0–)5.0–5.5 µm. The cells of the spores are about equal in length. McMullin *et al.* (2018a) recently reported it (sub *A. caudata*) as new to Nova Scotia, and McMullin and Lendemer (2016) listed it for southern Ontario. The species is, however, new for Quebec. The synonymy was reported in McMullin (2018).

+*Arthonia quintaria* Nyl. ON: Ottawa, Bells Corners, Stony Swamp, on maple (*Acer*), *Lendemer 28140* (NY).

Arthothelium anastomosans (Ach.) Arnold. QU: Gatineau Park, Meech Lake, on old poplar (*Populus*), *Brodo 25003.*

Arthrosporum populorum A. Massal. ON: Bells Corners, Stony Swamp (MCSA), on young Basswood (*Tilia americana* L.) trunk, *Lee 1120*. QU: Gatineau Park, Luskville Falls, corticolous on *Populus*, *McMullin 18757.*

Bacidia circumspecta (Nyl. *ex* Vain.) Malme. ON: Renfrew County, Stubirski Lake, near Madawaska River, on cedar, *Wong 3809*, det. Ekman 1994.

Bacidia laurocerasi (Del. *ex* Duby) Zahlbr. (confirmed for region). ON and QU: see Ekman (1996).

Bacidia subincompta (Nyl.) Arnold. QU: Gatineau Park, Chelsea, on shaded base of old Sugar Maple (*Acer saccharum* Marshall) near swamp, *Brodo 32405.*

Bacidina egenula (Nyl.) Vězda. ON: Ottawa, Rockcliffe Park, on White Elm (*Ulmus americana* L.), *M. Robitaille 149.4*, det. Ekman 1994.

Biatora printzenii Tønsberg. QU: Gatineau Park, Luskville Falls, on Northern Red Oak (*Quercus rubra* L.), *Tønsberg*, *B 21893* (BG) (Tønsberg 2002).

Bryoria nadvornikiana (Gyelnik) Brodo & D. Hawksw. QU: Gatineau Park, Trail 53, on Eastern Hemlock (*Tsuga canadensis* (L.) Carrière), *Freebury 1654*.

Buellia griseovirens (Turner & Borrer *ex* Sm.) Almb. ON: Fitzroy Harbour, on old fence along road, *Brodo 33178.* QU*:* Gatineau Park, Chelsea, on fallen *A. saccharum*, *Brodo 32408.*

Buellia schaereri De Not. ON: Renfrew, on *Tsuga*, *Brodo 31713A.*

Calicium parvum Tibell. ON: Bells Corners, Stony Swamp (MCSA), on rotted wood in old *Thuja* swamp, Lee *2195.*

Caloplaca ahtii Søchting. ON: Ottawa-Carleton County, South Gloucester, on Staghorn Sumac (*Rhus typhina* L.) near trail, *Brodo 25489*, det. Søchting. QU: Aylmer, on Trembling Aspen (*Populus tremuloides* Michaux), *Brodo 28935*, *28937A*, det. Wetmore.

Caloplaca chlorina (Flot.) H. Olivier. ON: Ottawa, Riopelle Island, north-facing cliff, at base of a young *Q. rubra*, *Brodo 29530*; on limestone at edge of escarpment, *Brodo 29520.*

Caloplaca parvula Wetmore. QU: Gatineau Park, near Pink Lake, on *Quercus*, *Goward* and *Clayden 82-73* (UBC); Aylmer, in wet woods under hydro lines, *Lendemer 28164* (NY); Cte. de Jacques-Cartier, Stoneham, on base of dead *Fagus*, *Brodo 29427. Caloplaca parvula* is easily identified by its small polarilocular spores (10–12.5 × 4.0–5.5 µm) having a very narrow isthmus in combination with its tiny black apothecia (under 0.3 mm in diameter) and grey non-sorediate thallus, all negative with KOH. It grows on deciduous trees, often in hardwood swamps. This rare lichen was described from Minnesota by Wetmore (1994), but it is also known from northern Michigan (CNALH 2018). In Canada, it is only known from the Ottawa region and Stoneham, near Quebec City (both cited above). It is new for Quebec and Canada.

Caloplaca pyracea (Ach.) Th. Fr. QU: Gatineau Park, Luskville Falls Trail, parking lot, on *Populus*, *McMullin 18754*.

Caloplaca reptans Lendemer & B.P. Hodk. ON: Cunningham Island, Champlain Bridge area, on erratic in partial shade, *Brodo 29514. Caloplaca reptans* is a sterile, sorediate lichen with a grey-green to brownish thallus and grows on non-calcareous rocks (Hodkinson and Lendemer 2012). The thallus is dispersed areolate with areoles 0.2–0.3(–0.5) mm in diameter, the areoles sometimes becoming somewhat lobulate at the margins. The soralia are laminal or marginal and contain fine, pale, creamy white soredia. This recently described species was previously known only from the Appalachian Mountains (Hodkinson and Lendemer 2012). It is new for Canada and Ontario.

Caloplaca subsoluta (Nyl.) Zahlbr. ON: Ottawa, Vincent Massey Park, on top surface of limestone boulder at falls, *Brodo 29213*. QU: Gatineau Park, base of King Mountain near Baillie Rd., on HCl– rock, *Freebury 1404*. We are including here Ottawa specimens previously identified as *Caloplaca velana* (A. Massal.) DuRietz (see Arup 1990; Wong and Brodo 1992; Brodo 2016).

Candelariella lutella (Vain.) Räsänen. ON: Ottawa, Vincent Massey Park, on dead bark, *Freebury 2181*. QU: Gatineau (Aylmer), on fallen Balsam Poplar (*Populus balsamifera* L.), *Brodo 33112B*

Catillaria lenticularis (Ach.) Th. Fr. QU: Pontiac County, Knox Landing sud, près de la pointe Ross, les alvars de la région du Lac des Chats, dallage calcaire fracturé et altéré, *Roy 99-4387C* (QFA).

Catillaria nigroclavata (Nyl.) Schuler. ON: Richmond, on *Q. rubra*, *Brodo 27633*; Bells Corners, Stony Swamp (MCSA), on Butternut (*Juglans cinerea* L.) branch, *Lee 1113*. QU: Lac la Pêche, on *Thuja*, *Brodo 33081*; Lac Richard, on *Thuja*, *Freebury 700.*

Chaenotheca chrysocephala (Ach.) Th. Fr. ON: Bells Corners, Stony Swamp (MCSA), on weathered Larch (*Larix*) wood, *Lee 2208.*

Chaenotheca gracilenta (Ach.) J. E. Mattsson & Middelb. ON: Bells Corners, Stony Swamp (MCSA), on basal bark of old *T. occidentalis* in old *Thuja* swamp, *Lee 2173.*

Chaenotheca laevigata Nádv. ON: Bells Corners, Stony Swamp (MCSA), on old *T. occidentalis* in old *Thuja* swamp, *Lee 2182.*

Chaenotheca trichialis (Ach.) Th. Fr. ON: Bells Corners, Stony Swamp (MCSA), on weathered *Larix* lignum, *Lee 2185.*

Chaenotheca xyloxena Nádv. ON: Ottawa, Delzotto Avenue and Quin Avenue, old-growth Red Ash (*Fraxinus pennsylvanica* Marshall) swamp, lignicolous on *T. occidentalis*, *Selva 8998* (UMFK). QU: Gatineau Park, Luskville Falls, lignicolous, on *P. strobus* snag, *McMullin 18779*.

+*Chaenothecopsis perforata* Rikkinen & Tuovila. ON: Fletcher Wildlife Garden, on *R. typhina* resin, *McMullin 20104*. QU: Gatineau Park, Luskville Falls parking lot, on *R. typhina* resin, *McMullin 19165*. Although not listed in Esslinger (2019), this species was recently reported as new to North America, Canada, Quebec, and Ontario by Gockman *et al.* (2019).

#*Chaenothecopsis pusiola* (Ach.) Vain. ON: Bells Corners, Stony Swamp (MCSA), on weathered *Larix* lignum, *Lee 2184.*

+*Chaenothecopsis savonica* (Räsänen) Tibell. ON: Bells Corners, Stony Swamp (MCSA), on softly rotted wood of tottering deciduous tree in old *Thuja* swamp, *Lee 2210.*

Cladonia farinacea (Vain.) A. Evans. ON: Bells Corners, Stony Swamp, *Brodo 28702.*

Cladonia floerkeana (Fr.) Flörke. ON: Fitzroy Harbour, on stump in partial shade, *Brodo 33157.*

Cladonia gracilis (L.) Willd. subsp. *turbinata* (Ach.) Ahti. QU: Gatineau Park, Hope's Trail, Lac Meech, on soil, *Hanes* s.n., CANL 096116.

Cladonia ochrochlora Flörke. ON: Bells Corners, Stony Swamp, on log, *Lendemer 28132* (NY). QU: Gatineau Park, Kidder Lake, on thin soil in forest glade, *Freebury 240*, det. Brodo.

Cladonia petrophila R.C. Harris. QU: Gatineau Park, Faris Creek, on rock, *Freebury 1439*, det. Lendemer. This lichen is an addition the lichen biota of Canada as well as Quebec.

Cladonia subulata (L.) F.H. Wigg. ON: Bells Corners, Stony Swamp, alvar, *Brodo 28889.*

**Clypeococcum hypocenomycis* D. Hawksw. QU: Chelsea, parasitic on *Hypocenomyce scalaris* (Ach. *ex* Lilj.) M. Choisy, *Freebury 1135*; Gatineau Park, Keogan Cabin, parasitic on *H. scalaris*, *McMullin 18782*.

**Cornutispora lichenicola* D. Hawksw. & B. Sutton. QU: Gatineau Park, on *Punctelia rudecta* (Ach.) Krog on dead wood, *R. Lowan 270* (NY), ver. R.C. Harris.

Cresponea chloroconia (Tuck.) Egea & Torrente. ON: Gloucester, on *B. alleghaniensis*, *Wong 4518*. QU: Gatineau Park, Meech Lake, *Hanes* s.n., CANL 96175.

Dictyocatenulata alba Finley & E.F. Morris. ON: Ottawa, Stony Swamp, on *B. papyrifera* base, *Lendemer 28142* (NY). QU: Gatineau Park, Church Hill; base of *B. alleghaniensis*, *Freebury 1445*, det. Lendemer; on *B. alleghaniensis*, *Lendemer 28317* (NY). This lichenized hyphomycete, reported for Canada by Seifert *et al.* (1987) as an unlichenized fungus, is recognized by its curious white, stalked synnemata, 1–1.5 mm tall, producing at the tips a mass of colourless, broadly ellipsoid, muriform conidia, 7–18 × 7–11 µm; it is not known to produce ascomata. Lendemer and Harris (2004) discuss its symbiotic nature and describe the species, which is usually found on the exposed roots of *B. alleghaniensis.* There is a particularly good description with many photographs in Diederich *et al.* (2008).

**Didymocyrtis epiphyscia* Ertz & Diederich (syn. *Phoma physciicola* Keissler). QU: Gatineau Park, Trail 53 near La Pêche River, on *Physcia aipolia* (Ehrh. *ex* Humb.) Fürnr., *Freebury 1119A.*

**Didymocyrtis xanthomendozae* (Diederich & Freebury) Diederich & Freebury (syn. *Phoma xanthomendozae* Diederich & Freebury). QU: Gatineau Park, Trail 53 near La Pêche River; on *Xanthomendoza hasseana*, *Freebury 1413.*

#*Diploschistes muscorum* (Scop.) R. Sant. ON: Lanark County, Burnt Lands, *Brodo 32625*. QU: Gatineau Park, Luskville Falls, on *Cladonia*, *Brodo 5587*, det. Lumbsch.

Diplotomma alboatrum (Hoffm.) Flot. ON: Dunrobin, Sheila McKee Park, on limestone cliff, *Lewis 2226*, with *J. Devlin*.

Enchylium tenax (Sw.) Gray var. *ceranoides* (Borrer) Cl. Roux *comb. prov.* (Gérault 2020). ON: Panmure Alvar, calcareous soil, *Lewis 2236b*; Burnt Lands Provincial Park, calcareous soil, *Lewis 2302. Enchylium tenax s. str.* is the most common, soil dwelling, *Collema*-like species in Ontario (Brodo *et al.* 2001, *sub Collema tenax*). It is notoriously variable, taxonomically complex, and difficult to identify correctly, with a number of morphotypes potentially attributed to environmental conditions (Jørgensen and Goward 2015). Degelius (1954) recognized seven varieties in his monograph on the European species. The material cited here represents the first vouchered published report of *E. tenax* var. *ceranoides* from Ontario. It is found growing on calcareous soil and is rarely fertile, unlike *E. tenax* var. *tenax* which is highly fertile. *Enchylium tenax* var. *ceranoides* has digitate, erect, vertical lobes, compared with the prostrate lobes or lack of lobes of *E. tenax* var. *tenax*, and the lobes are swollen when wet (Degelius 1954; Gilbert *et al.* 2009).

Enterographa zonata (Körb.) Källsten (syn. *Opegrapha zonata* Körb.). QU: Gatineau Park, Trail 5 near Asticou on rock, *Lendemer 28300* (NY).

Fuscidea arboricola Coppins & Tønsberg. ON: Prescott and Russell County, Larose Forest, on *A. rubrum* by creek, *Brodo 31802*. QU: Aylmer, on *A. rubrum*, *Brodo 28912.*

Fuscidea recensa (Stirt.) Hertel, V. Wirth & Vězda var. *arcuatula* (Arnold) Fryday. QU: Gatineau Park, Trail 5, Asticou, on rock, *Lendemer 28301* (NY).

Gyalecta fagicola (Hepp *ex* Arnold) Kremp. (syn. *Pachyphiale fagicola* (Arnold) Zwackh). ON: Ottawa, Gloucester, cedar swamp, on maple, *Wong 4540.*

Gyalecta truncigena (Ach.) Hepp. ON: Richmond, on *P. balsamifera*, *Brodo 27627.*

Halecania sp. QU: Gatineau Park, King Mountain off Mountain Rd., on shaded siliceous rock, *Brodo 32685a*. This interesting but inconspicuous crustose lichen is under study by Richard Harris and Doug Ladd and will be described as new based on collections from the Ozark Mountains. Its thin, areolate to subsquamulose thallus stains red with para-phenylenediamine (PD) under the apothecia and in the apothecial margins. The reaction is due to argopsin, found in several other species of *Halecania* such as *H. micacea* Fryday & Coppins, a rare British species with a dispersed areolate thallus. The 2-celled ellipsoid spores of the Ottawa specimen are (9.3–)10.3–11.8(–12.5) × 3.6–5.2 µm.

Heppia adglutinata (Kremp.) A. Massal. ON: Panmure Alvar, Timmins Road, on calcareous soil, *Lewis 2235*, *with J. Devlin*.

**Illosporiopsis christiansenii* (B.L. Brady & D. Hawksw.) D. Hawksw. QU: Gatineau Park, Luskville Falls, on *Physcia* sp., *Brodo 32142*.

**Illosporium carneum* Fr. QU: Gatineau Park, Lac Ramsay, on *Peltigera* sp., *Brodo 14628.*

Inoderma byssaceum (Weigel) Gray (syn. *Arthonia byssacea* (Weigel) Almq.). ON: Gloucester, Albion and Leitrim Roads, on White Cedar, *Wong 4522*; Ottawa, Black Rapids, on *T. americana*, *Brodo 27669.* QU: Gatineau Park, Lac Meech, on island in MacDonald Bay, on *Acer*, *Brodo 29726.*

Ionaspis alba Lutzoni. ON: Bells Corners, Stony Swamp (MCSA), on a non-calcareous sandstone boulder in a mature hardwood forest, *Lee 1991*. QU: Chelsea, on granitic outcrop in old *Acer* forest, *Brodo 32406*, with *C. Freebury.*

Kiliasia tristis (Müll. Arg.) Hafellner (syn. *Toninia subnitida* (Hellb.) Hafellner & Türk.). ON: North Gower, on stone in partly shaded area, under *Thuja* and Balsam Fir (*Abies balsamea* (L.) Miller), *Brodo 22760*. The classification of *K. tristis* has changed several times over the past 40 years.

As a species of *Catillaria*, *C. tristis* (Müll. Arg.) Arnold, it was included in the monograph on saxicolous species of *Catillaria* by Kilias (1981). Hafellner (1984) noted that in species of *Catillaria* belonging to the *C. athallina*-group of Kilias, the ascus tips were *Bacidia*-type, not *Catillaria*-type, and he therefore created a new genus, *Kiliasia*, to accommodate these species, including *C. tristis*. When Timdal (1991) synonymized *Kiliasia* within *Toninia*, he did not include *K. tristis* because some characters did not fit those of *Toninia* perfectly. Hafellner and Türk (2016) later concluded that the species should nevertheless be included in *Toninia*. To do so, they had to select the next older name at the species level, *Catillaria subnitida* Müll. Arg., from a list of its synonyms because the name *Toninia tristis* (Th. Fr.) Th. Fr., pertains to an entirely different lichen, precluding the use of another "*tristis*" in that genus. Recent molecular studies by Kistenich *et al.* (2018), however, show the phylogenetic distinctness of *Toninia athallina* (Hepp) Timdal, the type species of *Kiliasia*, and some related species. Although *K. tristis* was not included in their analyses, its similarity to *K. athallina* led those authors to include *K. tristis* in the resurrected *Kiliasia*.

The Ottawa specimen agrees in all respects with the description of *C. tristis* in Kilias (1981). It has a thin, dark, areolate thallus with flat, black apothecia, 0.3–0.6 mm in diameter, having prominent but thin margins. The spores are two-celled, (7.6–)9.5–11.4 × 3.6–4.6(–5.2) µm, colourless, and thin walled, but it is the exciple/hypothecium that sets it apart from superficially similar lichens. These tissues are red-black in the centre, becoming paler purplish or greenish to almost colourless at the outer edges. The pigmented parts turn purple with KOH or nitric acid; the epihymenium is greenish. It is a rare north temperate lichen in North America. CNALH (2019) (sub *Toninia subnitida*) has unverified records from British Columbia, Michigan, and Minnesota, and the species appears to be new for Ontario. It grows only on calcareous rock.

Lathagrium undulatum (Flot.) Otálora, P.M. Jørg. & Wedin var. *granulosum* (Degel.) M. Schultz & McCune. ON: Burnt Lands Provincial Park, on limestone, *Lewis 2305.*

Lecania fuscella (Schaer.) Körb. ON: Bells Corners, Stony Swamp (MCSA), on fallen crown of *P. balsamifera*, *Lee 1411.*

Lecania naegelii (Hepp) Diederich & Van den Boom. QU: Chelsea, on dead branch, *Freebury 2243*.

Lecanora appalachensis Lendemer & R.C. Harris. QU: Gatineau Park, Faris Creek, on *Tilia*, *Lendemer 28351* (NY).

Lecanora meridionalis H. Magn. ON: Bells Corners, *Brodo 33664.* QU: Gatineau Park, Lac la Pêche, *Brodo 33870*.

Lecanora perplexa Brodo. ON: Navan, Macoun (?). QU: Mayo, *Brodo 23585.*

Lecidea plebeja Nyl. QU: Aylmer, base of cedar stump, *Brodo 29774.*

Lecidella elaeochroma (Ach.) M. Choisy. QU: Gatineau Park, Heney Lake, on Sugar Maple, *Hanes* s.n., CANL 96178.

Lecidella euphorea (Flörke) Hertel. ON: Kemptville, on fence post, *Wong 1285.*

Lepraria cryophila Lendemer. QU: Gatineau Park, Trail 5, on under side of over-hanging rock, *Freebury 1450*, det. Lendemer.

Lepraria eburnea J.R. Laundon. ON: Bells Corners, Stony Swamp (MCSA), on *Thuja*, *Lendemer 28108* (NY).

Lepraria elobata Tønsberg. ON: Bells Corners, Stony Swamp (MCSA), on rock, *Lendemer 28160* (NY). QU: Gatineau Park, Church Hill, on *P. strobus* base, *Lendemer 28349-A* (NY), det. Lendemer.

Lepraria harrisiana Lendemer. ON: Bells Corners, Stony Swamp (MCSA), on *Thuja*, *Lendemer 28152* (NY). This recently described species (Lendemer 2013) is similar to *Lepraria caesiella* R.C. Harris in chemistry (atranorin, pallidic acid, and zeorin), but the soredia ("ecorticate granules" as used by Lendemer 2013) that make up the major part of the thallus lie on a white hypothallus, like a bed of white hyphae, visible between clumps of soredia or at the thallus margins.

Lepraria humida Slav.-Bayr. & Orange. QU: Gatineau Park, near Asticou, Trail 5, on shaded siliceous rock, *Freebury 2269*, det. Lendemer. This is a species of shaded rock walls and overhangs (Lendemer 2013). The soredia typically occur in dispersed patches, although they can coalesce in places into a continuous crust. It contains atranorin, rangiformic, and norrangiformic acids, lacking zeorin.

Lepraria normandinoides Lendemer & R.C. Harris. QU: Gatineau Park, near Hickory Trail, on rock face, *Brodo 32683*.

Lepraria oxybapha Lendemer. QU: Gatineau Park, near Eardley in waterfall area, on rocks at falls, *Brodo 16844*, with *L. Dickson* and *C. Jutras*, det. Lendemer. In this dust lichen, the soredia coalesce into small lobes often with thicker rims. Its chemistry, atranorin, fumarprotocetraric acid (PD+ red), and roccellic acid, makes it especially distinctive. It closely resembles *L. normandinoides*, which contains protocetraric rather than fumarprotocetraric acid and tends to be bluish grey rather than yellowish, as in *L. oxybapha.* The latter is an eastern North American, especially Appalachian, endemic (Lendemer 2013).

Leprocaulon adhaerens (K. Knudsen, Elix & Lendemer) Lendemer & B.P. Hodk. (syn. *Lepraria adhaerens* K. Knudsen, Elix & Lendemer). QU: Chelsea, on granitic rock in forest, *Brodo 32431B*, det. Lendemer; Gatineau Park, Faris Creek, on sheltered rock, *Lendemer 28376* (NY), with *C. Freebury*, det. Lendemer. First described as a species of *Lepraria*, this lichen was transferred to *Leprocaulon* by Lendemer and Hodkinson (2013). This and most other species of *Lepraria* and *Leprocaulon* are difficult if not impossible to identify reliably without recourse to thin layer chromatography or other methods for revealing the chemical products. *Leprocaulon adhaerens* is described and discussed in Knudsen *et al.* (2007), which is available online. It was described from California but is also known from eastern United States (Knudsen *et al.* 2007). Its chemistry is unusual among species of *Lepraria* or *Leprocaulon*, containing the PD+ orange substance pannarin, as well as zeorin. The leprose, bluish-grey thallus grows over bryophytes and sometimes soil and rocks (Lendemer 2013). This is a first report for Canada and Quebec.

**Marchandiomyces corallinus* (Roberge) Diederich & D. Hawksw. QU: Aylmer, parasitizing *Physcia* cfr. *stellaris* (L.) Nyl., *Freebury 2304.*

**Merismatium peregrinum* (Flot.) Triebel. QU: Gatineau Park, Church Hill, on rock, on thallus of *Rimularia badioatra* (Kremp.) Hertel & Rambold, *Lendemer 28336-A* (NY). This species, reported from Pennsylvania as new to North America by Harris and Lendemer (2005), is a pyrenomycete parasite apparently restricted to *R. badioatra* (also reported below as new to the Ottawa region). Hertel and Rambold (1990) describe it as having (2–)4-celled, rather dark brown spores, (12–)14–16(–17) × 4.5–7 µm. It is a new record for Canada.

+*Microcalicium ahlneri* Tibell. QC: Gatineau Park, Keogan Cabin, lignicolous, *McMullin 18780*.

Multiclavula mucida (Fr.) R.H. Peterson. ON: Gloucester, on cedar log, *Wong 4523*. QU: Gatineau Park, Black Lake, on rotting log near boggy area, *Brodo 31783.*

Mycobilimbia epixanthoides (Nyl.) Vitik., Ahti, Kuusinen, Lommi & T. Ulvinen. ON: Bells Corners, Stony Swamp (MCSA), on *Thuja*, *Lendemer 28145* (NY).

Mycoblastus caesius (Coppins & P. James) Tønsberg. QU: Chelsea; on fallen *A. saccharum*, *Brodo 32408.*

Nephroma helveticum Ach. var. *helveticum.* QU: Gatineau Park, Trail 5, Asticou, on mossy rock, *Freebury 20.*

Ochrolechia mexicana Vain. QU: Gatineau Park, Booth picnic field, Kingsmere, on *A. saccharum*, *Bégin-Robitaille* s.n., "4/11/1975."

Parmeliella triptophylla (Ach.) Müll. Arg. QU: Gatineau Park, Trail 5, Asticou, on base of *Quercus*, *Brodo 32682.*

Parmeliopsis capitata R.C. Harris *ex* J.W. Hinds & P.L. Hinds. QU: Gatineau Park, Lac Ramsay, on Black Spruce (*Picea mariana* (Miller) Britton, Sterns & Poggenburgh) in bog, *Brodo 13345.*

Parmotrema subtinctorium (Zahlbr.) Hale (= *Parmelia crinita* Ach. f. *varians* G. Merr.; ≡ *Canomaculina subtinctoria* (Zahlbr.) Elix). The voucher specimen cited here is the holotype of *Parmelia crinita* f. *varians* G. Merr. described in 1908 in a rarely cited paper on species of *Parmelia s. lat.* found at that time in CANL (Merrill 1908). The only other species of *Parmotrema* in the Ottawa region is *Parmotrema crinitum* (Ach.) M. Choisy, rather rare and confined to humid habitats such as old cedar swamps. *Parmotrema subtinctorium* is even rarer, having been found only twice in southern Ontario by John Macoun (Wong and Brodo 1992) and more typical of southeastern United States (Brodo *et al.* 2001, *sub Canomaculina subtinctoria*). It has not been found since and may well be extirpated in Canada. It somewhat resembles *P. crinitum* but has a pale lower surface without the naked margin characteristic of most species of *Parmotrema*, and the isidia do not sprout black cilia as do the isidia of *P. crinitum*. In addition, the voucher contains salazinic acid and norlobaridone rather than stictic acid.

Peltigera extenuata (Nyl. *ex* Vain.) Lojka. ON: Ottawa, southeast of Ottawa airport, over moss, *Freebury 2299.* QU: Gatineau Park, Ramsey Lake, on soil on rock ledges near lake, *Brodo 16795.*

Peltigera ponojensis Gyeln. ON: Bells Corners, on vertical surface of exposed boulder near swamp, *Brodo 13322B*, det. Goward. QU: Gatineau Park, Lac Meech, MacDonald Bay, on soil, *Brodo 25009*.

Pertusaria globularis (Ach.) Tuck. QU: Gatineau Park, King Mountain, on siliceous rock, *Freebury 261*, det. Brodo. There are four collections from Gatineau Park, all of them isidiate, thereby distinguishing them from the recently described *Pertusaria superiana* Lendemer & E. Tripp, which is similar but lacks isidia (Tripp and Lendemer 2019). The latter is cited from two localities in southern Ontario (Tripp and Lendemer 2019).

+*Phaeocalicium minutissimum* (G. Merr.) Selva. ON: Bells Corners, Stony Swamp (MCSA), on bark of 10-cm diameter *Q. rubra*, *Lee 2424*. QU: Gatineau Park, King Mountain, on *Q. rubra* saplings, *Brodo 30422*, det. Selva.

+*Phaeocalicium polyporaeum* (Nyl.) Tibell. ON: Gloucester, Leitrim, on "*Polyporus*", *Brodo 30427*. QU: Chelsea, on *Tricaptum* sp. (polypore), *Brodo 32411*.

+*Phaeocalicium populneum* (Brond. *ex* Duby) A.F.W. Schmidt. QU: Gatineau Park, Luskville Falls Trail, on *Populus*, *McMullin 18775*.

Phaeophyscia orbicularis (Neck.) Moberg. ON: Bel-Air Heights, on a deciduous shrub, *McMullin 18812*. QU: Gatineau Park, Pink Lake, on Scotch Elm (*Ulmus glabra* Hudson), *Goward 82-91* (UBC).

Phlyctis speirea G. Merr. *s. str.* ON: Bells Corners, Stony Swamp, on *Thuja*, *Lendemer 28118* (NY). QU: Gatineau Park, between Lac Ramsay and Lac Hawley, on *T. occidentalis*, *Brodo 16309.* We are using this name in the strict sense to refer to specimens that are fertile (i.e., with apothecia) containing asci, each having a single, large, muriform spore (see Muscavitch *et al.* 2017).

Physcia tenella (Scop.) DC. ON: Bells Corners, on north side of West Hunt Club Road just east of Moodie Drive, on deciduous tree, *Brodo 33104.*

Physciella melanchra (Hue) Essl. ON: Ottawa, McLeod Street, on roadside tree, *Brodo 33113.* QU: Gatineau Park, Luskville Falls parking lot area, on deciduous tree, *Brodo 32141* with *Freebury*.

Physconia leucoleiptes (Tuck.) Essl. ON: North Gower, on dead *Fraxinus*, *Brodo 22767*, det. Esslinger. QU: Poltimore, on limestone cliff, *Brodo 19167*, det. Esslinger.

Placidium squamulosum (Ach.) Breuss. ON: Burnt Lands alvar, 3.73 km north of Almonte, on soil, *Brodo 32619*. QU: Pontiac, Bristol, on soil in open, *Brodo 29711.*

Placynthium flabellosum (Tuck.) Zahlbr. QU: Gatineau Park, Luskville Falls, on streamside rock, *Brodo 29696.*

Placynthium stenophyllum (Tuck.) Fink var. *isidiatum* Henssen. ON: Burnt Lands Provincial Park, on limestone, *Lewis 2310*.

Porpidia contraponenda (Arnold) Hertel & Knoph (syn. *P. diversa* (Lowe) Gowan). QU: Papineau Co., 3.5 miles [5.6 km] north of Mayo, on granitic boulder, *Brodo 23578*, det. Gowan.

Porpidia soredizodes (Lamy *ex* Nyl.) J.R. Laundon. ON: Blakeney, on vertical rock wall near stream, *Brodo 29907*, det. Lendemer. QU: Gatineau Park, Church Hill, on rock, *Lendemer 28339* (NY), det. Lendemer.

Protoparmelia hypotremella Herk, Spier & V. Wirth. ON: North Gower, on sunny *A. balsamea*, parasitized by *Sphinctrina anglica* Nyl., *Brodo 22761B.*

Psilolechia lucida (Ach.) M. Choisy. ON: Fitzroy Harbour, on overhang by river, *Brodo 33160*. QU: Gatineau Park, Lac la Pêche, on rock wall near lake, *Brodo 31815.*

Psora decipiens (Hedw.) Hoffm. ON: Burnt Lands Provincial Park, on soil, *Brodo 32623*; on calcareous soil, *Lewis 2277*; Panmure Alvar, Timmins Road, on calcareous soil, *Lewis 2236a.*

Punctelia caseana Lendemer & B.P. Hodk. ON: Bells Corners, Stony Swamp (MCSA), on *Thuja*, *Lendemer 28150* (NY). QU: Luskville, Gibson Road, escarpment, on *Q. rubra*, *Freebury 630.*

Pyrenula micheneri R.C. Harris. ON: Ottawa, on Blue-beech (*Carpinus caroliniana* Walter), *Macoun*, 1893 (US) (Harris 1989). Unlike *Pyrenula pseudobufonia* (Rehm) R.C. Harris, which is the common *Pyrenula* in the Ottawa region, the thallus of *P. micheneri* does not fluoresce yellow with long-wave ultraviolet (UV) light, and the spores have thickened walls at the tips. When he described the species, Harris (1989) had only seen collections made before 1900 and believed it may already have been extinct. However, since then, he found it in the Ozark Mountain region (Harris and Ladd 2005) and North Carolina (CNALH 2020). It may, however, no longer be present in the Ottawa region.

Rhizocarpon badioatrum (Flörke *ex* Spreng.) Th. Fr. QU: Luskville, Gibson Road, escarpment, on acidic rock, *Freebury 641*, ver. Brodo.

Rhizocarpon timdalii Ihlen & Fryday. ON: Carp, Carp Hills, on exposed granite, *Brodo 24924*. This grey-brown map lichen was known only from northeastern United States and Europe (Ihlen and Fryday 2002) until it was recently reported from Sandbar Lake Provincial Park in northwestern Ontario's Kenora District by Dorval and McMullin (2020), the first report from Ontario and Canada. There are also specimens from Algoma District and Renfrew County in CANL; thus, the species probably has a wide hemi-boreal distribution.

Rimularia badioatra (Kremp.) Hertel & Rambold. QU: Gatineau Park, Church Hill, on rock, *Lendemer 28336* (NY), det. Lendemer. This Appalachian species is a first record for Quebec. It is also known from New Brunswick (CNALH 2019) as a result of collections made during the 2011

Tuckerman Workshop in the southeastern corner of that province. It has a thin, pinkish brown, areolate crust with immersed black apothecia containing broadly ellipsoid 1-celled spores, 10–17 × 7–10 µm (*fide* Giavarini and David 2009). The medulla of the thallus contains gyrophoric acid and turns pink when tested with bleach (C+ pink).

Rinodina fimbriata Körb. QU: Gatineau Park, Eardley, on rocks at edge of stream, *Brodo 16855* (Sheard 2010). *Rinodina fimbriata* is a saxicolous species growing on rock usually close to water. Its apothecia are immersed in the thallus like an *Aspicilia*, but it has large, brown, two-celled spores with hourglass-shaped lumina (*Mischoblastia*-type), ~19–24 × 10–14 µm, becoming somewhat inflated at the septum when the spores are old (Sheard 2010). It is quite rare in North America, and the specimens cited above were the only known Canadian records until it was recently found in Algonquin Provincial Park (*Lewis 366* [CANL]), a new record for Ontario.

Rinodina oxydata (A. Massal.) A. Massal. ON: Ottawa, Rockcliffe Park, on limestone ledges, river shore, *Brodo 22777*, det. Sheard. QU: Mayo, mixed hardwood stand, on rock, *Brodo 23592*.

Rinodina pachysperma H. Magn. ON: Ottawa, Britannia, on *A. rubrum*, *Macoun 357*, det. Sheard. QU: Gatineau Park, Luskville Falls, on bark, *Sheard 1431a*.

Rinodina siouxiana Sheard. ON: Blakeney, on vertical rock wall, *Brodo 29902*. QU: Gatineau Park, Chemin de la Montagne, base of King Mountain, siliceous rock in forest, *Brodo 32694*.

Rinodina subpariata (Nyl.) Zahlbr. (syn. *R. degeliana* Coppins). ON: Gloucester, on maple, *Wong 4525*. QU: Gatineau Park, east side of Beaver Canal, on Sugar Maple, *Hanes* s.n., 2 April 1972, det. Lendemer.

Ropalospora chlorantha (Tuck.) S. Ekman. QU: Poltimore, on *A. rubrum*, *Brodo 27645*.

Ropalospora viridis (Tønsberg) Tønsberg. ON: Fitzroy Harbour, on deciduous tree bark, *Brodo 33171*. QU: Aylmer, on *A. rubrum*, *Brodo 28913*.

Rusavskia sorediata (Vain.) S.Y. Kondr. & Kärnefelt (syn. *Xanthoria sorediata* (Vain.) Poelt). ON: Bells Corners, Stony Swamp (MCSA), on nonlimy sandstone boulder in old field, *Lee 1410*.

+*Sarea difformis* (Fr.) Fr. QU: Aylmer, CMN campus, resinicolous on *P. strobus*, *McMullin 21099*. See comments under *Sarea resinae* (Fr.) Kuntze.

+*Sarea resinae* (Fr.) Kuntze. ON: Bells Corners, Stony Swamp (MCSA), on hardened Balsam Fir gum, *Lee 229*; Stony Swamp, on *Abies* exudate, *Lendemer 28136* (NY). QU: Gatineau Park, Lac Philippe, north shore, on *T. occidentalis* resin, *Brodo 24930*; Keogan Lodge, on *P. strobus* resin, *McMullin 18781*. *Sarea* is a genus of unlichenized fungi that grow on the old, hardened resin of conifer trees. It has recently been classified in its own class, order, and family (Sareomycetes, Sareales, Sareaceae) as the result of molecular studies (Beimforde *et al.* 2020). These results are surprising because species of *Sarea* resemble some lichen fungi and even some lichens such as *Biatorella*, having club-shaped asci containing more than 100 globose, colourless spores, 2–3.5 µm in diameter. The apothecia of *S. resinae* are orange-brown, and those of *S. difformis*, a much rarer species, are black.

Scytinium schraderi (Bernh.) Otálora, P.M. Jørg. & Wedin (syn. *Leptogium schraderi* (Bernh.) Nyl.). ON: Burnt Lands Provincial Park alvar, on rock, *Lewis 2316b*. This small *Scytinium* species is found growing on calcareous rock in alvars. It is a misunderstood species that can be confused with another *Scytinium* species, *Scytinium turgidum* (Ach.) Otálora, P.M. Jørg.& Wedin, which can be found growing in similar habitats (Jørgensen 1994). The material examined here matches well with the description of *S. schraderi* having a thallus consisting of cylindrical, glossy brown lobes or branches that have a distinctly wrinkled upper surface when dry (Jørgensen 2007; Gilbert and Jørgensen 2009). This species looks like a robust *Scytinium teretiusculum* (Dickson) Otálora, P.M. Jørg. & Wedin, but with wrinkled, furrowed branches rather than smooth branches, more like a subfruticose form of *Scytinium lichenoides* (L.) Otálora, P.M. Jørg. & Wedin. It grows on limestone (see discussion under *S. subtile*, next entry). *Scytinium schraderi* was recently reported as new to Ontario from Frontenac Provincial Park by Lewis (2020) and again by Brinker (2020), with a colour photograph, from several localities in southern Ontario.

Scytinium subtile (Schrader) Otálora, P.M. Jørg. & Wedin (syn. *Leptogium subtile* (Schrader) Torss.). ON: Bells Corners, Stony Swamp (MCSA), on basal bark of *Fraxinus* in small swamp, *Lee 2423*. This species has already been reported from the Ottawa region by Lewis and Brinker (2017). It belongs to a group of species together with *S. schraderi*, *Scytinium tenuissimum* (next entry), and *Scytinium teretiusculum* (two entries below) all of which form tiny, subfruticose clumps and are often very difficult to distinguish. *Scytinium subtile* is the smallest, forming nothing more than tiny rosettes of squamules finely divided at the margins, surrounding a few convex, orange-brown apothecia under 0.5 mm in diameter, the entire rosettes usually under 2 mm in diameter. *Scytinium tenuissimum* is also fertile, but not forming rosettes and with larger, flat apothecia and a few distinct lobes that develop isidia-like margins. *Scytinium teretiusculum* is rarely fertile and usually consists entirely of long, cylindrical, isidia-like branches, forming tufts a few millimetres in diameter. *Scytinium schraderi*, until recently known only from western North America, differs from all these in having distinctly wrinkled and furrowed branches, more closely resembling subfruticose forms of *S. lichenoides*. In the latter species, the isidia can almost always be seen to be arising from broader, wrinkled lobes, something lacking in *S. schraderi*.

Scytinium tenuissimum (Dickson) Otálora, P.M. Jørg. & Wedin (syn. *Leptogium tenuissimum* (Dickson) Körb.). ON: Bells Corners, Stony Swamp (MCSA), on basal bark of *Fraxinus* at edge of swamp, *Lee 1343.*

Scytinium teretiusculum (Wallr.) Otálora, P.M. Jørg. & Wedin (syn. *Leptogium teretiusculum* (Wallr.) Arnold). ON: South Gloucester, on base of *Tilia*, edge of wet woods in shade, *Brodo 25501.*

Steinia geophana (Nyl.) Stein. ON: Ottawa, near Mer Bleu, on sandy soil under hydroelectric pylon, *Brodo 30300.* QU: Aylmer, on decaying vegetation and soil, *Brodo 30302A.* This very inconspicuous crustose lichen with a membranous thallus and tiny, brown, biatorine apothecia has thin-walled asci that contain (12–)16 colourless, globose, or almost globose ascospores, (3.3–)5.0–6.4 × 3.6–6.4 µm in the Ottawa material. It grows on poor, consolidated, metal-rich soil, often under hydroelectric pylons, and is associated with species of *Vezdaea* (see notes below under that genus; Brodo 2001).

+*Stenocybe major* Nyl. *ex* Körb. ON: Bells Corners, Stony Swamp (MCSA), on bark of 10-cm-diameter *A. balsamea*, *Lee 2425*.

+*Stenocybe pullatula* (Ach.) Stein. ON: Bells Corners, Stony Swamp (MCSA), on alder (*Alnus*) bark, *Lee 1894.*

Stereocaulon condensatum Hoffm. QU: Gatineau Park, Lac Ramsay, on sandy soil in abandoned picnic area, *Freebury 165*, det. Brodo.

Strangospora moriformis (Ach.) Stein. ON: Bells Corners, Stony Swamp (MCSA), on small Black Ash (*Fraxinus nigra* Marshall) trunk in young *Thuja* swamp, *Lee 1880.*

**Syzygospora physciacearum* Diederich. QU: Gatineau Park, Lac Ramsay, on sandy soil in abandoned picnic area, *Freebury 1416*, det. Diederich.

Thelidium fontigenum A. Massal. (syn. *T. microbolum* (Tuck.) Hasse). ON: Ottawa, Vincent Massey Park, on rocks along sandy beach beyond railroad bridge, *Brodo 29223*.

Thelidium minutulum Körb. ON: Burnt Lands Provincial Park, growing with *Bagliettoa calciseda* (DC.) Gueidan & Cl. Roux (see List III), *Brodo 32617.*

Thermutis velutina (Ach.) Flot. QU: Gatineau Park, Pink Lake, on shaded rock overhang, *Brodo 33219*.

Trapelia obtegens (Th. Fr.) Hertel. ON: Bells Corners, Stony Swamp (MCSA), on rock, *Lendemer 28127* (NY). QU: Gatineau Park, Chelsea, granitic rock overlooking pond, *Brodo 32417*.

Trapelia stipitata Brodo & Lendemer. ON, Blakeney, on partly shaded granite outcrop in woods, *Brodo 29875*. QU: Gatineau Park, Luskville Falls, on rock, *Brodo 21014.* (See Brodo and Lendemer 2015.)

Trapeliopsis flexuosa (Fr.) Coppins & P. James. ON: Limoges, LaRose Forest, on dead pine branch, *Brodo 31810*. QU: Gatineau Park, Trail 53 near parking lot 17, on rotting log, *Freebury 254*, ver. Brodo.

Trapeliopsis gelatinosa (Flörke) Coppins & P. James. ON: South March, in open clearing, *Shchepanek 155b.* QU: Gatineau Park, Church Hill, on soil, *Freebury 1446*, det. Lendemer.

**Tremella christiansenii* Diederich. QU: Gatineau Park, parking area 17, on *Physcia aipolia*, *Freebury 1412*, det. Diederich. New to the North American checklist (Esslinger 2019).

Tuckermannopsis orbata (Nyl.) M.J. Lai. ON: Burnt Lands Provincial Park, on Jack Pine (*Pinus banksiana* Lambert), *Lewis 2333*. QU: Gatineau Park, Lac Ste-Marie, on dead cedar, *Hanes* s.n., CANL 96152.

Verrucaria viridula (Schrader) Ach. [cf.]. QU: Gatineau Park, Lac Ramsay, on siliceous rock (normally on HCl+ rock), *Brodo 16828.*

Vezdaea acicularis Coppins. QU: Aylmer, on sandy soil and moss shaded by Common Juniper (*Juniperus communis* L.), *Brodo 29865* (Brodo 2001).

Vezdaea leprosa (P. James) Vězda. ON: Ottawa (Gloucester), Anderson Road, on sandy soil, *Brodo 30299.* QU: Aylmer, on decaying vegetation and soil, *Brodo 30302A*, with *Steinia geophana* (Brodo 2001).

Violella fucata (Stirton) T. Sprib. (syn. *Mycoblastus fucatus* (Stirton) Zahlbr.). ON: Bells Corners, Stony Swamp (MCSA), on *Thuja* branch, *Lendemer 28106* (NY); LaRose Forest, corticolous, *McMullin* s.n.

Xanthomendoza hasseana (Räsänen) Søchting, Kärnefelt & S.Y. Kondr. ON: Constance Lake area, on poplar, *Shchepanek 129.* QU: Gatineau

Park, Lac Ramsay, on *P. tremuloides*, *Brodo 29505*; Luskville Falls Trail, on *Populus*, *McMullin 18758*.

Xanthomendoza ulophyllodes (Räsänen) Søchting, Kärnefelt & S.Y. Kondr. ON: Manotick, on roadside poplar, *Brodo 5630*, det. Lindblom; Ottawa, Fisher Heights, on *Acer*, *McMullin 20096.* QU: Gatineau Park, Trail 5, near Asticou, on shaded acidic rock, *Freebury 219*, det. Brodo.

Xanthoria parietina (L.) Th. Fr. ON: Ottawa, Mooney's Bay, on bark of transplanted deciduous tree, *Freebury 2554*; Fisher Heights, on *Acer*, *McMullin 20097.* QU: Aylmer, Rue du Conservatoire, south of chemin Pink, on planted maple, *Brodo* and *Freebury* [sight record].

II. New records based on re-identifications of Ottawa specimens of species in Brodo (1988) list (i.e., not synonyms)

Bellemerea cinereorufescens (Ach.) Clauzade & Cl. Roux (= *Bellemerea* sp. in Brodo (1988)). ON: Renfrew Co., Mackie Creek, near Calabogie, on rock, partly shaded, *Brodo 27914*. QU: Gatineau Park, between Ramsay Lake and Holly Lake, on siliceous rock, *Brodo 29502*; Poltimore, on stone in shaded pasture glade, *Brodo 19179.*

Biatora pycnidiata Printzen & Tønsberg (= some specimens of *Lecidea helvola* (Körb. *ex* Hellb.) H. Olivier). QU: 7.5 km west of Poltimore, stand of Sugar Maple, on ash (*Fraxinus*) in stream area, *Brodo 24965*, det. C. Printzen. The PD+ red reaction in the thallus due to argopsin is sometimes hard to demonstrate because the thallus is thin and membranous to rimose-areolate, but it was seen in the voucher. The specimen, however, had smaller ascospores than usual: 9–11 × 2.3–2.5 µm versus (8.5–)12.5–15(–19) × 3.0–4.5(–5.5) µm in Brodo (2016).

Cladonia ignatii Ahti, Pino-Bodas & J.W. McCarthy (= specimens of *Cladonia ramulosa* (With.) J.R. Laundon). ON: Bells Corners (MCSA), *Brodo 32901*, det. J. Lendemer. QU: Gatineau Park, Lac Meech, on an island in MacDonald Bay, on top surface of log (*Thuja*) on clearing near lake shore, *Brodo 25005*. Ahti *et al.* (2018) recently described this species, segregated from the very similar *C. ramulosa* by having ecorticate, granulose to microsquamulose, cupless podetia (versus verrucose-corticate, granular, sometimes cupped), and small, very finely divided, coarsely granular-sorediate primary squamules that form an almost granulose crust (versus large, deeply lobed, largely esorediate primary squamules that remain well-defined). On re-examination, the material identified as *C. ramulosa* from the Ottawa region proved to be *C. ignatii*, confirming the suspicion of Ahti *et al.* (2018) that the species is probably widespread in the northern part of the East Temperate region (see Brodo *et al.* 2001), from Iowa to Newfoundland.

Endocarpon pallidulum (Nyl.) Nyl. (= specimens of *Endocarpon pusillum* Hedwig). ON: Rockcliffe Park, on limestone on river shore, *Brodo 22797*; North Gower, on shaded limestone, *Brodo 22731*. QU: Gatineau Park, base of King Mountain, on top of cliff, *Brodo 18811.*

Eopyrenula intermedia Coppins (= specimens of *Eopyrenula leucoplaca* (Wallr.) R.C. Harris). ON: Ottawa, "near Hintonburgh" [sic], on maple trees, *Macoun*, 18 April 1806. QU: Near Hull, on maple bark, *Macoun 3247.* This species may no longer be present in the region, although it is easily overlooked.

Lecania croatica (Zahlbr.) Kotlov (= "*Lecidea* sp. #4 *sensu* Harris"). ON: Bells Corners, Stony Swamp, on *Fraxinus*, *Lendemer 28117* (NY). QU: Aylmer, base of *Fraxinus*, *Brodo 29772*, with *P.Y. Wong*.

Lempholemma chalazanum (Ach.) B. de Lesd. (= specimens of *Lempholemma* sp.). ON: Rockcliffe Park, base of limestone cliff at river's edge, *Brodo 22801* with *Wong* and *Darbyshire*. QU: Aylmer, on soil, under hydro pylon, *Brodo 30705*. Apparently new for Ontario and Quebec.

Lepraria caesiella R.C. Harris (= some of the specimens of *Lepraria incana* (L.) Ach.). ON: Fitzroy Harbour, on *P. strobus*, partly shaded, *Brodo 33183*. QU: Gatineau Park, Church Hill, on *Tsuga*, *Lendemer 28332* (NY); Keogan Lodge, on *Pinus*, *McMullin 18785.* This species contains atranorin, zeorin, and a fatty acid and is, therefore, UV negative. *Lepraria incana* is an exclusively European lichen (Lendemer 2013). *Lepraria hodkinsoniana* Lendemer is also very similar and has been found just west of the limits of the Ottawa region in the White Lake area. It contains divaricatic acid in addition to zeorin and sometimes atranorin and is blue-white under long-wave UV light (Lendemer 2013).

Leptogium rivulare (Ach.) Mont. (= specimens of *Leptogium juniperinum* Tuck.), Flooded Jellyskin. ON: Bells Corners, Stony Swamp, on base of *Fraxinus*, *Brodo 18746*. QU: Aylmer, Boucher Forest, on Green Ash (*Fraxinus pennsylvanica* Marshall), *James Pagé ST82*, with *Shaun Thompson* (CANL). Flooded Jellyskin was thought to be extremely rare but has recently been found more frequently in its preferred habitats: vernal ponds in hardwood forests on the bases of *Fraxinus* and *Acer*, and, more rarely, on periodically flooded rocks (Environment Canada 2013). It is almost always fertile and its asci are consistently four-spored. It was first listed as Threatened under the federal *Species at Risk Act* (SARA) in 2005. In 2019, it was reassessed as Special Concern (SARA Registry 2021a) based on COSEWIC (2015).

Naetrocymbe punctiformis (Pers.) R.C. Harris (= specimens of *Arthopyrenia epidermidis* (DC.) A. Massal. ≡ *Arthopyrenia punctiformis* (Pers.) A. Massal.). ON: Ottawa, along Rideau River near Hogs Back, *Macoun 148*, det. R.C. Harris.

Phaeophyscia decolor (Kashiw.) Essl. (= specimens of *Phaeophyscia endococcina* (Körb.) Moberg). ON: Bells Corners, Stony Swamp (MCSA), on limy sandstone, *Lee 1402*. QU: Gatineau Park, King Mountain area off Mountain Road, on limestone on clifftop, *Brodo 18826.*

Phaeophyscia squarrosa Kashiwadani (includes *Phaeophyscia imbricata* (Vain.) Essl. sensu Esslinger 1978). QU: Gatineau Park, King Mountain off Mountain Road, on marble, *Brodo 21193.*

Physcia thomsoniana Essl. (= specimens of *Physcia subtilis* Degel.). ON: Carp Hills, on acidic rock, *Freebury 2294.* QU: Gatineau Park, Luskville Falls, saxicolous (non-calcareous), *McMullin 18771*; Gatineau Park, Faris Creek, on siliceous rock, *Freebury 188*, det. Brodo. This saxicolous species was recently segregated from the similar *P. subtilis* by Esslinger (2017). It is more common than *P. subtilis* and has larger lobes and a distinct, webby (hyphal) medulla. *Physcia thomsoniana* is less closely appressed to the rock substrate than *P. subtilis* and can, therefore, be easily removed from it; *P. subtilis* must be collected together with the substrate to get more than fragments. Based on the distribution maps in Esslinger (2017), it is likely that all specimens identified as *P. subtilis* from the Ottawa region should be referred to this new species, but this study has yet to be completed. Furthermore, because Esslinger (2017) states that the very similar *Physcia millegrana* Degel. is strictly corticolous, some or all of the many saxicolous records of the latter species in CANL may also represent *P. thomsoniana*. This also has to be explored.

Physconia subpallida Essl. (Figure 2; see McMullin *et al.* [2016] for additional images), Pale-bellied Frost Lichen (= specimens of *Physconia distorta* (With.) J.R. Laundon). ON: Ottawa, on trees, *Macoun*, 1891, CANL 19058, det. Werier and Cleavitt. QU: Gatineau Park, King Mountain summit area, on White Oak (*Quercus alba* L.) and Eastern Hophornbeam (*Ostrya virginiana* (Miller) K. Koch), *McMullin*, sight record.

Porpidia subsimplex (H. Magn.) Fryday (= specimens of *Porpidia cinereoatra* (Ach.) Hertel & Knopf). ON: Blakeney, on boulder in woods, *Brodo 29867.* QU: Gatineau Park, Luskville Falls, on siliceous rock, *Brodo 21017.*

Rhizocarpon infernulum (Nyl.) Lynge f. *sylvaticum* Fryday (= specimens of *Rhizocarpon hochstetteri* (Körb.) Vain.). QU: Gatineau Park, Lac la Pêche, on shaded rock in forest, *Brodo 16381.*

Rhizoplaca subdiscrepans (Nyl.) R. Sant. (= specimens of *Rhizocarpon chrysoleuca*). ON, Bells Corners, on partly exposed boulder in glade, *Brodo 13316*. QU: Gatineau Park, Luskville Falls, on siliceous rock, *Brodo 5583.*

Rinodina moziana (Nyl.) Zahlbr. (syn. *Rinodina destituta* (Nyl.) Zahlbr.) (= specimens named as *Rinodina iowensis* Zahlbr., *Rinodina cana* (Arnold) Arnold, or *Rinodina verrucosa* ined.; see Sheard [2010: 83]). ON: Blakeney, on rock near stream, *Brodo 29893*. Sheard (2018) recently discussed this species and its synonymy. It is closely related to *R. oxydata*, also known from the region.

Rhizoplaca weberi (Ryan) Leavitt, Zhao Xin & Lumbsch (syn. *Lecanora weberi* Ryan) (= specimens of *Lecanora chlorophaeodes* Nyl.). ON: Carp Hills, Thomas Dolan Parkway, on acidic rock, *Freebury 1454*. QU: Gatineau Park, Renaud Ridge, on exposed siliceous rock, *Freebury 705*, det. Brodo.

Sarcogyne wheeleri K. Knudsen, J.H. Adams, Kocourk. & Y. Wang (= specimens of *Acarospora glaucocarpa* (Wahlenb. *ex* Ach.) Körb.). ON: Constance Lake, on exposed rock in mixed woodlot, *Shchepanek 10.* QU: Gatineau Park, Meech Lake, on an island in MacDonald Bay, on limestone, *I. Brodo 25700B*, *with F. Brodo.* New molecular studies of the phylogeny of *Acarospora* and *Sarcogyne* by Knudsen *et al.* (2020) have resulted in a surprising reclassification of both *Acarospora glaucocarpa s. lat.* and the closely related *Acarospora canadensis* H. Magn., placing them both into the genus *Sarcogyne*, a genus in which most species have a black, carbonaceous exciple. Furthermore, the North American specimens usually identified as *A. glaucocarpa* represent a separate species, which was named *S. wheeleri* (Knudsen *et al.* 2020).

Thyrea confusa Henssen (= specimens of *Thyrea pulvinata* (Schaer.) A. Massal.). ON: Burnt Lands alvar, on rock, *Brodo 32618A*.

Umbilicaria americana Poelt & T. Nash (= specimens of *Umbilicaria vellea* (L.) Ach.). QU: Gatineau Park, King Mountain, on acidic rock, *Freebury 625.*

Xanthoparmelia viriduloumbrina (Gyeln.) Lendemer (= specimens of *Xanthoparmelia somloënsis* (Gyeln.) Hale). ON: Bells Corners, Stony Swamp (MCSA), on boulder in open field, *Wong & Nicholson 1866*, det. Wong. QU: Base of King Mountain, Hollow Glen Road, on mossy rock, *Freebury 1401*.

III. Species listed in Brodo (1988) that are new for either the Ontario or Quebec parts of the Ottawa region

Baeomyces rufus (Hudson) Rebent. QU: Gatineau Park, Eardley, Kidder Lake, on soil of roadbank, *Brodo 25959.* The species was included in the Ottawa list of Brodo (1988) based on sight records.

Bagliettoa calciseda (DC.) Gueidan & Cl. Roux (syn. *Verrucaria calciseda* DC.). ON: Ottawa, Vincent Massey Park, on exposed limestone at river's edge, *Brodo 29227*.

Caloplaca microphyllina (Tuck.) Hasse. QU: Gatineau Park, Eardley and Bradley Roads, on wood, *Freebury 319*, ver. Brodo.

Caloplaca sideritis (Tuck.) Zahlbr. ON: Bells Corners, Stony Swamp (MCSA), on granite boulder, *Lee 1498*

Caloplaca ulmorum (Fink) Fink. ON: Bells Corners, Stony Swamp (MCSA), on *J. cinerea* branch, *Lee 1161*.

Candelariella aurella (Hoffm.) Zahlbr. QU: Gatineau Park, Luskville, Fire Tower, on concrete, *Freebury 195*.

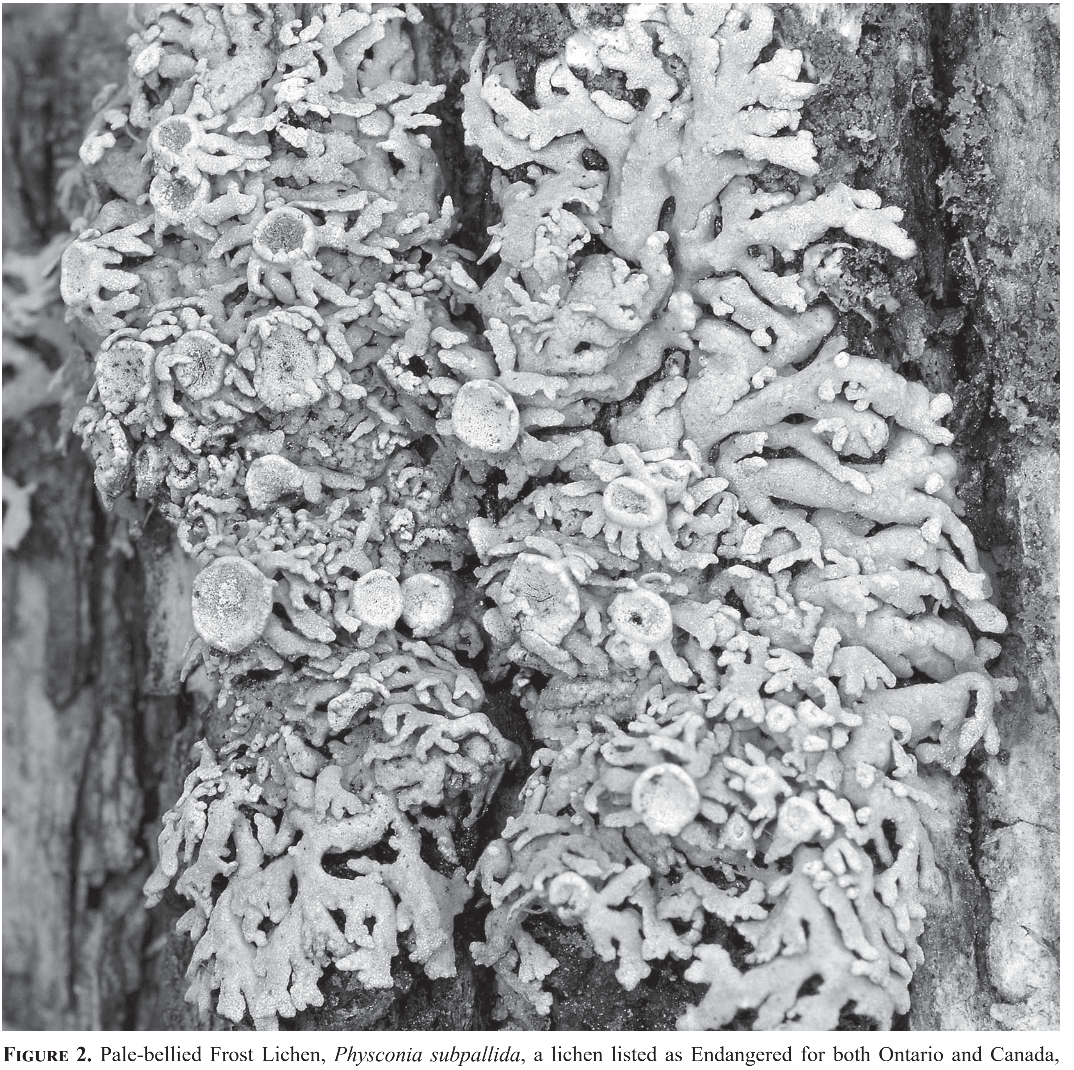

FIGURE 2. Pale-bellied Frost Lichen, *Physconia subpallida*, a lichen listed as Endangered for both Ontario and Canada, recently found in the Ottawa region, Calabogie Peaks, Renfrew County, Ontario, March 2010. Photo: Chris Lewis.

Candelariella efflorescens R.C. Harris & Buck. ON: Bells Corners, Stony Swamp, on dead *Populus*, *Lendemer 28141* (NY); Burnt Lands alvar, on deciduous shrub, *Brodo 32616*.

Chaenotheca brunneola (Ach.) Müll. Arg. ON: Gloucester, Leitrim wetlands, on ash stump in forest, *Brodo 30425*, with S. Selva and A. Dugal.

Chaenotheca stemonea (Ach.) Müll. Arg**.** ON: Bells Corners, Stony Swamp (MCSA), from rotted wood in old, sunken wound on Tamarack (*Larix laricina* (Du Roi) K. Koch) in old *Thuja* swamp, *Lee 2238.*

Chrismofulvea dialyta (Nyl.) Marbach. ON: Bells Corners, Stony Swamp (MCSA), on *J. cinerea* branch, *Lee 226.*

Cladonia botrytes (K. Hagen) Willd. QU: Kirk's Ferry near Meech Lake, on exposed log near swamp, *Brodo 9639.*

Cladonia caespiticia (Pers.) Flörke. QU: Gatineau Park, Lac Richard, base of *A. balsamea*, *Freebury 383A*, ver. Brodo.

Cladonia magyarica Vain. QU: Gatineau Park, Boulevard de la Cité-des-Jeunes, on exposed calcareous soil, *Freebury 357.*

Cladonia parasitica (Hoffm.) Hoffm. QU: Gatineau Park, Kidder Lake, on conifer log, *Freebury & Loesel* 129, ver. Brodo.

Cladonia symphycarpa (Flörke) Fr. QU: Gatineau Park, Eardley-Masham Road, on thin soil, *Freebury 160*, ver. Brodo.

Flavopunctelia flaventior (Stirton) Hale. QU: Gatineau Park, Luskville Falls parking-picnic area, on *Acer*, *Brodo 32140*.

Flavopunctelia soredica (Nyl.) Hale. QU: Gatineau, off Vanier Road north of Pink Road, on Cherry (*Prunus*), *Brodo 31782.*

Lecanora albella (Pers.) Ach. ON: Bells Corners, Jackpine Trail, *Brodo 33511.*

Melanohalea exasperatula (Nyl.) O. Blanco *et al.* ON: Bells Corners, Stony Swamp (MCSA), on *A. balsamea* twig, *Lee 1439*.

Micarea peliocarpa (Anzi) Coppins & R. Sant. ON: Bells Corners, Stony Swamp, on *Thuja* log, *Lendemer 28114* (NY).

+*Mycocalicium subtile* (Pers.) Szat. ON: Bells Corners, Stony Swamp, on wood, *Lendemer 28109* (NY).

Myriolecis sambuci (Pers.) Śliwa, Zhao Xin & Lumbsch. ON: Ottawa, Hog's Back Park, on *Populus*, *Freebury 2191.*

Peltigera lepidophora (Nyl. *ex* Vain.) Bitter. ON: Carp, Carp Hills, on thin soil over granitic outcrop, *Brodo 24928.*

Pertusaria consocians Dibben. ON: Bells Corners, Stony Swamp (MCSA), on trunk of old Ameerican Beech (*Fagus grandifolia* Ehrhart), *Lee 1682.*

Physcia stellaris (L.) Nyl. QU: Gatineau Park, Trail 5, Relais Plein Air, on *Ulmus*, *Freebury 1132*; Gatineau Park, Trail 53, on fallen willow (*Salix*), *Freebury 1121*.

Physciella chloantha (Ach.) Essl. QU: Lac Meech on an island in McDonald Bay, on limestone rock, *Brodo 25007A*, det. Brodo & Freebury.

Protoblastenia rupestris (Scop.) J. Steiner. QU: Pontiac County, Knox Landing sud, près de la pointe Ross, les alvars de la région du Lac des Chats, dallage calcaire fracturé et altéré, *Roy 99-4387C* (p.p., with *Catillaria lenticularis* (Ach.) Th. Fr.) (QFA).

Psorotichia schaereri (A. Massal.) Arnold. ON: Burnt Lands Provincial Park, on limestone, *Lewis 2316a*.

Ramalina intermedia (Delise *ex* Nyl.) Nyl. ON: Ottawa (metro), near Fitzroy Harbour, on sandstone at river edge, *Brodo 33168*.

Rinodina polyspora Th. Fr. QU: Gatineau Park, Luskville, at Luskville Falls, on *Quercus*, *Sheard 1428.*

Rinodina populicola H. Magn. ON: Ottawa (Benson Street), *Brodo 33856B*.

Rinodina subminuta H. Magn. ON: South Gloucester, on *A. saccharum*, *Wong 4368*.

Staurothele fissa (Taylor) Zwackh. ON: Blakeney, on submerged rock, *Brodo 29900.*

Strigula jamesii (Swinscow) R.C. Harris. QU: Aylmer (NHC), on *Thuja*, *Lendemer 28163* (NY).

IV. Summary of new records for North America, Canada, Ontario, and Quebec

New to the Checklist of North American lichens and lichenicolous fungi (Esslinger 2019)**:** **Tremella christiansenii.*

New to Canada: *Caloplaca parvula*, *Caloplaca reptans*, *Cladonia petrophila*, *Enchylium tenax var. ceranoides*, *Leprocaulon adhaerens*, *Merismatium peregrinum.*

New for Ontario: *Caloplaca reptans*, *Kiliasia tristis*, *Lempholemma chalazanum*. Also *Rinodina fimbriata*, Ontario record, but not from Ottawa region (see entry in List I).

New for Quebec*:* *Arthonia helvola*, +*Arthonia hypobela*, *Caloplaca parvula*, *Cladonia petrophila*, *Lempholemma chalazanum*, *Leprocaulon adhaerens*, **Merismatium peregrinum*, *Rimularia badioatra*, **Tremella christiansenii.*

V. Name Changes

Name in Brodo (1988)	Accepted name
Acarospora canadensis H. Magn.	*Sarcogyne canadensis* (H. Magn.) K. Knudsen J.H. Adams, Kocourk. & Y. Wang
Acarospora glaucocarpa (Wahlenb. *ex* Ach.) Körb.	[specimens = *Sarcogyne wheeleri* K. Knudsen, J.H. Adams, Kocourk. & Y. Wang]
Anisomeridium nyssaegenum(Ellis & Everh.) R.C. Harris	*Anisomeridium polypori* (Ellis & Everh.) M.E. Barr
Arthonia caesia (Flot.) Körb.	*Chrysothrix caesia* (Flot.) Ertz & Tehler
Arthopyrenia epidermidis (DC.) A. Massal.	*Naetrocymbe punctiformis* (Pers.) R.C. Harris
Arthothelium ruanum (A. Massal.) Zwackh	*Arthonia ruana* A. Massal.
Aspicilia cinerea (L.) Körb.) var. *laevata* (Ach.) Körb.	*Aspicilia laevata* (Ach.) Arnold
Bacidia beckhausii Körb.	*Biatora beckhausii* (Körb.) Tuck.
Bacidia inundata (Fr.) Körb.	*Bacidina inundata* (Fr.) Vězda
Bacidia obscurata (Sommerf.) Zahlbr.	*Mycobilimbia tetramera* (De Not.) Vitik., Ahti, Kuusinen, Lommi & T. Ulvinen
Bacidia sabuletorum (Schreb.) Lettau	*Bilimbia sabuletorum* (Schreb.) Arnold
Bacidia sphaerioides (Dickson) Zahlbr.	*Mycobilimbia carneoalbida* (Müll. Arg.) S. Ekman & Printzen
Bellemerea sp.	*Bellemerea cinereorufescens* (Ach.) Clauzade & Roux
Buellia dialyta (Nyl.) Tuck.	*Chrismofulvea dialyta* (Nyl.) Marbach
Buellia turgescens Tuck.	*Buellia badia* (Fr.) A. Massal.
Buellia polyspora (Willey in Tuck.) Vainio	*Amandinea polyspora* (Willey) E. Lay & P. May
Buellia punctata (Hoffm.) Massal.	*Amandinea punctata* (Hoffm.) Coppins & Scheid.
Catinaria laureri (Hepp *ex* Th. Fr.) Degel.	*Megalaria laureri* (Hepp *ex* Th. Fr.) Hafellner
Cetraria ciliaris Ach. var. *ciliaris*	*Tuckermannopsis ciliaris* (Ach.) Gyeln.
Cetraria ciliaris var. *halei* (W.L. Culb & C.F. Culb.) Ahti	*Tuckermannopsis americana* (Spreng.) Hale
Cetraria oakesiana Tuck.	*Usnocetraria oakesiana* (Tuck.) M.J. Lai & C.J. Wei
Cetraria pinastri (Scop.) S. Gray	*Vulpicida pinastri* (Scop.) J.-E. Mattsson & M.J. Lai
Cetraria sepincola (Ehrh.) Ach.	*Tuckermannopsis sepincola* (Ehrh.) Hale
Cladina mitis (Sandst.) Hustich	*Cladonia mitis* Sandst.
Cladina rangiferina (L.) Nyl.	*Cladonia rangiferina* (L.) F.H. Wigg.
Cladina stellaris (Opiz) Brodo	*Cladonia stellaris* (Opiz) Pouzar & Vězda
Cladonia bacillaris Nyl.	*Cladonia macilenta* Hoffm. var. *bacillaris* (Genth) Schaer.
Cladonia cervicornis (Ach.) Flot. subsp. *verticillata* (Hoffm.) Ahti	*Cladonia verticillata* (Hoffm.) Schaer.
Cladonia dahliana Kristinsson	*Cladonia symphycarpa* (Flörke) Fr., psoromic acid chemotype
Cladonia ramulosa (With.) J.R. Laundon	[specimens = *Cladonia ignatii* Ahti, Pino-Bodas & J.W. McCarthy]
Collema bachmanianum (Fink) Degel.	*Enchylium bachmanianum* (Fink) Otálora, P.M. Jørg. & Wedin
Collema coccophorum Tuck.	*Enchylium coccophorum* (Tuck.) Otálora, P.M. Jørg. & Wedin
Collema fuscovirens (With.) J.R. Laundon	*Lathagrium fuscovirens* (With.) Otálora, P.M. Jørg. & Wedin
Collema limosum (Ach.) Ach.	*Enchylium limosum* (Ach.) Otálora, P.M. Jørg. & Wedin
Collema polycarpon Hoffm.	*Enchylium polycarpon* (Hoffm.) Otálora, P.M. Jørg. & Wedin

Name in Brodo (1988)	Accepted name
Collema tenax (Sw.) Ach. *em.* Degel.	*Enchylium tenax* (Sw.) Otálora, P.M. Jørg. & Wedin
Conotrema urceolatum (Ach.) Tuck.	*Stictis urceolatum* (Ach.) Gilenstam
Cyphelium tigillare (Ach.) Ach.	*Calicium tigillare* (Ach.) Pers.
Dimerella lutea (Dickson) Trev.	*Coenogonium luteum* (Dickson) Kalb & Lücking
Dimerella pineti (Schrad. *ex* Ach.) Vězda	*Coenogonium pineti* (Schrad. *ex* Ach.) Lücking & Lumbsch
Endocarpon pusillum Hedwig	[specimens = *Endocarpon pallidulum* (Nyl.) Nyl.]
Eopyrenula leucoplaca (Wallr.) R.C. Harris	[specimens = *Eopyrenula intermedia* Coppins]
Haematomma elatinum (Ach.) A. Massal.	*Loxospora elatina* (Ach.) A. Massal.
Haematomma ochrophaeum (Tuck.) A. Massal.	*Loxospora ochrophaea* (Tuck.) R.C. Harris
Haematomma pustulatum Brodo & W.L. Culb.	*Lepra pustulata* (Brodo & W.L. Culb.) Lendemer & R.C. Harris
Hymenelia lacustris (With.) Poelt & Vězda	*Ionaspis lacustris* (With.) Lutzoni
Hypocenomyce anthracophila (Nyl.) P. James & Gotth. Schneid.	*Carbonicola anthracophila* (Nyl.) Bendiksby & Timdal
Hypocenomyce friesii (Ach.) P. James & Gotth. Schneid.	*Xylopsora friesii* (Ach.) Bendiksby & Timdal
Lecania cyrtellina (Nyl.) Sandst.	*Lecania cyrtella* (Ach.) Th. Fr.
Lecanora chlorophaeodes Nyl.	[specimens = *Rhizoplaca weberi* (Ryan) Leavitt, Zhao Xin & Lumbsch]
Lecanora crenulata Hook.	*Myriolecis crenulata* (Hook.) Śliwa, Zhao Xin & Lumbsch
Lecanora dispersa (Pers.) Sommerf.	*Myriolecis dispersa* (Pers.) Śliwa, Zhao Xin & Lumbsch
Lecanora fuliginosa Brodo	*Lecanora argentea* Oxner & Volkova
Lecanora hagenii (Ach.) Ach.	*Myriolecis hagenii* (Ach.) Śliwa, Zhao Xin & Lumbsch
Lecanora muralis (Schreb.) Rabenh.	*Protoparmeliopsis muralis* (Schreb.) M. Choisy
Lecanora opiniconensis Brodo	*Rhizoplaca opiniconensis* (Brodo) Leavitt, Zhao Xin & Lumbsch
Lecanora pallida (Schreb.) Rabenh. var. *rubescens* Imsh. & Brodo	*Lecanora albella* (Pers.) Ach. (including var. *rubescens*)
Lecanora piniperda Körb.	*Lecanora albellula* Nyl.
Lecanora sambuci (Pers.) Nyl.	*Myriolecis sambuci* (Pers.) Śliwa, Zhao Xin & Lumbsch
Lecanora symmictera Nyl.	*Lecanora symmicta* (Ach.) Ach.
Lecanora umbrina (Ach.) A. Massal. f. *gregata* Harm.	[specimens = *Myriolecis hagenii* (Ach.) Śliwa, Zhao Xin & Lumbsch or other *Myriolecis* spp.]
Lecanora sp. #3	*Myriolecis* sp.??
Lecidea berengeriana (A. Massal.) Nyl.	*Mycobilimbia berengeriana* (A. Massal.) Hafellner & V. Wirth
Lecidea botryosa (Fr.) Th. Fr.	*Hertelidea botryosa* (Fr.) Printzen & Kantvilas
Lecidea delincta Nyl.	*Bryobilimbia ahlesii* (Körb.) Fryday, Printzen & S. Ekman
Lecidea elabens Fr.	*Ramboldia elabens* (Fr.) Kantvilas & Elix
Lecidea erratica Körb.	*Leimonis erratica* (Körb.) R.C. Harris & Lendemer
Lecidea helvola (Körb. *ex* Hellb.) H. Olivier	[specimens = *Biatora vernalis* (L.) Fr. or *Biatora pycnidiata* Printzen & Tønsberg.]
Lecidea sp. #4 sensu Harris (1977)	*Lecania croatica* (Zahlbr.) Kotlov
Lecidea vernalis (L.) Ach.	*Biatora vernalis* (L.) Fr.
Lempholemma myriococcum (Ach.) Th. Fr.	*Lempholemma polyanthes* (Bernh.) Malme
Lempholemma sp.	[specimens = *Lempholemma chalazanum* (Ach.) B. de Lesd.]

Name in Brodo (1988)	Accepted name
Lepraria incana (L.) Ach.	[specimens = misidentifications of other species of *Lepraria*, especially *L. caesiella* R.C. Harris]
Lepraria membranacea auct.	[specimens = *Lepraria oxybapha* Lendemer or *L. normandinioides* Lendemer & R.C. Harris]
Lepraria zonata Brodo	*Lepraria neglecta* (Nyl.) Erichsen
Leptogium azureum (Sw.) Mont.	[specimen appears to be a non-isidiate *L. cyanescens*]
Leptogium burnetiae Dodge var. *hirsutum* (Sierk) P.M. Jørg.	*Leptogium hirsutum* Sierk
Leptogium dactylinum Tuck.	*Scytinium dactylinum* (Tuck.) Otálora, P.M. Jørg. & Wedin
Leptogium juniperinum Tuck.	[specimens = *Leptogium rivulare* (Ach.) Mont.]
Leptogium lichenoides (L.) Zahlbr.	*Scytinium lichenoides* (L.) Otálora, P.M. Jørg. & Wedin
Lobaria quercizans Michx.	*Ricasolia quercizans* (Michx.) Stizenb.
Megalospora porphyritis (Tuck.) R.C. Harris	[specimens = *Megalaria tuberculosa* (Fée) Sipman??]
Melanelia disjuncta (Erichsen) Essl.	*Montanelia disjuncta* (Erichsen) Divakar, A. Crespo, Wedin & Essl.
Melanelia exasperatula (Nyl.) Essl.	*Melanohalea exasperatula* (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch
Melanelia olivacea (L.) Essl.	*Melanohalea olivacea* (L.) O. Blanco, A. Crespo, Divakar, Essl., D.Hawksw. & Lumbsch
Melanelia septentrionalis (Lynge) Essl.	*Melanohalea septentrionalis* (Lynge) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch
Melanelia sorediata (Ach.) Goward & Ahti	*Montanelia sorediata* (Ach.) Divakar, A. Crespo, Wedin & Essl.
Melanelia subaurifera (Nyl.) Essl.	*Melanelixia subaurifera* (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch
Micarea bauschiana (Körb.) Wirth & Vězda	*Brianaria bauschiana* (Körb.) S. Ekman & M. Svensson
Ochrolechia rosella (Tuck.) Vers.	*Ochrolechia trochophora* (Vain.) Oshio var. *trochophora*
Opegrapha varia Pers.	*Alyxoria varia* (Pers.) Ertz & Tehler
Pannaria ahlneri P.M. Jørg.	*Fuscopannaria ahlneri* (P.M. Jørg.) P.M. Jørg.
Pannaria leucophaea (Vahl) P.M. Jørg.	*Vahliella leucophaea* (Vahl) P.M. Jørg.
Parmelina aurulenta (Tuck.) Hale	*Myelochroa aurulenta* (Tuck.) Elix & Hale
Parmelina galbina (Ach.) Hale	*Myelochroa galbina* (Ach.) Elix & Hale
Parmelina obsessa (Ach.) Hale	*Myelochroa obsessa* (Ach.) Elix & Hale
Peltigera polydactyla (Neck.) Hoffm. *s. lat.*	*Peltigera polydactylon* (Neck.) Hoffm.
Pertusaria amara (Ach.) Nyl.	*Lepra amara* (Ach.) Hafellner
Pertusaria leucostoma (Bernh.) A. Massal.	*Pertusaria leioplaca* DC.
Pertusaria multipunctoides Dibben	*Lepra multipunctoides* (Dibben) Lendemer & R.C. Harris
Pertusaria ophthalmiza (Nyl.) Nyl.	*Lepra ophthalmiza* (Nyl.) Hafellner
Pertusaria trachythallina Erichsen	*Lepra trachythallina* (Erichsen) Lendemer & R.C. Harris
Pertusaria velata (Turner) Nyl.	*Varicellaria velata* (Turner) Schmitt & Lumbsch
Pertusaria waghornei Hulting	*Lepra waghornei* (Hulting) Lendemer & R.C. Harris
Phaeophyscia cernohorskyi (Nádv.) Essl.	*Phaeophyscia hirsuta* (Mereschk.) Essl.
Phaeophyscia endococcina (Körb.) Moberg	[specimens = *P. decolor* (Kashiw.) Essl.]
Phaeophyscia imbricata (Vain.) Essl.	[specimens = *Phaeophyscia squarrosa* Kashiw.]

Name in Brodo (1988)	Accepted name
Physcia subtilis Degel.	[specimens = *P. thomsoniana* Essl.]
Physconia distorta (With.) J.R. Laundon	[specimens = *Physconia subpallida* Essl.]
Plagiocarpa hyalospora (Nyl.) R.C. Harris	*Lithothelium hyalosporum* (Nyl.) Aptroot
Plagiocarpa macrospora R.C. Harris	*Lithothelium macrosporum* (R.C. Harris) Aptroot
Plagiocarpa phaeospora R.C. Harris	*Lithothelium phaeosporum* (R.C. Harris) Aptroot
Plagiocarpa septemseptata R.C. Harris	*Lithothelium septemseptata* (R.C. Harris) Aptroot
Polysporina simplex (Dav.) Vězda	*Acarospora privigna* (Ach.) A. Schneid.
Porpidia cinereoatra (Ach.) Hertel & Knoph	[specimens = *Porpidia subsimplex* (H. Magn.) Fryday]
Rhizocarpon hochstetteri (Körb.) Vainio	[specimens = *Rhizocarpon infernulum* (Nyl.) Lynge f. *sylvaticum* Fryday]
Rhizocarpon obscuratum (Ach.) A. Massal.	[specimens = *Rhizocarpon reductum* Th. Fr.]
Rhizocarpon plicatile (Leight.) A.L. Sm.	*Rhizocarpon rubescens* Th. Fr.
Rhizoplaca chrysoleuca (Sm.) Zopf	[specimens = *Rhizoplaca subdiscrepans* (Nyl.) R. Sant.]
Rinodina dakotensis H. Magn.	*Amandinea dakotensis* (H. Magn.) P. May & Sheard
Rinodina farinosa Sheard, ined.	*Rinodina efflorescens* Malme
Rinodina glauca Ropin	*Rinodina freyi* H. Magn.
Rinodina iowensis Zahlbr.	[specimens = *Rinodina moziana* (Nyl.) Zahlbr.]
Rinodina magnussonii Sheard, ined	*Rinodina freyi* H. Magn.
Rinodina thujae (H. Magn.) Sheard	*Rinodina excrescens* Vain.
Sarcogyne privigna (Ach.) A. Massal.	*Sarcogyne hypophaea* (Nyl.) Arnold
Staurothele catalepta auct.	*Staurothele monicae* (Zahlbr.) Wetmore
Staurothele diffractella (Nyl.) Tuck.	*Willeya diffractella* (Nyl.) Müll. Arg.
Thyrea nigritella Lettau	*Lichinella nigritella* (Lettau) P.P. Moreno & Egea
Thyrea pulvinata (Schaer.) A. Massal.	[specimens = *Thyrea confusa* Henssen]
Trapelia involuta (Taylor) Hertel	*Trapelia glebulosa* (Sm.) J.R. Laundon
Trypethelium virens Tuck. *ex* E. Michen.	*Viridothelium virens* (Tuck. *ex* E. Michen.) Lücking, M.P. Nelson & Aptroot
Umbilicaria vellea (L.) Ach.	[specimens = *Umbilicaria americana* Poelt & T.H. Nash]
Usnea filipendula Stirton	*Usnea dasopoga* (Ach.) Nyl.
Verrucaria calciseda DC.	*Bagliettoa calciseda* (DC.) Gueidan & Cl. Roux
Verrucaria fuscella (Turner) Winch	*Placopyrenium fuscellum* (Turner) Gueidan & Cl. Roux
Xanthoparmelia somloënsis (Gyeln.) Hale	[specimens = *Xanthoparmelia viriduloumbrina* (Gyeln.) Lendemer]
Xanthoria elegans (Link) Th. Fr.	*Rusavskia elegans* (Link) S.Y. Kondr. & Kärnefelt
Xanthoria fallax (Hepp *ex* Arnold) Arnold	*Xanthomendoza fallax* (Hepp *ex* Arnold) Søchting, Kärnefelt & S.Y. Kondr.

Discussion

Changes in landscape, habitat, and lichen diversity

Many lichens originally present in the Ottawa region have not been collected since 1930 and appear to have been lost along with the original forests they inhabited. Wong and Brodo (1992) reported 41 such losses from southern Ontario, including *Anzia colpodes* (Ach.) Stizenb., *Leptogium corticola* (Taylor) Tuck., and *Pyrrhospora varians* (Ach.) R.C. Harris from the Ottawa region. Several of the species that we now report as additions actually date from that early period rather than the present, but they were only recently recognized among Macoun's pre-1900 collections, with no modern specimens recorded in the region (e.g., *Anaptychia crinalis*, *Parmotrema subtinctorium*, and *Pyrenula micheneri*). On the other hand, some species on the Wong and Brodo (1992) list of lichens not found since 1930 have recently been rediscovered, e.g., *Scytinium tenuissimum*, *Phaeocalicium polyporeum*, and, just outside the boundaries of the Ottawa region near White Lake, *Megaspora verrucosa* (Ach.) L. Arcadia & A. Nordin and *Leptogium corticola*.

Following deforestation during the 1800s (through the initial waterway-based lumber trade, clearing for agriculture, and forest fires), some lands were abandoned for cultivation owing to wet, thin, or excessively sandy or stony soil. Ring counts on fresh stumps and tree cores (R.E.L. unpubl. data) reveal that these marginal lands have been reverting to mixed forest vegetation for the past 70–150 years, and, in a few places, 200 years. Maples, oaks, and pines are frequent; ash or cedar swamps are not uncommon. Those recovering woodlots and swamps in private hands have been subject to selective woodcutting that has tended to remove the biggest and oldest, as well as the most "defective" trees—the very trees most likely to host a diversity of lichens. Even the oldest of these regenerating forests and swamps, however, are second-growth and fall short of re-establishing the old-growth conditions required by most calicioid lichens and fungi (Selva 2003). The Ottawa Greenbelt and Gatineau Park were withdrawn from timber and firewood extraction when they became public conservation lands over 60 years ago.

The area covered by woodlands seems to have remained stable over the past three decades, with destruction by urban development apparently balanced by regrowth, but forest diversity is being diminished by invasive fungal pathogens and insects. Twenty percent (eight of ~40) of the native tree species are declining significantly and may be lost (R.E.L. pers. obs.). The three local species of elm are in slow decline because of Dutch elm disease, which first peaked around 1970, but is now killing younger, succeeding generations (Swingle and Whitten 1967; R.E.L. unpubl. data). Butternut is severely afflicted with the novel Butternut canker disease, which appeared here around 1990 and had killed half the trees by 2010 (Lee 2010). All three local species of ash are rapidly being eliminated in the region by Emerald Ash Borer (*Agrilus planipennis*), which had a solid foothold in Ottawa by 2009 (Lee 2020). American Beech, which is in the first, insect-mediated stage of beech bark scale disease, was noted locally in 2016 (R.E.L. unpubl. data).

Particularly hard-hit are Black Ash swamps, which in some areas no longer support living Black Ash trees. Lichen species that are more or less locally restricted to Black Ash include *Arthonia fuliginosa*, *Scytinium tenuissimum*, *S. subtile*, and *Strangospora moriformis*. Most local populations of Flooded Jellyskin (*Leptogium rivulare*) are on ash, too. These species are now presumably in decline in the Ottawa area. The same may occur for *Viridothelium virens* as American Beech begins to die.

Cultivated tree species have become widespread across the settled parts of the Ottawa region, and some of them, especially rosaceous trees such as apple, amalachier, and cherry, host a rich variety of lichens. Nursery stock from outside the region has resulted in the apparent introduction of *Xanthoria parietina* into managed parks and around homes (C.F., C.J.L., and I.M.B. unpubl. data). This species normally occurs along the Atlantic coast of North America and the Niagara escarpment in southern Ontario, 400 km from Ottawa (Brodo *et al.* 2007).

Thus, for lichens that grow on trees or rocks generally, and specialists that occur only on certain species of trees, or prefer rocks of either acidic or calcareous nature, a wide range of substrates is available within the region. Exceptionally, too, small patches of forest or swamp not immediately recognizable as old growth have been found to have very old trees supporting lichens associated with extended forest continuity (Lesica *et al.* 1991; Selva 1994; McMullin *et al.* 2008). Given the apparently limited ability of such lichens to become established in emerging habitat, it appears that these particular lichen populations have persisted throughout the post-settlement period.

Lichens and climate change

Warming trends have been noted in the Ottawa region, as they have in other parts of Canada. The mean annual temperature in Ontario is already 1.5°C warmer than it was in 1950 (OCCIAR 2015). The possibility of change in lichen communities in response to a warming climate has been of interest since van Herk *et al.* (2002) related rising temperature to increases in "warmth-loving" species and declines in "boreo-alpine" species in the Netherlands. Although the rise in average temperature reported there (0.8°C) was comparable to the 1°C rise recorded in Ottawa (Catling 2016), an increase that was regarded to be sufficient to explain the northern range extension of two dragonflies (Catling 2016), we have not observed such changes in the lichen biota.

Van Herk *et al.* (2002) were exploring the possibility of temperature having a 'direct' effect on the limiting factors of lichen distributions. In the Ottawa region, however, we are witnessing 'indirect' effects. As noted above, for example, particular tree species that certain substrate-specific lichens grow on are either dying back or dying out in the Ottawa region because of infestations of alien insects. Changes in climate may well be affecting the range of these insects rather than the lichens themselves. It may work as follows.

In contrast with the imperceptible rise of the annual mean temperature, the rate at which episodes of extreme cold have eased is dramatic. Extreme lows in recent decades have been 6–7°C warmer than they were 70 years ago. From the 1920s through the 1950s, the Ottawa region (as measured at the Central Experimental Farm, CDA station) experienced from one to three years in each decade with low temperatures falling to −37°C or below, but not since 1959. Extreme lows from 1990 to the present have been around −31°C (Osborn 2020, summarizing the dataset in Government of Canada 2020b). This trend has been noted globally as well (Folland *et al.* 2001).

Viridothelium virens, as noted above, occurs in the Ottawa region only on American Beech, and from what we see, we predict a significant die-off over the next 10 years or so as the newly arrived Beech-bark Scale (*Cryptococcus fagi* Baer.) initiates the trees' ultimate destruction by a pathogenic fungus. Winter temperatures of −37°C kill most of the scale insects and have, in the past, been credited with controlling their northward spread (Shigo and Stone 1967).

Also as noted above, a small number of other lichen species are represented in the Ottawa region only by specimens collected from ash trees, and we have observed that the local populations of ash species are dying following invasion by Emerald Ash Borer, a widespread phenomenon in eastern North America (COSEWIC 2018). The failure to maintain extreme lows has probably also been a factor enabling the spread of this beetle into the Ottawa region, as this insect experiences high overwintering mortality at −35°C (Christianson and Venette 2018; COSEWIC 2018).

Unusual warmth might have another indirect effect on lichens. Pale-bellied Frost Lichen (*Physconia subpallida*; Figure 2) is listed as Endangered or "Imperiled" both provincially (OMNR 2018) and federally (SARA Registry 2021b). Common enough and more varied in its range of substrates in John Macoun's time, within the Ottawa region it is now known only from a small area near the summit of King Mountain in Gatineau Park (McMullin *et al.* 2016). There, it is found only on White Oak and Eastern Hop-hornbeam. When, in the summer of 2012, the mean temperature was nearly 2°C above 1970 levels and followed an extended period of below-normal precipitation, Annecou (2014) observed that hectares of hardwood forest at several points along the crest of Gatineau Park's southwest-facing escarpment in Quebec turned colour in July and dropped their leaves. Some trees died that year, and more the next. At the King Mountain site, she found that 23 of 37 (62%) White Oaks in semi-open woodland had died by 2013 (Annecou 2014). Although the *P. subpallida* populations discovered in 2016 were on trees that had survived the drought of 2012, it is not known how many might have been lost. More severe droughts are likely. Annecou (pers. comm. 2019) suggests that there may eventually be a shift there from forest to savannah-like conditions that are unsuitable for *P. subpallida*.

As so many of our lichens grow on trees, changing environmental factors related to climate that affect the forest flora may, in turn, become significant in determining the future composition of the lichen biota.

"Hot-spots" of diversity

With the benefit of more than 50 years of concentrated study of the Ottawa region's lichen biota, it is now possible to highlight some areas that have unusually high lichen diversity, the "hot-spots" (Figure 1). As mentioned above, Gatineau Park and Ottawa's Greenbelt forest are rich in lichens, but even within these areas, some specific habitat types are more diverse than others.

Old-growth maple forests—Old-growth forests, characterized by deep soil, ample moisture, and old trees with soft bark, are mainly found on the Quebec side of the river, especially in Gatineau Park (e.g., the MacDonald Bay area of Lac Meech and some forests adjoining Lac la Pêche). Indicator species include calicioid lichens and fungi, *Alyxoria varia*, *Bacidia rubella* (Hoffm.) A. Massal., *Cresponea chloroconia*, *Inoderma byssaceum*, and *Lobaria pulmonaria* (L.) Hoffm.

Gatineau escarpment—Elevated temperatures on the south-facing rocky cliffs of Gatineau Park are suitable for a special forest type including White Oaks, as well as exposed outcroppings of granite and, in a few spots, calcareous marble. These combine to produce conditions suitable for many rarities including *Phaeocalicium minutissimum*, *Physconia subpallida*, *Porpidia soredizodes*, and *Rhizocarpon lecanorinum* Anders. Of particular note are two escarpment localities associated with streams and waterfalls: Church Hill near Eardley, and Luskville Falls above Luskville. The latter has a number of rarities in and around the stream and falls, e.g., *Chaenotheca xyloxena*, *C. perforata*, *Flavoparmelia flaventior*, *Phaeocalicium populneum*, *Placynthium flabellosum*, *Porpidia subsimplex*, *Ramalina intermedia*, *Rhizocarpon lavatum* (Fr.) Hazsl., and *Scytinium tenuissimum.* At Church Hill, rarities were found, such as *Trapeliopsis gelatinosa*, *Dictyocatenulata alba*, and *Merismatium peregrinum* growing on thalli of *Rimularia badioatra* (both rare).

Alvars—In the Burnt Lands area near Almonte and Packenham on the Ontario side of the Ottawa River, and along the Ottawa River near Pontiac on the Quebec side, there are areas of exposed limestone pavement with scattered trees and shrubs (including Eastern Red Cedar [*Juniperus virginiana* L.] and Canada Yew [*Taxus canadensis* Marshall]) with many rare vascular plants, animals, and lichens (Catling 2013; Catling *et al.* 2014). Examples of the latter include

Heppia adglutinata, *Placidium squamulosum*, *Psora decipiens*, and *Thyrea confusa*.

Old White Cedar swamps—White Cedar is a common tree in the Ottawa region, with older trees supporting an unusual lichen biota including *Biatora* spp., *Menegazzia terebrata* (Hoffm.) A. Massal., and *Parmotrema crinitum*. Some relatively old cedar stands are in the Greenbelt, and others are just outside the 50-km radius in the White Lake area.

Blakeney Rapids Provincial Park—This surprising hot-spot of diversity and rare taxa supports a stand of mature maple, White Pine, White Cedar, elm, and hemlock along the Mississippi River where the river makes a sharp turn, first to the northeast, then to the northwest, creating a series of rapids that flow over and between small islands just off the shore of the peninsula. On shore, an outcrop of granite has formed a grotto of shaded, mossy, vertical rock walls. A "bioblitz" at this locality in 2000 uncovered a dazzling array of rare lichens on the rock walls and trees including *Porpidia soredizodes*, *Rinodina destituta*, *R. siouxiana*, and *Trapelia stipitata*. In the list of 42 species collected on the bioblitz, nearly 40% (17) are uncommon or rare in the Ottawa Region. A number of other, more common species reliably identified in the field were recorded as sight records. It is likely that the moist air associated with the rapids, especially in spring, promotes a rich variety of saxicolous and corticolous lichens.

Conclusions

Over the past 32 years, the known lichen biota of the Ottawa region has increased by over 40% mainly because of new lichenological studies and intensive fieldwork. The actual increase in number of species in the region, however, has probably been small and is more than offset by the loss of species due to habitat reduction resulting from urbanization and climate change. On the other hand, the improvement in air quality throughout the region has resulted in an increase in lichen cover in most areas. In the decades ahead, we will undoubtedly see additional changes and discoveries.

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Loon abundance and behaviour over four decades at a remote ecological reserve on Haida Gwaii, British Columbia, Canada

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Abstract
Early studies (1976–1982) of the Drizzle Lake Ecological Reserve on Haida Gwaii, British Columbia focussed on the endemic Giant Threespine Stickleback (*Gasterosteus aculeatus*) and their predators. These surveys showed daily visits to the small lake (110 ha) by up to 59 adult non-breeding Common Loon (*Gavia immer*), an important stickleback predator and up to 19 breeding and non-breeding adult Red-throated Loon (*Gavia stellata*), which leave daily to forage in nearby marine waters. We continued loon surveys for 17 additional years (1983–1989, 2011–2020) and found that aggregations of non-breeding Common Loons occurred annually on the lake during July with maximum daily numbers of 78–83 individuals in 1987, 2018, and 2020 and a large increase from 2011 to 2020. We did not detect any relationship of these differences with the Pacific Decadal Oscillation but a significant inverse correlation with average wind speed. Average yearly numbers of Red-throated Loons declined by 50% from 1976 to 1989 and have remained low, with lowest numbers (<2) occurring in 2017. Two Red-throated Loon nesting territories on the lake were occupied from 1976 to 1995, with chicks occurring in 24 of 36 nests, but no successful nesting was observed on the lake over the last decade. The relative decline of Red-throated Loon in this reserve is similar to that reported in Arctic and Subarctic surveys of the species in the north Pacific and northern Europe. We discuss the implications for the evolutionary ecology of the sticklebacks and the conservation of the ecological reserve.

Key words: Common Loon; *Gavia immer*; *Gasterosteus*; Drizzle Lake; dystrophic; ecological reserve; Haida Gwaii; predation; Red-throated Loon; *Gavia stellata*

Introduction
Ecological reserves are part of an international program of protected spaces that offer opportunities for studies of intact ecosystems (Krajina *et al.* 1978). Systematic baseline surveys on reserves become more valuable over time given the rapid anthropogenic changes in ecosystems (Arcese and Sinclair 1997). British Columbia, Canada, has 148 reserves that represent the major biogeographic regions in the province (http://bcparks.ca/eco_reserve/). Initial species inventories of many of these reserves provide a baseline assessment of the general occurrence and distribution of species within the reserve but replicated surveys over time are limited.

The Drizzle Lake Ecological Reserve on Haida Gwaii was established in 1973 as a representative bog lake ecosystem that included an endemic population of Giant Threespine Stickleback (*Gasterosteus aculeatus*), assessed and listed as Special Concern (COSEWIC 2013; SARA Registry 2020). The reserve is surrounded by Provincial Crown Land and has no road or boat access so remains relatively intact (Figure 1). Examination of aquatic birds on Drizzle Lake from 1976 to 1982 showed extensive use by Common Loon (*Gavia immer*) and Red-throated Loon (*Gavia stellata*; Reimchen and Douglas 1980, 1984a). These studies found that numbers of non-breeding adult Common Loons on the lake increased sharply in early July, reaching a peak (59 individuals) in the third week of July and thereafter gradually declining. These birds arrived on the lake singly or in small groups near dawn, with numbers increasing until mid-morning. Most individuals departed the lake in large groups by mid-day, moving to marine waters or adjacent lakes, with this daily pattern repeating itself for much of July. Common Loon are important predators on the endemic giant stickleback, with yearly fluctuations in Common Loon numbers producing a detectable evolutionary response on stickleback defense morphology (Reimchen 1994, 1995).

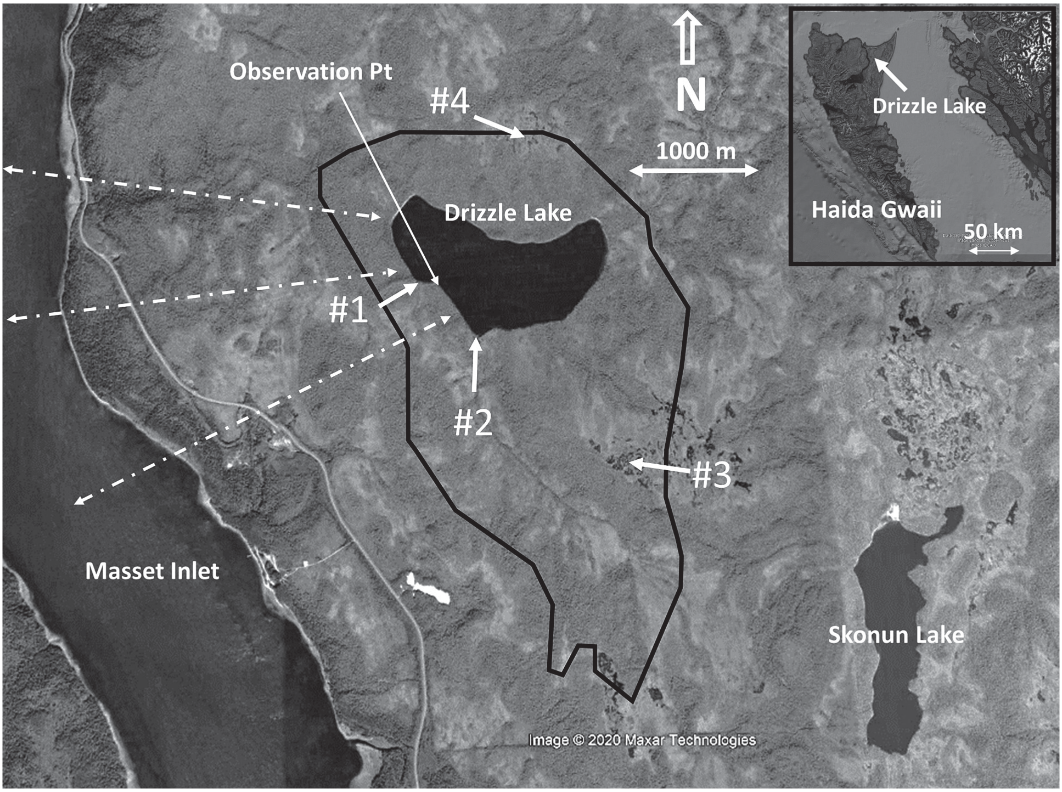

FIGURE 1. Drizzle Lake Ecological Reserve, Haida Gwaii, British Columbia. #1 to #4 show Red-throated Loon (*Gavia stellata*) nesting sites. Dashed lines indicate region of dominant flight paths of Common Loon (*Gavia immer*) and Red-throated Loon between the lake and marine waters of Masset Inlet. Ecological reserve boundary shown by dark solid line. Inset shows Haida Gwaii and location of Drizzle Lake. Imagery date: 13 December 2015. Accessed 18 March 2021.

Red-throated Loon, which on Haida Gwaii is at the southern reaches of their circumboreal breeding distribution (Rizzolo *et al*. 2020), increased over April to about 10–15 individuals. They usually arrived at the lake in pairs at dusk, stayed for the night and returned to adjacent marine waters at dawn. This diel pattern repeated itself from April to August. While most Red-throated Loons were non-breeding adults, up to four pairs occupied nesting territories on the lake and adjacent ponds. Adults foraged intermittently on the lake but young were not fed lake-resident fish. Rather, the attending adults made multiple daily flights from the lake and returned marine fish for the young throughout the 50 day pre-fledging period (Reimchen and Douglas 1984b, 1985).

Loons feature prominently in environmental assessment due to their sensitivity to anthropogenic impacts on nesting lakes and to adverse influences in overwintering marine habitats (Evers *et al*. 2019; Bianchini *et al.* 2020; Piper *et al.* 2020). Despite these effects, Common Loon appear to show relative stability in long-term continental population trends (Evers *et al.* 2020) even though productivity is declining in some regions (e.g., Tozer *et al.* 2013). However, Red-throated Loon in the north Pacific and northern Europe have suffered declines up to 85% over the last 40 years, largely due to low over-winter survival in marine habitats (Skov *et al*. 2011; Larned *et al*. 2012; Schmutz 2014).

For comparison with our initial loon studies, we extended observations on the Drizzle Lake Ecological Reserve (1983–1989, 2011–2020), with occasional summer visits in intervening years (1990–1996, 2003). In this paper, our objective is to: 1) report long-term trends in abundance of both loon species, 2) describe seasonal and daily patterns in abundance of Common Loon, 3) test whether abundance of Common Loon is influenced by wind, tides, or the Pacific Decadal Oscillation, 4) describe behaviour of both species including responses to disturbances, and 5) quantify long-term yearly patterns in reproductive success of Red-throated Loon. We also comment on several changes occurring on the reserve since its establishment that could influence variation in loon activity.

Methods

Drizzle Lake is one of several small lakes in an expanse of low-lying raised bog and coniferous forest in northeastern Haida Gwaii (Figure 1). The 837 ha Drizzle Lake Ecological Reserve encompasses the entire watershed of the lake (Krajina *et al*. 1978). Surveys of Common and Red-throated Loons were made on the lake during 1983–1989 and 2011–2020 for comparison with baseline data (1977–1982 for Common Loon; 1976–1982 for Red-throated Loon). We also made single visits to the reserve during the summers of 1990–1996 and in 2003 and recorded whether the major Red-throated Loon nesting territory was occupied. We did not obtain counts of Common Loons for 2013 or Red-throated Loons for 2020. Numbers of survey days varied among years and differed between species. For Common Loon, there was an average of 15 survey days (range 1–31) in July for each year. For Red-throated Loon, the average was 17 survey days (range 4–34), primarily in July but also including several surveys from May and June. To obtain daily loon counts on the lake, we used a protocol similar to that of the baseline data (Reimchen and Douglas 1980) and made multiple full-lake counts every 30 min from dawn until mid-morning (1000 h), intermittently near mid-day (1000–1400 h), and in the evening (1900–2200 h). These time blocks were chosen following baseline data that showed Common Loon numbers increased from dawn and reached a maximum near mid-morning, while Red-throated Loons, which were usually absent from the lake during the day, began to increase near 1800 h and reached a maximum just before dark.

All observations were made from the same position on the lakeshore that allowed observation of 97% of the lake surface (53.934177°N, 132.082024°W; Figure 1). Common Loons moved over the entire lake surface and regularly made foraging dives, but any single scan did not detect all birds. Consequently, we made multiple sequential scans until a maximum count was replicated on multiple further scans. Maximum numbers of Red-throated Loon may be slightly under-estimated due to the limited visibility near twilight, although we consider this to have a minimal effect on our counts. Even during the latest arrival to the lake near darkness, Red-throated Loon pairs vocalized, which helped us detect them. Individual pairs were recognizable as they tended to land in specific regions of the lake (Reimchen and Douglas 1980). There were four Red-throated Loon nesting territories within the reserve of which two (#1, #2; Figure 1) were monitored for occupancy and presence/absence of eggs or young over multiple years (1976–1996, 2003, 2011–2020). The remaining two (#3, #4) received nest surveys only several times, although their territory use was often identified through flight arrivals and departures. Pacific Loon (*Gavia pacifica*) was infrequent on the lake, occurring as solitary birds in two of 22 survey years (July 1979, July 2014), and each time, remained on the lake for several weeks. We saw no interactions between this species and Common and Red-throated Loons and do not consider it further in this study.

We plotted average daily counts and maximum July counts for each species for each year (1976–2020). "Average daily counts" comprised the maximum count per day averaged over all of the observation days during July, while "maximum July counts" comprised the daily maximum counts for all observation days. We grouped data into three time blocks: 1976–1982 (baseline surveys), 1983–1989, and 2011–2020, which provided an equal partition for the first survey period (1976–1989) that was separated from the third block by two decades. We used analysis of variance (ANOVA) to compare counts among years and among time blocks, and regression to evaluate the linear trends in abundance in the third time block.

To evaluate potential environmental predictors for yearly variability in Common Loon abundance, we used data on the Pacific Decadal Oscillation (PDO), a continuous monthly index of oceanic temperature that is associated with primary productivity including fish abundance (Mantua *et al.* 1997). PDO data were extracted from the National Oceanic and Atmospheric Administration (NOAA 2020), from which we computed a yearly average (all months), spring–summer average (April–July), and July only. To examine daily variability in Common Loon abundance on the lake each July, we extracted historical records of daily tidal conditions for adjacent marine waters (maximum daily tidal height, Masset tidal station, British Columbia) and maximum daily and monthly wind speeds (Sandspit Airport, British Columbia; Environment and Climate Change Canada 2020), and calculated correlations with daily numbers of Common Loon. We examined tidal cycles because during the baseline surveys, July daily loon counts appeared to show the same seven day cyclicity as the interval between spring and neap tidal heights. Wind speeds were also examined, as loons were rarely observed in flight during strong winds, which were prevalent in this geographical region. We used Spearman's rank correlation coefficients for correlating average monthly wind speed with average Common Loon numbers for each month (extracted from Reimchen and Douglas 1984a) and maximum daily wind speed with maximum daily Common Loon numbers for July. We also performed a combined analysis using a 2-way ANCOVA with Common Loon numbers as the dependent (response) variable and wind speed and tidal cycle as independent (explanatory) covariates. All statistics were done with SPSS Version 25 (IBM 2020).

Results

Common Loon

Throughout the observation period, Common Loon showed similar daily movement patterns, with singles or small groups arriving near dawn on the lake from adjacent marine waters and numbers increasing to a maximum by mid-morning. All loons were in adult summer plumage. There were minimal agonistic interactions, and birds commonly foraged while on the lake. Most loons departed the lake by mid-day and moved to the adjacent marine waters of Masset Inlet or to other lakes (Figure 1). This daily regime occurred throughout much of July and probably represents repeated visits by many of the same individuals. Baseline surveys (1977–1982) yielded average daily July counts of 15.6 birds with a maximum of 59 in 1978 (Figure 2). Subsequent counts (1983–1989) averaged 17.3 birds with maximum counts of 61 and 78 in 1983 and 1987, respectively. Resumption of counts during 2011–2020 showed an average of 19.0 with maximum values of 79 and 83 birds in 2018 and 2020, respectively. Although there were significant differences in average counts among individual years ($F_{22,373} = 7.4$, $P < 0.001$), there was no significant difference among the three time blocks ($F_{2,393} = 2.2$, $P = 0.12$). There was, however, evidence for a substantial increase in numbers over the most recent decade with the lowest average counts of 6.6 occurring in 2011 followed by an increase to an average of 48.1 in 2020 (regression slope $b = 3.0$, t = 9.2, $P < 0.001$).

We examined whether climatic conditions influenced the yearly variability in Common Loon numbers visiting the lake. Overall, the lowest monthly average wind speed of the year occurs during July, the month with the highest Common Loon numbers on the lake ($r_{22} = -0.62$, $P < 0.03$). However, July wind speeds for each year were not correlated with average Common Loon counts ($r_{22} = 0.17$, $P = 0.46$) or with maximum counts ($r_{22} = 0.07$, $P = 0.76$). Average PDO from April to July was not associated with mean Common Loon counts ($r_{22} = -0.02$, $P = 0.91$) or with maximum counts ($r_{22} = 0.04$, $P = 0.85$). As well, July PDO was not associated with mean counts ($r_{22} = 0.07$, $P = 0.75$) or with maximum counts ($r_{22} = 0.13$, $P = 0.58$).

Number of Common Loon arriving at the lake each day oscillated during the month (Figure 3). In several years (1988, 1989, 2015, 2017), the highest peaks were separated by six or seven days, yet in other years the interval between peaks ranged from three to 11 days. We tested whether tidal cycle or wind speed could contribute to these oscillations. Among the eight years for which we had continuous

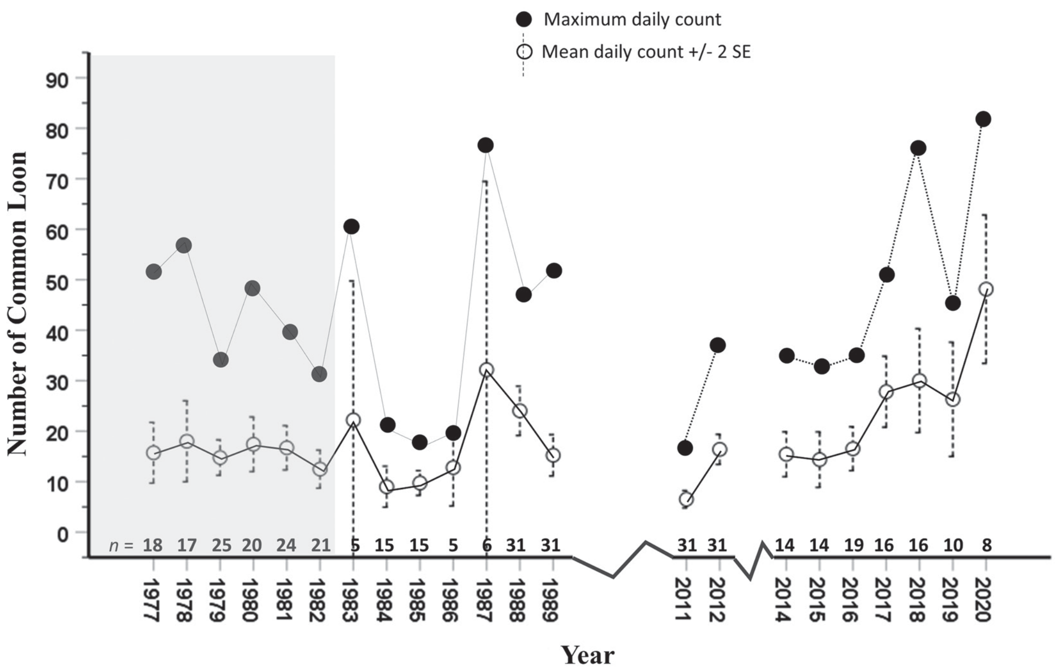

FIGURE 2. July average and maximum numbers of adult Common Loons (*Gavia immer*) at Drizzle Lake, Haida Gwaii, British Columbia. 1977–2020. *n* = number of census days. Shaded area shows baseline surveys (1977–1982).

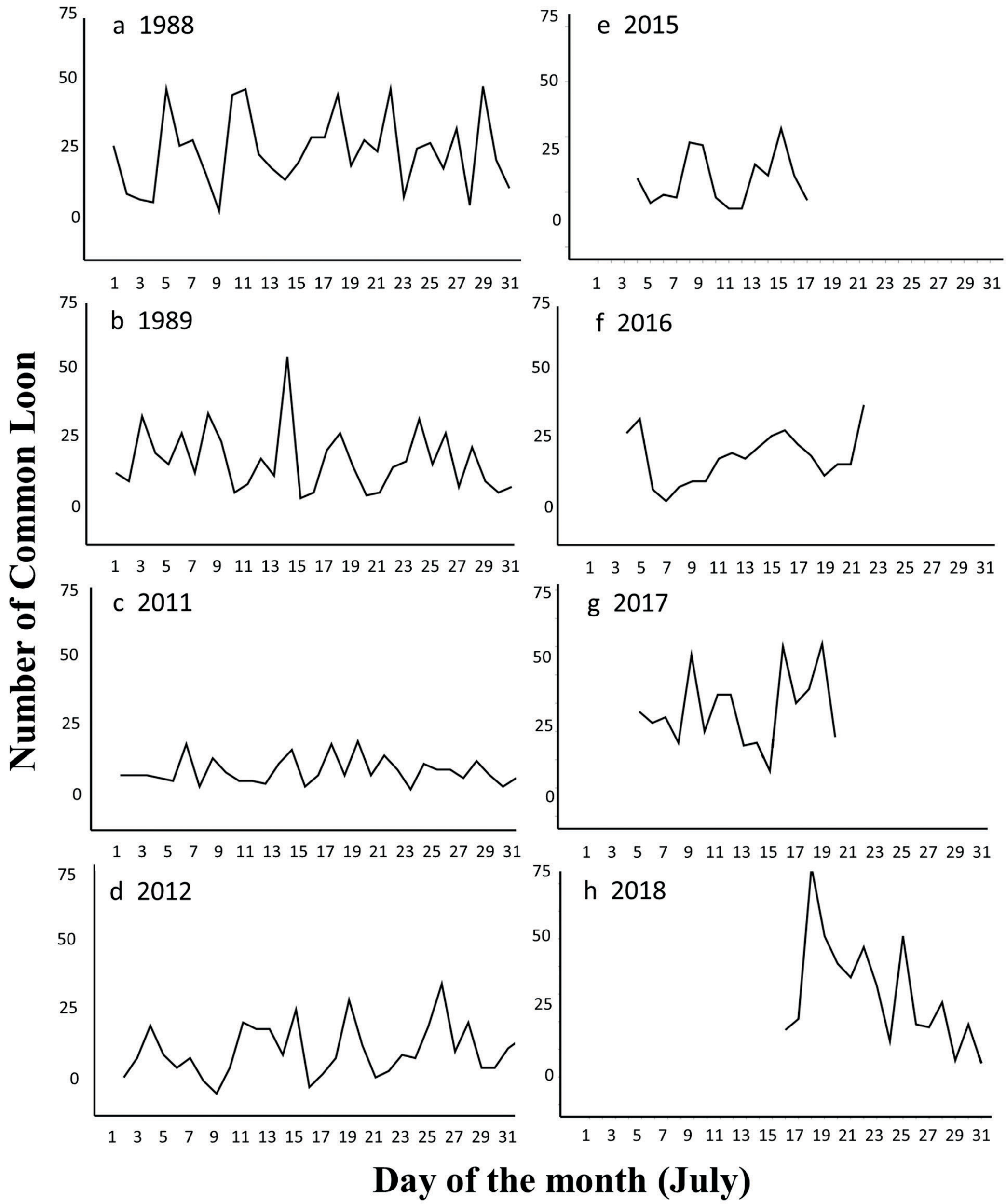

FIGURE 3. July daily oscillations in maximum count of Common Loon (*Gavia immer*) at Drizzle Lake, Haida Gwaii, British Columbia. All years with 14 or more days of continuous loon data (i.e., full tidal cycle) are shown.

daily counts in July for at least a two-week period (a full tidal cycle), there was a single year (2018) in which tidal cycle exhibited a significant correlation (r_s = 0.54, $P < 0.01$) but in none of the remaining years were any trends evident (all $P > 0.1$). However, Common Loon numbers and wind speed were inversely correlated (r_s) in seven of the nine years, two of which were statistically informative ($P < 0.02$). Inclusion of both variables as independent covariates and Common Loon numbers as the dependent response indicated a significant inverse effect for wind speed ($F_{1,188}$ = 5.5, $P < 0.03$) and no effect for tidal cycle ($F_{1,188}$ = 0.2, $P = 0.7$) or wind speed × tidal cycle interaction ($F_{1,188}$ = 0.6, $P = 0.45$).

Common Loon numbers ranged from solitary birds to large groups (20–60 individuals). Both solitary and group foraging were common. On most days, we observed loons that were initially scattered over the lake surface converge towards shoreline disturbances such as the arrival of a Black-tailed Deer (*Odocoileus hemionus)*, American Black Bear (*Ursus americanus*), Sandhill Crane (*Antigone canadensis*), and even the authors when we arrived at the lake to make observations. This behaviour also occurred when a Bald Eagle (*Haliaeetus leucocephalus*) arrived from adjacent marine waters, perched in lakeside trees, or bathed in the shallows. Loon aggregations remained in close proximity (10–50 m) to the eagle. This stereotyped behaviour of converging on shoreline disturbances was observed multiple times every year.

Common Loon were highly vocal and used calls in three different contexts. The most common was the Tremolo flight call used by single or multiple birds following take-off from the lake; the call appeared to encourage flight from other birds on the surface. Vocalizations did not occur during any flight arrivals to the lake. The Tremolo was also voiced following a 'splash dive' and loons appeared to maintain elevated alertness for several minutes. The second call—the Wail—was heard only in association with over-flights or proximity of a Bald Eagle and was usually followed by Tremolos and convergence and aggregation of other loons towards the shoreline position of the eagle.

Red-throated Loon

Baseline surveys (1976–1982) showed an average of 13.5 loons each summer with a maximum of 19 individuals in 1979 (Figure 4). Average numbers from 1983 to 1989 declined to 10 ($F_{1,58} = 21.3$, $P < 0.001$) with lowest numbers (six) at the end of the decade. The 2011–2019 surveys showed a further reduction in average counts (average = 6.2) relative to both the 1983–1989 period ($F_{1,83} = 64.2$, $P < 0.001$) and to the baseline surveys ($F_{1,63} = 125.3$, $P < 0.001$). Maximum counts from 2011 to 2019 did not exceed 10 birds. Of the 22 years of observation involving 485 survey days, there were only 14 days with no Red-throated Loon on the lake during summer and all of these occurred in 2017. We did not quantify the soundscape, but an additional change evident relative to the baseline surveys was the major decline in the vocalizations of the Red-throated Loon during the frequent intra-specific encounters from dusk into darkness.

The four Red-throated Loon nesting territories identified on the reserve varied in their occupancy over time (Figure 5). Territory #1, monitored for 32 years, had chicks in 20 years, but this territory has not been occupied in any of the last ten years (2011–2020). Territory #2, on the inlet stream to the lake, was occupied in all of the 23 survey years, although no chicks have been observed since 1986. Territory

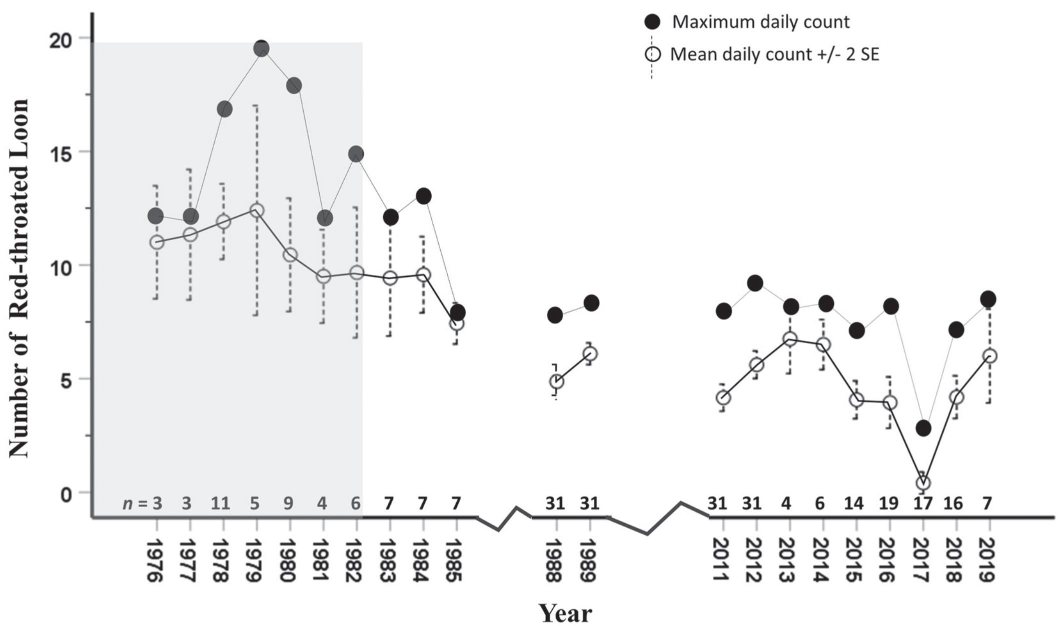

Figure 4. July average and maximum number of adult Red-throated Loons (*Gavia stellata*) at Drizzle Lake, Haida Gwaii, British Columbia, 1976–2019. *n* = number of census days. Shaded area shows baseline surveys (1977–1982).

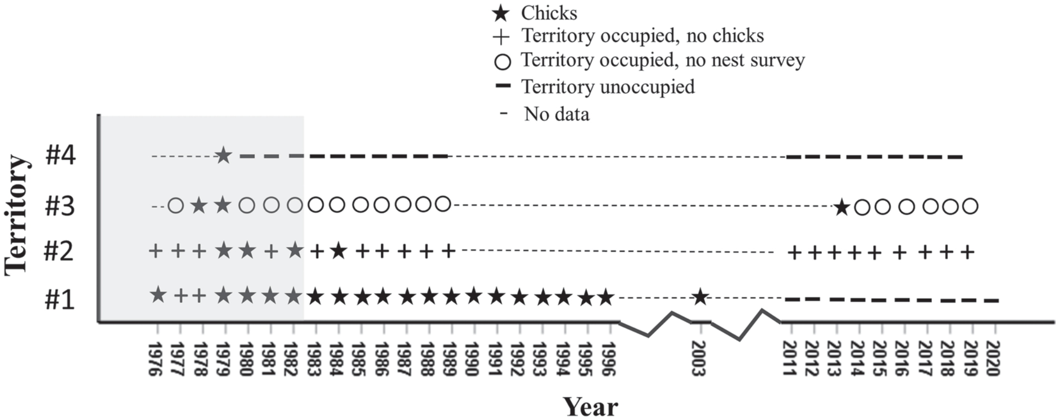

FIGURE 5. Yearly activity at the four Red-throated Loon (*Gavia stellata*) nesting territories at Drizzle Lake, Haida Gwaii, British Columbia. Shaded area shows baseline surveys (1977–1982).

#3, a small pond, was occupied in all years while Territory #4, an additional small pond, was occupied only in 1979.

Discussion

Our extended surveys at the Drizzle Lake Ecological Reserve showed that numbers of adult Common Loon, although variable among years, exhibited a similar average and maximum within each of the three time blocks from 1976 to 2020. The only evidence of a consistent yearly change in numbers occurred recently, from the lowest count of 16 in 2011 to the highest count of 83 in 2020. Low numbers in 2011 correspond to marine waterbird surveys (1999–2011) of inner coastal regions of eastern Vancouver Island that also showed lowest Common Loon counts in 2011 (Crewe *et al*. 2012). As well, the increase we observed during 2011–2020 is also consistent with an increase in Common Loon in additional marine waterbird surveys (1999–2019) from outer coastal waters including Haida Gwaii (Ethier *et al*. 2020). Fluctuations in average or maximum numbers of birds between successive years strongly suggest that these fluctuations are not the result of broader demographic trends but reflect yearly differences in the extent of coastal movement of Common Loon in marine waters around Haida Gwaii. Common Loon in Alaska have had a stable or increasing population from 1985 to 2015 (McDuffie *et al*. 2019) while those in Ontario and Wisconsin show declining reproductive success and abundance from anthropogenic influences (Tozer *et al.* 2013; Bianchini *et al.* 2020; Piper *et al.* 2020). Currently, continental trends in Common Loon abundance appear stable (Evers *et al*. 2020).

While our data confirm the distinctive July influx of adult non-breeding loons to this coastal lake seen during the baseline surveys (1976–1982), they give limited insight as to why these birds should leave marine waters daily in July and fly to Drizzle Lake. The birds commonly forage on the lake and it is possible that prey capture rates during July exceed those from marine habitats. Rather than clear oceanic waters, Drizzle Lake is situated on a large expanse of *Sphagnum* bog that results in deep tannin staining of the lake. This staining greatly limits the amount and the spectrum of light penetration that reduces the detection and reaction distances of subsurface interactions (Reimchen 1989). Despite the challenges of low light, we suspect that diving loons are able to exploit these restricted and unusual photic conditions allowing improved prey capture rates (http://web.uvic.ca/~reimlab/sticklelloonvoice640.mp4). An additional piscivore in Drizzle Lake is Cutthroat Trout (*Oncorhynchus clarkii*), which exhibits their highest predation rates on stickleback during summer months (Reimchen 1990) when loons are present. How these piscivores interact behaviourally or trophically is currently unknown. Furthermore, as loons are long-lived, exceeding 30 years (Evers *et al*. 2020), some or many of the adult birds may be the same individuals that return to these lakes each year. As such, these may represent long-term 'information centres' (Galef and Wigmore 1983; Harel *et al.* 2017) that, in addition to foraging, are used for social interactions or pre-migratory grouping (McIntyre and Barr 1983; Paruk 2006). That the loons arrived at the lake as singles or small groups but left in large groups is consistent with a combination of these processes. These aggregations in July occur several months before successful completion of reproduction by loons in western Canada, Alaska, or the Arctic and several months prior to the southerly migration of both successful and unsuccessful nesters from the Arctic (Evers *et al.* 2020); this suggests a novel component of the life history in Common Loons in western North America. Satellite tracking, as well as other markers such as banding or genomic data, would yield insight into the origin of lake aggregations on Haida Gwaii.

We detected substantial daily variability in numbers of Common Loon using the lake in July of each year. Rather than gradual increases or decreases over the month, there were peaks in abundance, separated by three or more days of low abundance. We suspected that this periodicity, with a mode at seven days, could be associated with conditions in marine waters that reduced foraging opportunities for the loons. For example, neap and spring tidal cycles are separated by seven days, with associated current conditions being much stronger during spring tides. Such currents could be expected to alter fish activity and foraging opportunities for avian piscivores that, in turn, could increase or decrease prospects for movement to alternate foraging habitats in lakes. However, we found limited support for any association between tidal cycle and lake visits. We also examined average daily wind speed, suspecting that the high wing loading of Common Loon (Savile 1957; Gray *et al*. 2014) would result in significant flight constraints during take-off in very calm conditions or during flight in strong winds. We observed that on windless days at Drizzle Lake, loons required greater take-off distance in flat surface waters and typically did not leave the lake until local winds increased, usually by midday. As well, large surface waves limited take-off and strong winds compromised aerial flight for the loons. Our data are consistent with this suggestion as they show a significant inverse relationship between daily Common Loon arrivals on the lake and daily wind speed. Assuming that this is a causal explanation for the within month periodicity, perhaps it also contributes to why loon visitations are largely restricted to the month of July because this month, specifically its third week, has the lowest average wind speed throughout the year (Sandspit Airport; Environment and Climate Change Canada 2020). Although suggestive, over the 22 years of our surveys, we did not detect any relationship between average July winds each year and abundance of Common Loon and infer that average monthly wind speed is not an important factor in year-to-year variation in lake visitation.

Consistent with the trends seen during the baseline surveys (Reimchen and Douglas 1980), we found that Red-throated Loon are generally not on the lake during the day but arrive at dusk, spend the night, and then depart for marine waters at dawn, a recurring behaviour from late-April to August. Although they arrive at the lake as pairs, these often congregate in groups during which there is extensive agonistic displays and vocalizations (Douglas and Reimchen *in press*). Foraging activity is much less prevalent than with Common Loon (Reimchen and Douglas 1980). We observed an approximate 50% reduction in average and maximum evening counts of Red-throated Loon between 1976 and 2019, and while most of this reduction happened by the end of the 1980s, the lowest counts occurred in 2017 when on the majority of evenings, no Red-throated Loon were present on the lake. There has been no successful nesting on the lake over the last decade and the most consistently used territory (#1, Figure 1) has not been occupied since 2011 although lake and shoreline conditions appear similar to those in the previous decades.

The reduced abundance and activity of Red-throated Loon on Drizzle Lake parallels that in other geographical areas. In the Arctic Coast Plain, northern Alaska, there was a 40% reduction in Red-throated Loon from 1992 to 2000, but then stability thereafter (Larned *et al.* 2012). In the Baltic Sea, northern Europe, an important overwintering habitat of aquatic birds, there was an 85% reduction of Red-throated Loon and Arctic Loon (*Gavia arctica*) from 1987 to 2000 (Skov *et al.* 2011), declines generally considered to originate from increased mortality in marine habitats (Schmutz 2014), but also from ecological disturbance to nesting ponds in Swedish populations (Eriksson 1994). Red-throated Loon from Haida Gwaii are thought to overwinter on inshore marine waters in southern British Columbia (Campbell *et al*. 1990) and possibly further south, as recent satellite-tracking of Alaskan birds (McCloskey *et al*. 2018) indicates that some adults overwinter in coastal waters of Mexico. Inshore habitats impose the highest risk to overwintering seabirds (Croxall *et al*. 2012).

Apart from the possible marine influences, are there ecological changes that have occurred in the Drizzle Lake Ecological Reserve during 1976–2020 that could influence the abundance or activity pattern of the loons? There is no clear evidence for any long-term shifts in water levels, pH, water spectra, and fish community (Reimchen 1990, 1994; Reimchen unpubl. data). Raccoon (*Procyon lotor*), an invasive species on Haida Gwaii, is a predator on Red-throated Loon nests (Douglas and Reimchen 1988) and while uncommon, could be associated with the reduced nesting success over the last two decades. Additionally, number of daily helicopter flights directly over the lake has increased over the last two decades during summer months when Common Loon and nesting Red-throated Loon are on the lake surface or in flight. The brief and intense engine noise from the low-flying aircraft has no counterpart in this remote reserve and may contribute to the failed reproduction of the

Red-throated Loon. Although it appears not to have affected the visiting Common Loons, the numbers of which have not declined over the same period. Perhaps nesting loons are more vulnerable to this potential disturbance than visiting loons. Loons are considered a high-risk species for aircraft collisions (Pfeiffer *et al.* 2018) and the probability of collisions could be substantial at Drizzle Lake given the daily movement of groups of 10–30 loons in perpendicular flight paths, at similar elevation and at the same time of day as north-south aircraft flight paths. Apart from the potential human cost and loon mortality, the ecological impact of such an event could seriously compromise the integrity of the reserve.

The Drizzle Lake Ecological Reserve was originally established in 1973 primarily for the protection of the endemic Giant Threespine Stickleback (Krajina *et al.* 1978). Long term studies on this reserve showed that avian piscivores, of which Common Loon is the most prevalent, are the dominant predators on the sub-adult and adult sticklebacks in this lake (Reimchen 1988, 1994). Yearly and seasonal shifts in the amount of loon predation observed in the baseline surveys are linked to the frequency of defensive armour phenotypes of the stickleback (Reimchen 1995) and, as such, it seems probable that the prevalence of Common Loon, evident in most years from 1977 to 2020, represents post-glacial continuity of the major selective pressure that has led to the evolution of gigantism and the distinct defense morphology of this endemic stickleback population. A reduction in the predation pressure from Cutthroat Trout and/or Common Loon was identified as a potential threat to the stickleback (COSEWIC 2013).

In summary, our surveys of the Drizzle Lake Ecological Reserve encompass numerical data on loon abundance for 22 years between 1976 and 2020. We confirm exceptionally high abundance of Common Loon on this small lake, substantial variation among years, and no current indication of any long-term changes. In contrast, Red-throated Loon show an approximately 50% decline in both breeding and non-breeding pairs, trends that are similar to those in Alaska and Northern Europe. Our data provide a broad baseline for future biophysical surveys at this reserve.

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Timing of pair formation and male acquisition of alternate plumage by three wintering dabbling ducks

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Abstract
Pair formation in ducks is thought to be influenced by the acquisition of breeding plumage, the occurrence of courtship display, or both. We examined the frequency of pair formation in Mallard (*Anas platyrhynchos*), Green-winged Teal (*Anas crecca carolinensis*), and Northern Shoveler (*Spatula clypeata*) in the central valley of California in relation to the frequencies of male attainment of breeding plumage and courtship display. Predictions related to two hypotheses are: (1) the timing of pair formation is directly related to the attainment of breeding (definitive alternate) plumage by males, and (2) frequencies of courtship display are highest during pair formation. Most female Mallard were paired by the end of October, with >80% in pairs by early December. Of Northern Shoveler, 90% were paired by early January and 90% of female Green-winged Teal were paired by early February. The highest rates of courtship display by Mallard were observed during October through November, by Northern Shoveler in November, and by Green-winged Teal in November through January. Courtship display was, therefore, relatively frequent at the same time as pair formation for all three species. Northern Shoveler spent less time in courtship display than the other two species. Most (90%) male Mallard had acquired alternate plumage by mid-November, Northern Shoveler by early February, and Green-winged Teal by mid-December. Thus, timing of pair formation coincided with timing of attainment of breeding plumage in Mallard and Green-winged Teal but not Northern Shoveler.

Key words: Pair formation; alternate plumage; winter; courtship; Northern Shoveler; *Spatula clypeata*; Green-winged Teal; *Anas crecca carolinensis*; Mallard; *Anas platyrhynchos*

Abrégé
On considère que la formation de couples chez les canards est influencée par l'acquisition du plumage de reproduction et le comportement social. Deux hypothèses découlent : (1) la chronologie de la formation des couples est directement lié à l'acquisition du plumage nuptial (alternatif définitif) par les mâles; (2) la fréquence de la parade nuptiale est particulièrement élevé pendant la formation des couples. Dans la vallée centrale de la Californie, une majorité de femelles du canard colvert (*Anas platyrhynchos*) ont été accouplées à la fin du mois d'octobre, et > 80 % au début du mois de décembre. Chez le canard souchet (*Spatula. clypeata*), 90 % des femelles ont été appariées au début de janvier et 90 % des femelles sarcelle d'hiver (*Anas crecca carolinensis*) été en couple au début de février. Les taux les plus élevés de parade nuptiale ont été observés chez le canard colvert en octobre et novembre, en novembre pour le canard souchet et durant la période de novembre à janvier pour la sarcelle d'hiver. La parade nuptiale a donc eu lieu en même temps que la formation des couples chez les trois espèces. Le souchet a passé moins de temps en parade nuptiale que les deux autres espèces. Quatre-vingt-dix pour cent des mâles du canard colvert avaient acquis leur plumage alternatif à la mi-novembre, au début de février pour le canard souchet et à la mi-décembre pour la sarcelle d'hiver. Ainsi, la formation des couples a eu lieu au même temps que l'acquisition du plumage nuptial, sauf pour le canard souchet.

Mots clefs: formation de couples; plumage nuptial; hiver; parade nuptiale; canard souchet; *Spatula clypeata*; sarcelle d'hiver; *Anas crecca carolinensis*; canard colvert; *Anas platyrhynchos*

Introduction
Studies of waterfowl biology show events on the wintering grounds influence breeding success and population dynamics (Raveling 1970; Fretwell 1972; Tamisier 1972, 1976; Paulus 1983; Sedinger and Alisauskas 2014). Acquisition and storage of energy for reproduction occurs in waterfowl in late winter and early spring and can impact reproductive success (Krapu 1981; Devries *et al.* 2002). Pair formation occurs during the winter among most dabbling ducks.

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Various hypotheses have been proposed to explain the prevalence of pair formation before breeding season, including possible benefits associated with familiarity of a breeding partner, opportunity to test a bond and assess mate quality, and male protection of a female allowing her to feed, avoid disturbance from predators or conspecifics, and accumulate nutrient and energy reserves (Milne 1974; Paulus 1983; Rohwer and Anderson 1988).

Field data on the timing of pair formation in North American ducks are rather limited, although their courtship displays are well documented (Lorenz 1971; Johnsgard 1960, 1965; McKinney 1992). Some rough counts of the frequency of paired wintering Mallard (*Anas platyrhynchos*) and Green-winged Teal (*Anas crecca carolinensis*) are cited by Palmer (1976) and Bellrose (1976) and information about timing and displays is given for six species of dabblers in North Carolina, including Northern Shoveler (*Spatula clypeata*) and Green-winged Teal (Hepp and Hair 1983).

We examined the timing of pair formation over winter in three species of dabbling ducks in the central valley of California, United States, to determine the association of alternate plumage acquisition and the performance of courtship display. We chose to study Northern Shoveler, Green-winged Teal, and Mallard based on their close taxonomic relationship, their range in body size, and abundance in the study area during winter.

We assume that alternate plumage (Howell *et al.* 2003) occurs to enhance a male's acquisition of a mate (McKinney 1992). As such, pair formation could be dependent on male attainment of alternate plumage. This hypothesis predicts that paired males have already acquired their alternate plumage; the contrasting null prediction is that pairs occur at high frequency without the male having attained this plumage. Thus, individual males in more advanced plumage should be paired more frequently than those that have not yet attained alternate plumage, and, conversely, those not yet in alternate plumage should be unpaired more frequently than those in alternate plumage. Weller (1965) suggested that the timing of plumage acquisition evolved simultaneously with early pair formation in *Aythya,* an idea that has not been evaluated in dabbling ducks. Another hypothesis concerning the timing of pair formation is that courtship display has a major influence (McKinney 1992). Prediction 2 is that pair formation should be associated with increases in the frequency of courtship display. Courtship display should thus be correlated with pair formation.

Methods

Study area

The central valley of California is a major overwintering area for waterfowl that breed in the northern portions of the central and Pacific flyways (Bellrose 1976). We conducted our study by observing ducks on the flooded impoundments in the Suisun Marsh, Grizzly Island, and Joyce Island Wildlife Areas (38.1724°N, 121.9644°W) near Fairfield, California, and the Gray Lodge Wildlife Area (39.3727°N, 121.7060°W) near Gridley. Vegetation grew along the dikes; although there were some patches of emergent vegetation, extensive open water facilitated observation.

Observations

We observed the birds using a spotting telescope or binoculars and measured activity with scan sampling, recording instantaneous behaviour of individuals alone, paired, or in flocks at timed intervals using a metronome (Altmann 1974). Scans typically surveyed flocks ranging from 40 to 600 individuals. For each observation, we recorded the species, sex, and pair status of the bird. The timing of scans was systematically assigned to cover all daylight hours. Attempts to view animal activity at night with a night vision telescope failed. We compiled frequencies for 10 different behaviours. Courtship display included burp, introductory shake, grunt-whistle, head-up-tail-up, down-up, bill-up, turn-back-of-the-head, bridling, nod-swim, swim, preen, maintenance, and inciting; the other nine categories were not related to courtship (Lorenz 1971; Johnsgard 1965). We determined whether a female and a male were paired based on behaviour toward each other and proximity. Females of all three species are known to breed in the first year after hatching, although factors may influence whether they attempt to breed (Devries *et al.* 2008; Drilling *et al.* 2020; DuBowy *et al*. 2020; Johnson *et al.* 2020).

Frequencies of males in three plumage classes were made during the scans. The plumage classes were based on completion of the pre-alternate moult as shown by new colouration on the head, breast, and flank regions: A = full alternate plumage, B = 50–95% complete, and C = <50% complete. Six arbitrary time periods were designated to examine changes in plumage and behaviour over the study period (15 October 1981 to 10 April 1982): 15 October–14 November; 15 November–12 December; 13 December–9 January; 10 January–6 February; 7 February–6 March; and 7 March–10 April.

Measurements at hunter check stations

Sex, age, and plumage score (as above) were recorded at hunter check stations in the Wildlife Areas for 656 Green-winged Teal, 846 Northern Shoveler, and 526 Mallard during the legal hunting season from 17 October 1981 to 17 January 1982 (periods 1 through early 4). With the aid of legal volunteers, R.T. collected additional specimens under scientific permits during periods 5 and 6. Hunters were also asked whether a given bird was part of a pair when shot. We judged whether answers were credible based on hunter experience, description of events including consideration of proximity, and behaviour of birds toward each other when they were shot. We did not include pair status information in analysis if answers were not deemed credible.

Analysis

Our data consist of four observational variables collected for three species during up to six periods over winter: (1) percentages of females paired, considering that because of a male-biased sex ratio this represents a reliable indication of pair formation (Hepp and Hair 1983) and, alternatively, (2) percentages of paired and unpaired males; (3) percentages of males in alternate plumage; and (4) percentages of individuals observed in courtship. Prediction 1 and corollaries were tested by comparing frequencies of pairs formed over time with frequencies of males having attained full alternate plumage over time as well as comparing paired versus unpaired males with attainment of alternate plumage using χ^2 tests (Zar 1974). For prediction 2, we compared frequencies of courtship behaviour with frequencies of pairs over time using Scheffe's test and Spearman rank correlations (Zar 1974) using SAS (SAS Institute Inc., Cary, North Carolina, USA). All tests were two tailed.

Results

Pair formation and male alternate plumage acquisition

Most female Mallard (61%) were already paired when we began our observations in October (Table 1; Figure 1), whereas significantly lower proportions of female Green-winged Teal ($\chi^2_1 = 257.5$; $P < 0.001$) and Northern Shoveler ($\chi^2_1 = 372.5$; $P < 0.001$) were paired during the first observation period. It took until January (period 4) for over 90% of Northern Shoveler to be paired and another month for this proportion to be achieved by Green-winged Teal.

Alternate plumage in males was acquired earlier in Mallard and Green-winged Teal than in Northern Shoveler. Behavioural scans showed that 97% and 92% of combined paired and unpaired male Mallard and Green-winged Teal had full breeding colours by mid-November (i.e., end of period 1), compared with 9% of Northern Shoveler (Table 2; Figure 1). Analyses of plumage class from hunter-collected males during period 1 yielded a somewhat similar result to that of scan samples, although the proportion of male Green-winged Teal that attained alternate plumage was lower for the former (55%; Figure 2). Nearly all hunter-collected Mallard and Green-winged Teal had alternate plumage by mid-December (i.e., period 2), whereas most Northern Shoveler did not have alternate plumage until early January.

Only 13.9% of paired male Northern Shovelers observed during scan samples for period 1 had acquired alternate plumage (Table 2, Figure 1). By period 2, nearly 95% of paired male Northern Shoveler had acquired alternate plumage in contrast with only 21% of unpaired males. Analyses of hunter-collected birds supported scan sample observations: all three paired males collected during period 1 did not have alternate plumage, whereas 10 of 16 (63%) paired males collected during period 2 had acquired alternate plumage (Figure 2). Thus, female Northern Shoveler paired early in the season chose males that had yet to acquire full breeding colours; this was not the case for Mallard and Green-winged Teal. Most female Green-winged Teal were not paired before early February (period 4), so pair formation in this species occurred after males had attained full alternate plumage.

Pair formation and courtship display

The percentages of female Northern Shoveler and Green-winged Teal that were paired did not correlate significantly with courtship ($r_s = 0.71$, $P = 0.11$; $r_s = 0.49$, $P = 0.33$, respectively), although there was a general tendency for the percentage of paired females of both species to increase with courtship activity

TABLE 1. Paired female Northern Shoveler (*Spatula clypeata*), Green-winged Teal (*Anas crecca carolinensis*), and Mallard (*Anas platyrhynchos*) observed in northern California during six periods in winter 1981–1982, determined from behavioural scan samples (including adult and juvenile birds).

Period	Northern Shoveler, no. (%)	Green-winged Teal, no. (%)	Mallard, no. (%)
15 Oct.–14 Nov.	2318 (15.6)	526 (10.0)	353 (61.2)
15 Nov.–12 Dec.	1763 (64.3)	541 (28.4)	563 (77.4)
13 Dec.–9 Jan.	2083 (86.8)	238 (58.4)	75 (85.4)
10 Jan.–6 Feb.	2041 (94.3)	1126 (78.2)	497 (95.9)
7 Feb.–6 Mar.	4562 (97.9)	935 (94.5)	181 (99.4)
7 Mar.–7 Apr.	2482 (98.8)	1748 (98.7)	388 (99.7)

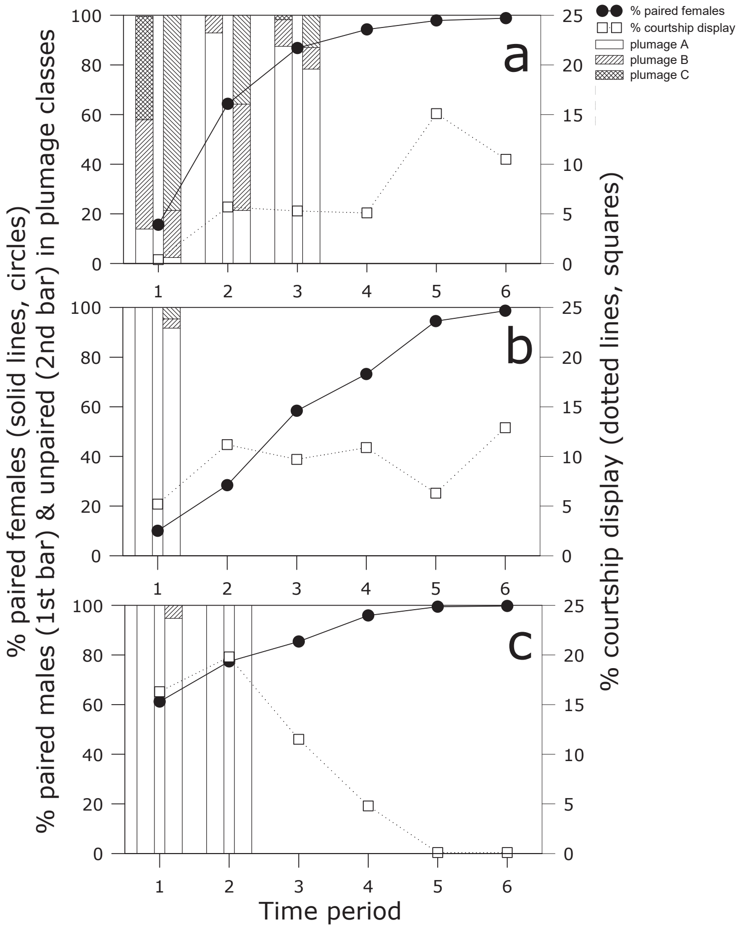

FIGURE 1. Relation between acquisition of alternate plumage by male ducks with pairing and courtship display: a. Northern Shoveler (*Spatula clypeata*), b. Green-winged Teal (*Anas crecca carolinensis*), and c. Mallard (*Anas platyrhynchos*) during six observation periods, winter 1981–1982 in California State Wildlife Areas of northern California, USA. Plumage class A = full alternate plumage, B = 50–95% of pre-alternate moult complete, C = <50% complete. Period 1 = 15 October to 14 November, period 2 = 15 November to 12 December, period 3 = 13 December to 3 January, period 4 = 10 January to 6 February, period 5 = 7 February to 6 March, and period 6 = 7 March to 7 April. Plumage data were obtained from separate purposeful scans at close distance where pair status and plumage condition were readily apparent; however, adults could not be distinguished from juveniles (see Table 2 for sample sizes). Sample sizes for counts assessing frequency of courtship display in periods 1 to 6 are: Northern Shoveler: 164, 138, 120, 155, 114, 106; Green-winged Teal: 77, 116, 112, 158, 96, 103; Mallard:109, 101, 106, 112, 64, 78.

after period 1 (i.e., mid-November). The frequency of courtship activity in Northern Shoveler was highest in periods 5 and 6 ($P < 0.001$, Scheffe's test) just as the frequency of pairs began exceeding 95%. Courtship activity for Green-winged Teal was greatest in mid-winter, as most pair formation was occurring. The percentage of paired female Mallard declined with greater courtship activity ($r_s = -0.71$, $P = 0.008$). A high proportion of females was paired by mid-October when migrants were arriving on the wintering area to meet local breeders (Drilling *et al.* 2020); then, an increase in courtship display, often associated with copulation, occurred just before departure of migrants and local breeders. Frequencies of courtship display were relatively high until pair bonds were formed (Table 1, Figure 1).

Discussion

Earlier studies indicate that female ducks use plumage as a criterion for choosing one male among many displaying to them (Weller 1965; McKinney 1992). This was likely true during fall and winter in northern California for female Mallard and Green-winged Teal, as they appeared to have a good choice

Table 2. Pair status and frequency of plumage class of paired and unpaired male Northern Shoveler (*Spatula clypeata*), Green-winged Teal (*Anas crecca carolinensis*), and Mallard (*Anas platyrhynchos*) over three periods of early winter 1981–1982 in northern California.

Period	Species/pair status (*n*)	Frequency (%) of plumage class*		
		A	B	C
1. 15 Oct.–14 Nov.	Northern Shoveler			
	Paired (144)	13.9	44.0	41.7
	Unpaired (126)	2.4	19.0	78.6
	Green-winged Teal			
	Paired (7)	100.0	0.0	0.0
	Unpaired (108)	91.7	3.7	4.6
	Mallard			
	Paired (17)	100.0	0.0	0.0
	Unpaired (19)	94.7	5.2	0.0
2. 15 Nov.–12 Dec.	Northern Shoveler			
	Paired (71)	92.9	7.0	0.0
	Unpaired (70)	21.4	42.8	35.7
	Mallard			
	Paired (15)	100.0	0.0	0.0
	Unpaired (29)	100.0	0.0	0.0
3. 13 Dec.–3 Jan.	Northern Shoveler			
	Paired (56)	87.5	10.7	1.8
	Unpaired (23)	78.3	8.7	13.0

*Plumage class A = full alternate plumage, B = 50–95% of pre-alternate moult complete, C = <50% complete. These frequencies were obtained from separate purposeful scans at close distances where pair status and plumage condition were readily apparent, yet one could not distinguish adults from juveniles.

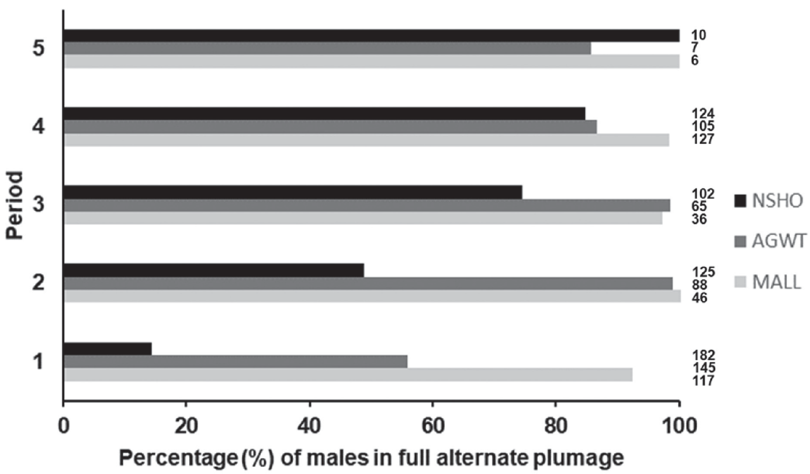

Figure 2. Proportion of males in full alternate plumage over five periods for Northern Shoveler (*Spatula clypeata*, NSHO), Green-winged Teal (*Anas crecca carolinensis*, AGWT), and Mallard (*Anas platyrhynchos*, MALL) at hunter check stations and collected under permit in state wildlife areas of northern California in 1981–1982. Includes both adults and juveniles. Period 1 = 15 October to 14 November, period 2 = 15 November to 12 December, period 3 = 13 December to 3 January, period 4 = 10 January to 6 February, and period 5 = 7 February to 3 April. Sample sizes are given for each bar.

of males already in full alternate plumage; Northern Shoveler males at differing stages of moult displayed to females during October–November. This suggests that a unifying set of hypotheses explaining timing of pair formation in dabbling ducks may be complex and elusive.

Our prediction 1 (males acquire alternate plumage before forming a pair bond) held for Mallard and Green-winged Teal but not for Northern Shoveler. Full breeding plumage is not necessary for pair formation to occur in Northern Shoveler; however, males that were more advanced in their pre-alternate molt appeared to be paired earlier than others (R.D.T. pers. obs.). A corollary to prediction 1 is that pair formation is ordered according to the sequence of male alternate plumage acquisition. Some male Mallard had acquired alternate plumage before our first observations; all were in full alternate plumage by period 1 and they were paired first. In contrast, Green-winged Teal acquired their alternate plumage by period 2 (November), and over 90% were not paired until period 5. Over 90% of Northern Shoveler were paired by period 3 (December) when 15–25% of males had yet to acquire full alternate plumage (Table 2, Figures 1, 2). Therefore, the evidence above leads us to reject prediction 1 only for Northern Shoveler. Dubowy *et al*. (2020: 9) stated: "Only males in Alternate plumage display to females wintering in North Carolina", but this was certainly not the case for Northern Shoveler in our study in California.

The late acquisition of breeding plumage in Northern Shoveler coupled with their early pairing schedule tends to suggest that selection has favoured individuals with full alternate plumage arriving on the breeding ground over having this plumage earlier for mate acquisition. Perhaps the most important function of alternate plumage is for territorial advertisement and defense. Northern Shovelers are very strongly territorial while breeding when the males have their brightest and most conspicuous alternate plumage. Display, plumage quality, and other aspects of morphology can influence mate choice (Klint 1980). For example, Omland (1996) found that female Mallard selected males based on bill characteristics and plumage ornamentation. Is it not possible that female Northern Shoveler can use other cues, such as condition or bill characteristics or colouration, to select mates? This also begs the question: why do Northern Shovelers not act as do Mallards and Green-winged Teal which keep their alternate plumage from fall through to the breeding season? Is this related to nutrient availability or perhaps feather wear caused by Northern Shovelers' habit of ploughing with their head through water and floating vegetation? Hohman *et al*. (1992: 136) have stated that "waterfowl are able to make physiological adjustments to meet the energy/nutrient demands of molt when presented with seasonal constraints or variation in food resources".

Mallards engage in courtship display during fall staging and migration when pair formation begins with intensity (Drilling *et al.* 2020). Increased courtship display was followed by an increase in the frequency of pairs. Mallard courtship display peaked in period 2 (late November/early December) and this was the first of the three species to pair at a high level. Green-winged Teal courtship peaked in period 6 (April), but showed high levels of courtship in periods 2, 3, and 4 (November through January); this was the last of the three species in timing of pairing. Northern Shoveler courtship peaked in period 5 (February/March), but this species showed increasing courtship display in periods 2, 3, and 4 and was the second in order of pairing. Together, these observations are consistent with prediction 2 (frequencies of courtship display are highest during pair formation), but correlation tests were not significantly positive for any of the three species. Once pairs have formed, the frequency of courtship display declines. It reached zero in Mallards in the last two periods of winter. A significant negative correlation for Mallards may reflect that courtship is no longer necessary once pairs are formed.

Neither peak courtship display nor peak acquisition of alternate plumage in Green-winged Teal coincided with high frequencies of pairs, although trends toward these coalescing were observed. Early high frequencies of courtship display were noted. It was difficult to distinguish first-year males (juveniles) from adults, which most likely influenced the results. It is reasonable to expect that adults should attain full alternate plumage earlier and, therefore, court and pair earlier than juveniles, but we could not determine this. However, one cannot discount the possibility of other factors, such as hormone levels and condition, influencing aggressive tendencies in males, making dominant individuals more attractive apart from plumage and displays (Davis 2002; Devries *et al.* 2008). We cannot claim that either plumage acquisition or courtship display is the definitive influence on pair formation in Green-winged Teal, but they do affect the timing of pair formation.

Pair formation for all three species increased with time over the winter until the proportion of females that were paired reached ~90% in early February. This rate of pair formation may have been prevented from increasing more rapidly by the deaths of members of pairs (Ackerman *et al*. 2006), especially males. Our hunter bag checks until the end of the hunting season revealed that males were shot more frequently than females (proportion of males harvested: Northern Shoveler = 63%, Green-winged Teal = 62%, Mallard = 61%).

We examined the influence of two proximate factors on the timing of pair formation without considering important ultimate factors, such as availability and use of nutrient resources and predation (risk aversion). Over the winter, considerable body moult occurred in the ducks we examined (R.D.T. unpubl. data). Protein from invertebrates is needed to build the keratin constituting feathers during moult for each of the three species in our study, and exogenous contributions from daily diet are a major source of protein for this moult (Hohman *et al*. 1992). In winter, Northern Shovelers feed primarily on nektonic invertebrates with some seeds (Dubowy *et al.* 2020), Green-winged Teal diet is 62% seeds and 38% animal matter (Johnson *et al*. 2020), and Mallards eat 88% plant material and 12% animal matter (Hohman *et al*. 1992) to acquire this protein. Since our study, habitat manipulation in Suisun Marsh that particularly improved seed availability has resulted in greater body mass of dabbling ducks, except Green-winged Teal (Fleskes *et al*. 2016). This change in body condition could reflect changes in nutrients affecting moult and behaviour and, thus, the timing of pair formation. Further observations at our study site are warranted, including determining whether Northern Shoveler pairing without achieving full alternate plumage still prevails. The fact that our study area was highly desired and managed for hunting has further impact on aspects, such as risk aversion and other behaviour (e.g., mate guarding) that may also influence pair formation (Ackerman *et al*. 2006). Thus, beyond the plumage characteristics and courtship we studied, there are other factors requiring further examination in the context of pair formation.

We conclude that timing of pair formation in Northern Shoveler, Green-winged Teal, and Mallard is closely tied to frequency of courtship display, whereas our results, especially for Northern Shoveler, show that timing of pair formation is not consistently related across species to attainment of male breeding plumage. Further consideration of other factors driving timing of pair formation, some of which we have discussed above, may help develop a more effective set of hypotheses that apply across more duck species.

Author Contributions

Writing – R.D.T.; Writing – Review & Editing: R.D.T. and S.R.C., Conceptualization: R.D.T., Investigation: R.D.T. and E.A.T.; Methodology: R.D.T.; Formal Analysis: R.D.T. and S.R.C.; Funding Acquisition: R.D.T.

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Terrestrial dispersal of juvenile Mink Frog (*Lithobates septentrionalis*) in Algonquin Provincial Park, Ontario

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Abstract
Dispersal following metamorphosis is critical for sustaining anuran metapopulations. Mink Frog (*Lithobates septentrionalis*) is a primarily aquatic species that is common in eastern Canada. The species is not well studied, and little is known about the terrestrial dispersal of recently metamorphosed individuals. Here we present our observations on the phenology of terrestrial activity in recently metamorphosed Mink Frogs in Algonquin Provincial Park, Ontario, Canada. Despite a sampling effort of over 26 000 trap nights over two years (2010 and 2011) in an area with a known population of Mink Frogs, we observed only 35 individuals, all of which were recent metamorphs, in late summer 2011, suggesting annual variability of recruitment. Because all Mink Frogs were observed in a riparian area, it is likely that this species uses riparian corridors to disperse toward other wetlands, thus avoiding forested areas.

Key words: Mink Frog; *Lithobates septentrionalis*; dispersal; riparian habitat; Algonquin Provincial Park; Ontario

Introduction

Amphibians often occur in metapopulations, defined as a grouping of local populations inhabiting specific patches of habitat which are prone to extinction and colonization events (Hanski 1998; Marsh and Trenham 2001). The sustainability of metapopulations depends on distances between habitat patches, connectivity, and the number and quality of habitat patches (Howell *et al.* 2018; Fahrig 2020). Maintaining connectivity requires that patches are within an organism's dispersal or migratory ability or that a suitable corridor exists to link them (Fahrig *et al.* 1983). However, many amphibian populations experience localized extinctions despite assumed connectivity in their natural environment (Hecnar and M'Closkey 1996; Green 2003). For instance, the ability of recently metamorphosed individuals to disperse several hundred metres in a short period can sustain "sink" populations (Sinsch 1997) that experience greater mortality than recruitment (Krebs 2001). Furthermore, gene flow between patches allows for genetic diversity to be maintained over time in the face of habitat fragmentation which contributes to the long-term survival of a population (Lesbarrères *et al.* 2003, 2006). Although dispersal to new habitat patches is undertaken by both adults and newly metamorphosed individuals, those in the latter life stage tend to move much greater distances from natal ponds (Preisser *et al.* 2000). Therefore, post-metamorphic dispersal is critical to long-term survival and persistence of regional populations for many species (Sinsch 1997). Yet, amphibian dispersal events remain difficult to assess because of their small size and unpredictable timing.

Mink Frog (*Lithobates septentrionalis*) has an extensive distribution in eastern Canada and the Great Lakes area of the United States (Dodd 2013). This species is highly aquatic, rarely venturing overland, making use of large permanent ponds and lakes, but also occurring in bogs, beaver ponds, and even rivers and streams (Dodd 2013). Mink Frogs typically have a minimum year-long larval period, and froglets metamorphose by mid to late summer the year following hatching (Harding 1997; Dodd 2013; Mills 2016).

Despite being widespread and common throughout much of its range, Mink Frog is not well studied. Compared with other sympatric species in the same genus, such as Green Frog (*Lithobates clamitans*), American Bullfrog (*Lithobates catesbeianus*), and Northern Leopard Frog (*Lithobates pipiens*), little has been written about the post-metamorphic dispersal of Mink Frog. In particular, little has been reported on the terrestrial activity of recently metamorphosed individuals, leading to speculation on the role of this life-history stage in the persistence of local populations and metapopulations in general (Hedeen 1986; Schueler 1987). Here, we present observations on the phenology of terrestrial dispersal of Mink Frogs in Algonquin Provincial Park.

Methods

The study site is in western Algonquin Provincial Park (Ontario, Canada), Hunter Township, on the shore of Brown Lake (45.615°N, 78.854°W). The forest is typical of the area, composed primarily of Sugar Maple (*Acer saccharum* Marshall). Brown Lake is small (66.1 ha) with extensive riparian vegetation. A small creek flowing through a large beaver meadow empties into the lake at the southwest end of the study site.

Drift fence and pitfall trap arrays were used to sample dispersing individuals on the road and forested habitat at varying distances from Brown Lake (LeGros *et al.* 2014, 2017). Two 200-m drift fences were installed on an unused forest road with 26 pitfall traps on each side of the fences (n = 104); an additional 54 traps divided among six X-shaped drift fence arrays were placed in the adjacent forest (Figure 1). The road and forest arrays were 97–150 m and 60–175 m from the shoreline of Brown Lake, respectively. Pitfall traps were 19-L white plastic buckets (ICL Canada, Toronto, Ontario, Canada) buried flush with the soil surface next to the drift fence. A moistened sponge was placed in the bottom of the traps to allow animals to hide under it to prevent drying or sit on top in wet conditions. A 3-mm hole was drilled in the bottom of each bucket to allow rainwater to drain. No sticks were placed in the trap to allow bycatch to escape, as we were sampling other amphibians as well that could have escaped.

Traps were checked every morning from May to September in 2010 and 2011, and all captured animals were processed within 1–2 minutes and released on the opposite side of the fence. Snout-to-urostyle length (SUL) was measured to the nearest 0.5 mm using vernier calipers, and mass was measured with a spring scale (model no. 10020 [20 g] and model no. 10100 [100 g], Pesola, Präzisonswaagen, AG, Switzerland), by placing the animal in small plastic bag and subtracting the mass of the bag. To avoid counting recaptured animals as new captures, frogs were marked using a simple toe clip. All capture dates were converted to Julian dates. Trap-nights were calculated by counting the number of sampling nights multiplied by the number of traps in operation. Catch-per-unit-effort (CPUE) was calculated by dividing the number of frogs captured by trap nights.

Results

Mink Frogs were captured in only six of the 104 traps on the road, and five of the 54 traps in the adjacent forest. All six of these road traps were located closest to the stream in the beaver meadow (within 4–10 m); however, they were 97–150 m from the lake. A total of 35 Mink Frogs were captured in all pitfall traps, with only one recapture. Mink Frogs represented 0.84% of the 4260 anurans of eight species captured. Most captures (33 of 36) were on the east side of the drift fence (proximal to Brown Lake), with only three on the west side (coming from upstream of the beaver meadow). We sampled for a total of 26 159 trap nights (11 917 in 2010 and 14 242 in 2011), but Mink Frogs were captured only in 2011. Captures occurred between 24 July and 3 September with two waves of captures during 30 July to 10 August (14 individuals) and 18–27 August (18 individuals). In particular, nights with precipitation yielded many individuals the following day. In 2010, CPUE was 0.25, requiring 395.69 trap nights to capture one individual. All Mink Frogs were recent metamorphs and could not be sexed. Their size range was 30–39 mm SUL (mean 34.47 mm, SE 0.38, n = 35) and their mass 2.8–5.9 g (mean 4.04 g, SE 0.12, n = 34).

Discussion

Despite an extensive sampling period over two field seasons, Mink Frogs were only captured during a specific period corresponding with metamorphosis (Hedeen 1972) in late summer 2011. Like many ranid frogs, Mink Frog exhibits dramatic fluctuations in population size over time and among sites (Shirose and Brooks 1997). Based on previous studies (Wright and Wright 1949; Hedeen 1972; Gilhen 1984; Leclair and Laurin 1996), all individuals encountered were recent metamorphs (under 39 mm SUL). Although Mink Frogs were captured in pitfall traps only in 2011, adults were heard calling during daylight hours nearby in both 2010 and 2011. Although it is possible that adult frogs could escape from pitfall traps, the large 19-L buckets (38 cm deep) likely prevented such escapes, as many adult and immature Green Frogs (n = 2311) and American Bullfrogs (n = 72) were also captured (LeGros 2012). In addition, Mink Frogs are noted for being late-night callers (Bishop *et al*. 1997; Lepage *et al.* 1997) and may have been even more abundant in the area than daytime calling would suggest.

The activity period for this cold-adapted species is surprisingly short, ceasing by 30 September in

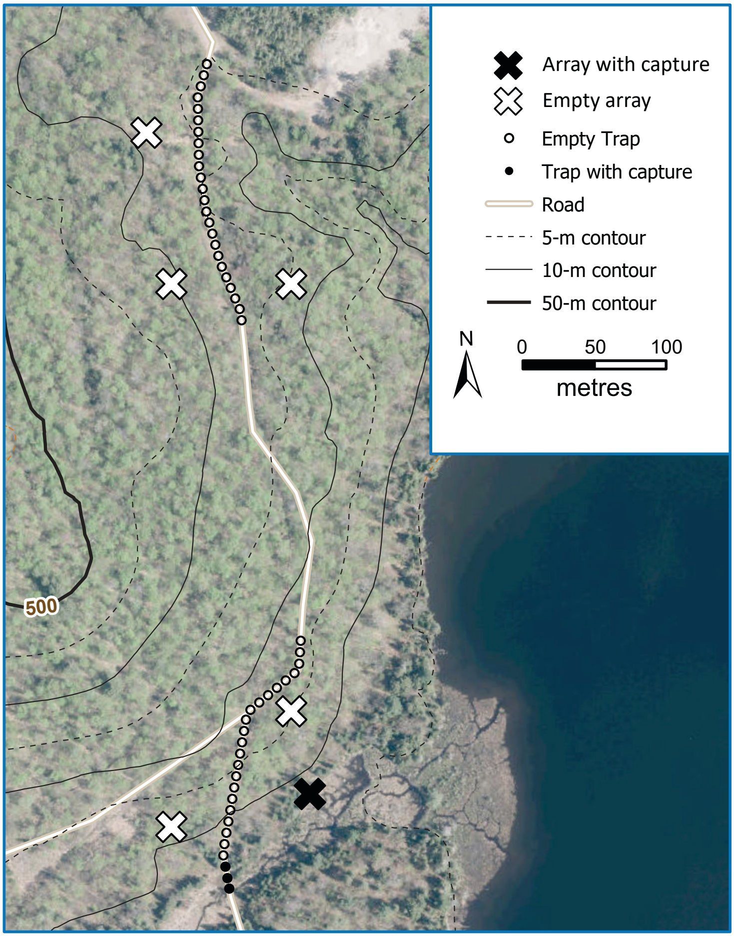

Figure 1. Pitfall traps at the Brown Lake study site, Hunter Township, Algonquin Provincial Park, Ontario, Canada. Circles and Xs indicate paired pitfall traps and arrays, respectively, installed on the unused forest road and in the adjacent forest. Filled symbols represent traps in which Mink Frogs (*Lithobates septentrionalis*) were captured in 2011.

Nova Scotia (Gilhen 1984) and the end of October in Ontario (iNaturalist.org 2020). In Algonquin, our final capture was recorded on 4 September 2011, suggesting a relatively brief period of terrestrial activity for post-metamorphic individuals (42 days between 24 July and 3 September) followed by hibernation. However, Schueler (1987; pers. comm. 10 September 2020) noted that some Mink Frogs were found moving overland in several Ontario locations late in the active season, and many individuals found in October had empty stomachs, suggesting that they were moving to hibernation sites.

Juvenile amphibians are important in maintaining metapopulations, although there are limitations to their ability to disperse long distances, such as small size and a predisposition to rapid water loss and predation (Rothermel and Semlitsch 2002; Lemckert 2004; Smith and Green 2005; Howell *et al.* 2018). Anuran species with short larval periods and small body sizes at metamorphosis, such as American Toad (*Anaxyrus americanus*) and Wood Frog (*Lithobates sylvaticus*), require a pre-dispersal period to improve metabolic function to sustain dispersal activity (Pough and Kamel 1984). In contrast, anurans with longer larval periods and large metamorphic body sizes, such as Green Frog, are capable of near immediate dispersal at metamorphosis (Pough and Kamel 1984). Given that Mink Frogs are particularly prone to desiccation, more so than other immature frogs (Schmid 1965), it is likely that their dispersal is limited to riparian and aquatic habitats to prevent water loss.

The distance between habitat patches and the quality of those patches can also influence rates of dispersal and colonization of amphibians (Howell *et al.* 2018). In our observations, it appears that recently metamorphosed Mink Frogs use riparian habitats, such as streams and beaver meadows, that connect aquatic habitats as corridors for dispersal, as they were not captured at other locations, particularly inland. In the beaver meadow, the stream did have deeper pools that frogs could occupy before hibernation, and if frogs followed the creek upstream 1.7 km, they would encounter another small lake. The use of riparian corridors may not only reduce mortality from desiccation but also provide more feeding opportunities for Mink Frogs, as this species feeds primarily on aquatic prey (Hedeen 1972). By staying close to aquatic habitats, Mink Frogs may also reduce contact with other hazards, such as roads.

Conclusion

Although many species of ranid frogs make overland movements through forest habitats (Lamoureux *et al.* 2002), Mink Frogs rarely do so. However, overland movements may occur at specific times and in concentrated locations, particularly along riparian habitat. Therefore, efforts should be made to maintain connectivity among aquatic habitats to minimize impacts on dispersing amphibians and other wildlife reliant on riparian corridors. In addition, Mink Frogs may not be as affected by road mortality as other ranid frogs because of their habitat preferences during dispersal; however, road construction near riparian corridors and their associated water crossings should be designed to avoid sensitive areas and allow wildlife to follow natural corridors, contributing to the ecological integrity of a site, especially those within protected areas.

Author Contributions

Writing – Original Draft: D.L.L.; Writing – Review & Editing: D.L.L., D.L., and B.D.S.; Conceptualization: D.L., B.D.S., and D.L.L.; Investigation: D.L.L.; Methodology: D.L.L., D.L., and B.D.S.; Formal Analysis: D.L. and D.L.L.; Funding Acquisition: B.D.S., D.L., and D.L.L.

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Note

Further occurrences of melanism in a northern, peripheral, population of Bobcat (*Lynx rufus*)

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Abstract

Although melanism is understood to occur commonly among some felids, it is reported to be most frequent among cat species that occur in humid, tropical, and densely vegetated habitats. Previously, a single record of a melanistic Bobcat (*Lynx rufus*) from eastern Canada (New Brunswick) appeared to be a northern outlier, with all other reports of melanism in this species restricted to the warm, humid, climate of southern peninsular Florida. Here, I document a further five occurrences of melanism in Bobcat from New Brunswick and review evidence that a mutation in an agouti-signalling protein gene may be responsible for melanism in New Brunswick Bobcats.

Key words: Agouti-signalling protein gene; coat colouration; Felidae; genetic mutation; pelage

It has been suggested that an understanding of melanism in felids may shed light on the genetic basis and evolutionary history of pigment diversity and how natural selection has influenced pigment patterns in mammals (Schneider *et al.* 2012, 2015). Furthermore, Candille *et al.* (2007) have noted that an understanding of colour variation in mammals can provide fundamental insights into human biology and disease. Roulin (2014) believes that an increase in the frequency of melanism may reflect either the direct or indirect (i.e., through pleiotropic effects) influence of climate warming.

Although melanism is understood to occur commonly among some felids (Schneider *et al.* 2012), it is reported to be frequent among cat species that occur in humid, tropical, and densely vegetated habitats (Sunquist and Sunquist 2009). This pattern of occurrence would appear to follow Gloger's rule, an ecogeographical rule that states that, among endotherms, more heavily pigmented forms tend to be found in more humid environments, i.e., near the equator (Delhey 2017). Melanism has also been commonly observed in some southern hemisphere felids with distributions that encompass temperate forest, grasslands, open woodlands, and savannah-type habits, including Colocolo (*Leopardus colocolo*), Geoffroy's Cat (*Leopardus geoffroyi*), and Kodkod (*Leopardus guigna*; Sunquist and Sunquist 2009). In fact, among the 23 felid species (out of 37–41) currently recognized in which melanism has been reported to date (Sunquist and Sunquist 2009; Medina and Medina 2019), nearly all have their principal distribution in the southern hemisphere. This is certainly the case for the eight wild cat species in which melanism is reported to be common (Colocolo, Geoffroy's Cat, Jaguar [*Panthera onca*], Jaguarundi [*Puma yagouaroundi*], Kodkod, Leopard [*Panthera pardus*], Oncilla [*Leopardus tigrinus*], and Serval [*Leptailurus serval*]; Sunquist and Sunquist 2009; Schneider *et al.* 2012). Among the remaining 15 species, only Bobcat (*Lynx rufus*) has an essentially northern distribution.

Of the 15 occurrences of melanism in Bobcat previously reported, 13 are from the warm, humid climate of southern peninsular Florida (Regan and Maehr 1990; Hutchinson and Hutchinson 2000; Dubetz 2007). Until now, a single record from eastern Canada (New Brunswick) appeared to be a northern outlier (Tischendorf and McAlpine 1995; but see WMUR News 2020). Here I document further instances of melanistic individuals from the northern, peripheral Bobcat population that occupies New Brunswick, demonstrating a geographic cluster of occurrences, and discuss their significance.

Bobcat occur throughout New Brunswick, where the species approaches its northern range limit (Naughton 2012) and is legally harvested during a November–February trapping season. From 1983 to 2016 (the period during which melanistic Bobcat were obtained in New Brunswick; season closed 1987–1991), 100–800 Bobcat were harvested annually (New Brunswick Fish and Wildlife Branch n.d.)

Tischendorf and McAlpine (1995) reported the first record of a melanistic Bobcat from New Brunswick: a male trapped on 18 November 1983 near Henry Lake, Saint John County. Since then, a further five cases have been recorded (Table 1), all of which I have had an opportunity to examine (four skins, two with skeletons are now in the New Brunswick Museum [NBM] collection; plus the skeleton of one privately held mount; Figure 1). All show the pelage colour pattern described by Ulmer (1941): darkest on the back, lighter on the belly, a scattering of white hairs, and spotting and facial stripes visible and decidedly darker than the background. Older skins that have been exposed to light seem subject to decolourization in the ground colour (i.e., a colour on which other colours are superimposed to create a pattern), such that spotting and facial stripes are more evident on taxidermied animals than fresh-dead specimens that have not been exposed to light for extended periods after death (Figure 2). All New Brunswick melanistic Bobcats were taken in the southcentral and southeastern part of the province (Figure 3) in a landscape mosaic of industrial woodland, cleared forest, agricultural and rough pasture land, and rural communities. Most were trapped, but one was secured as a roadkill. Among the six specimens are three males and two females (sex for one animal unknown).

Investigations of melanism in felids have revealed that this colour morph arose independently among cats on at least eight occasions (Eizirik *et al.* 2003;

Table 1. Occurrences of melanistic Bobcat (*Lynx rufus*) in New Brunswick.

Date	Location	Sex	Confirmation
18 November 1983	Henry Lake, 45.4042°N, 65.6105°W	Male	NBM-MA-4819
~1987	Coburg, 46.0248°N, 64.1179°W	?	Figure 1a
22 January 1998	Little Shemogue, 46.1152°N, 64.0207°W	Female	NBM-MA-5785, Figure 1b
2 December 2000	1.9 km west of Searsville, 47.7125°N, 65.7196°W	Male	NBM-MA-18054
11 January 2013	Gaspereau Forks, 46.2328°N, 65.8508°W	Male	NBM-MA-12400
25 December 2016	0.71 km northeast of Upper Saint-Maurice, 46.48194°N, 64.83611°W	Female	NBM-MA-18069, Figure 1c

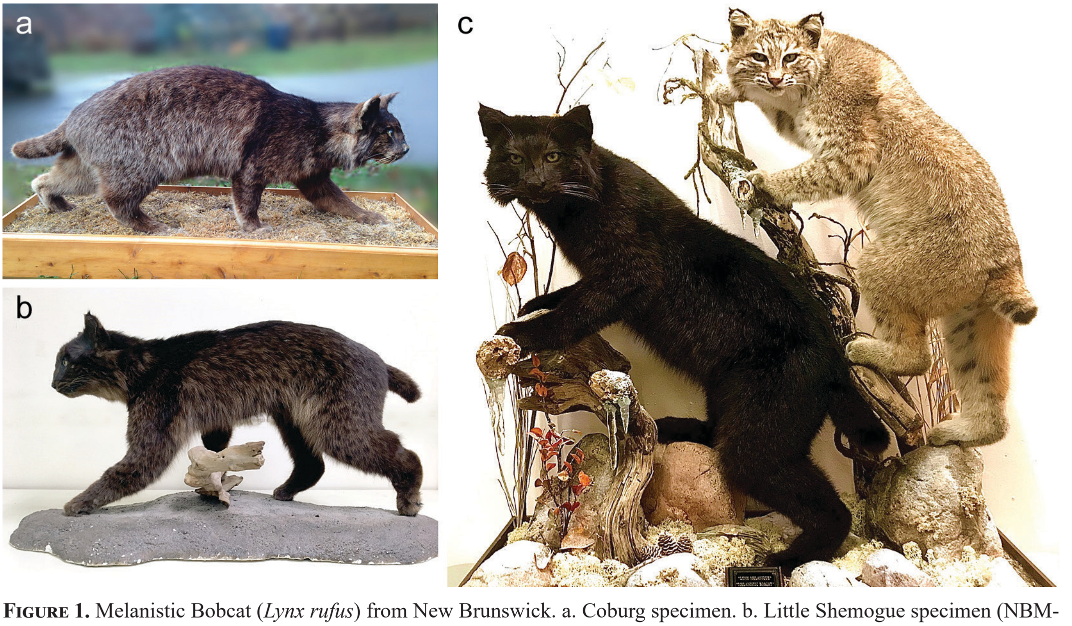

Figure 1. Melanistic Bobcat (*Lynx rufus*) from New Brunswick. a. Coburg specimen. b. Little Shemogue specimen (NBM-MA-5785; skeleton only, mount in private hands. c. Upper Saint-Maurice specimen (NBM-MA-18069) paired with a normal pelage Bobcat. Photos: D.F. McAlpine.

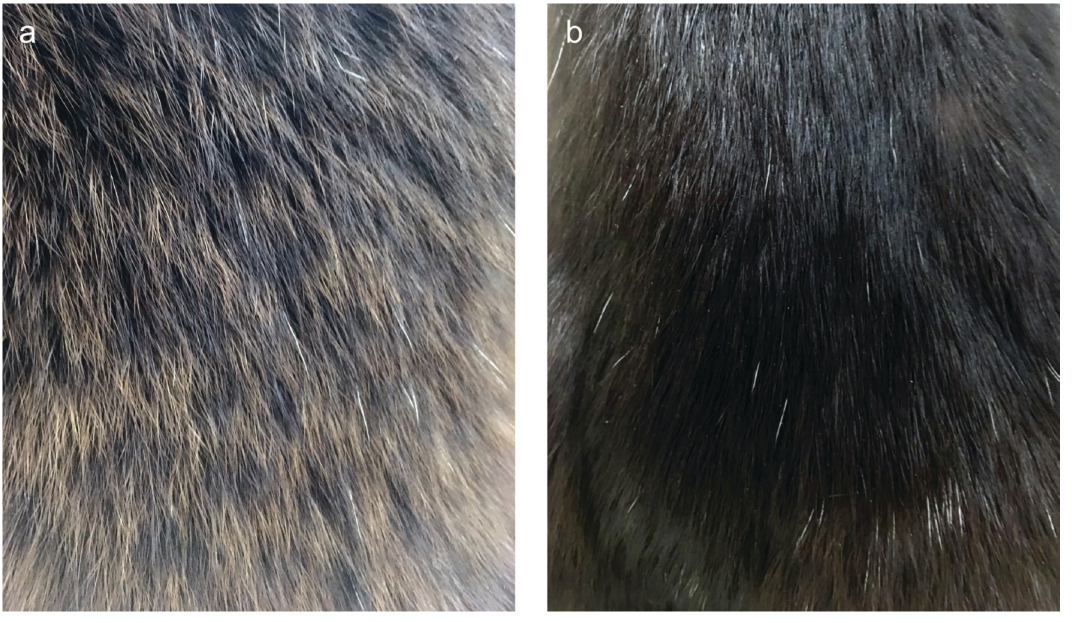

FIGURE 2. Melanistic Bobcat (*Lynx rufus*) pelage detail. a. Little Shemogue specimen. This mount has been exposed to moderate to high light levels and decolourization of the ground colour has made the pattern more visible than in a live or fresh-dead animal. b. Gaspereau Forks specimen (NBM-MA-12400). This specimen was prepared fresh-dead from a roadkill and has since been exposed to very little light. Photos: D.F. McAlpine.

Schneider *et al*. 2012, 2015). Current evidence suggests that melanism in cats is caused most frequently by a loss-of-function mutation in the agouti-signalling protein (ASIP) gene or, less frequently, by a gain-of-function mutation in the melanocortin-1 receptor (MC1R) gene (Eizirik *et al.* 2003; Candille *et al.* 2007; Schneider *et al.* 2012, 2015). This seems to be in contrast with other vertebrates generally, where MC1R has been found to be the more common cause of melanism (Hubbard *et al.* 2010).

It has been suggest that interspecific hybridization may play a role in melanism. Hybridization is not uncommon among some felid species and has been documented between New Brunswick Bobcat and Lynx (*Lynx canadensis*; Homyack *et al.* 2008; Huynh *et al.* 2019). Sunquist and Sunquist (2009) noted that melanism in Wildcat (*Felis silvestris*) may be the result of introgressive hybridization with Domestic Cats (*Felis catus*), but Schneider *et al.* (2015) found no evidence that hybridization might play a role in the presence of melanism among *Leopardus* species. Hybridization between wolves and dogs is known to produce melanistic individuals; however, the genetic mutation involved, a gain-of-function alteration in the beta-defensin 103 gene, appears to be restricted to canids (Candille *et al.* 2007). Although the genetic origin of melanism in Bobcat has yet to be examined, homozygosity for ASIP is associated with a "ghost pattern" of visible spotting and striping over a dark ground colour (Kaelin *et al.* 2012), as reported here for melanistic New Brunswick Bobcat. Although the presence of still-visible spotting among some melanistic felid species has been reported as evidence that coat pattern formation is more complex in cats than mere ASIP-MC1R gene expression (Kaelin *et al.* 2012), any role that hybridization might play in melanism in New Brunswick Bobcat awaits further investigation.

The ecological basis for melanism in felids is poorly understood. ASIP-induced melanism is recessive, MC1R is dominant. Kingsly *et al.* (2009) have suggested that MC1R-induced melanism should be prevalent when the trait is adaptive, but ASIP-induced darkening would be expected when melanism is deleterious. Kingsley *et al*. (2009) have also hypothesized that natural selection should readily produce a rise in MC1R melanism where it is advantageous. ASIP-induced melanism, although taking more time to rise in frequency in a population when favourable, should also persist in the population for longer when negatively selected. Schneider *et al.* (2012) note that the ASIP coding region is quite variable across felid species and that this mutation may be associated with fewer pleiotropic effects in cats and is, thus, less constrained and, for this reason, more often involved in melanism in felids. Furthermore, the high frequency of ASIP-induced melanism in some tropical

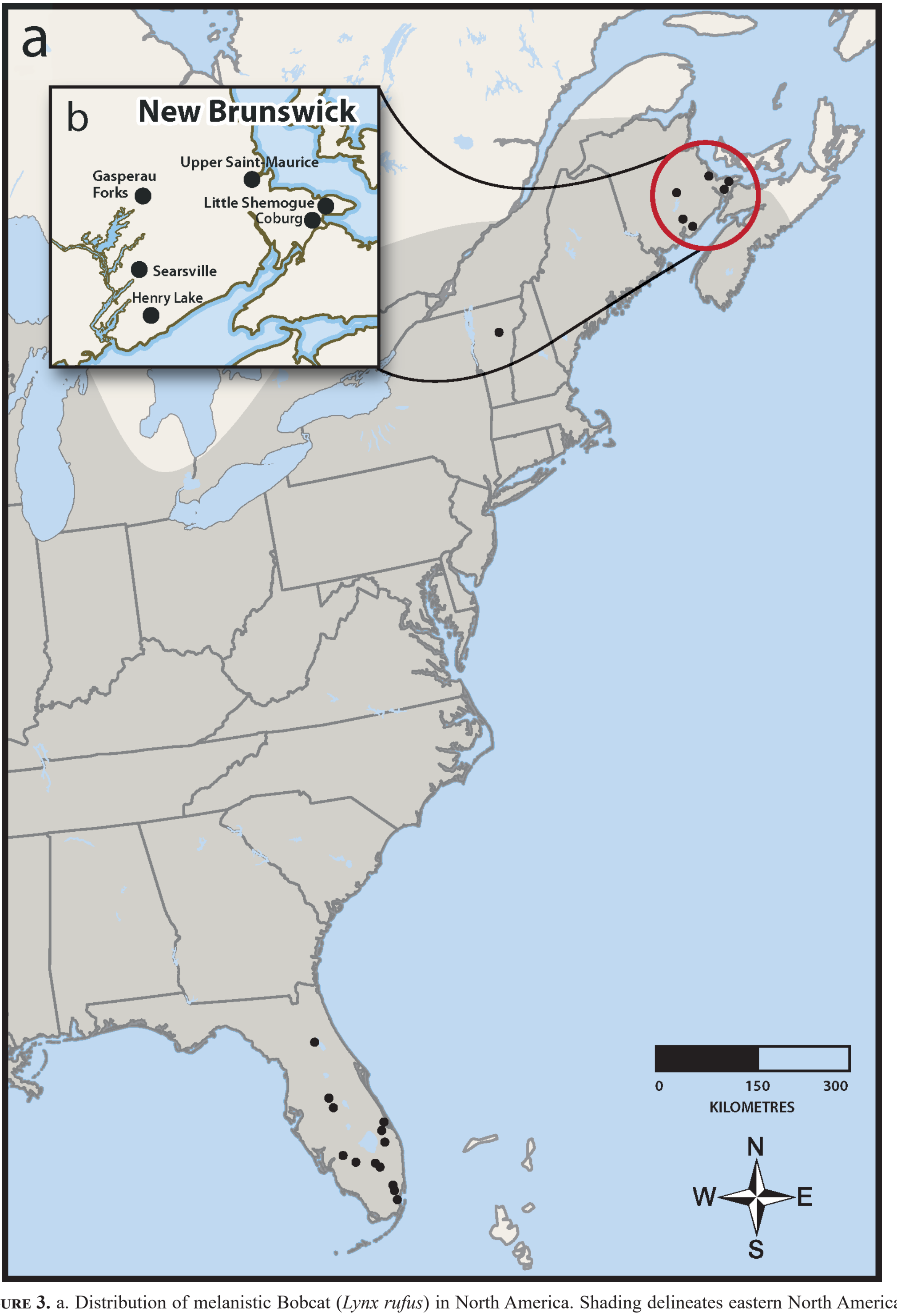

Figure 3. a. Distribution of melanistic Bobcat (*Lynx rufus*) in North America. Shading delineates eastern North American distribution for the species after Naughton (2012). Records for New Brunswick (b) are detailed in Table 1, those for Florida are taken from Regan and Maehr (1990), Hutchinson and Hutchinson (2000) and Dubetz (2007). The Vermont report is from WMUR News (2020).

cat species suggests that this trait may sometimes be adaptive, with recent molecular genetic evidence supporting this (Schneider *et al.* 2015). Although the selective process behind the presence of melanism in New Brunswick Bobcats is unknown, the low frequency of occurrence, the "ghost pattern" of visible spotting in the pelage, and the more common occurrence of ASIP-induced melanism among those felids examined to date (five of eight species), circumstantially suggests that an ASIP gene mutation may be responsible for melanism in these Bobcats.

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Note

Predation of a brown bat (Vespertilionidae*)* by a Green Frog (*Lithobates clamitans*) in Ontario, Canada

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Abstract
On 31 July 2019, a Green Frog (*Lithobates clamitans*) was observed consuming a Big Brown Bat (*Eptesicus fuscus*) at Meux Creek, Neustadt, Ontario. The bat was likely roosting at a nearby undercut bank when it was predated by the frog, which required nearly 90 min to consume its prey. This is the first record of a Green Frog consuming a bat species in Canada.

Key words: Green Frog; *Lithobates clamitans*; Big Brown Bat; *Eptesicus fuscus*; opportunistic feeding; first record; amphibians; bats

The diet of adult (post-metamorphic) Green Frog (*Lithobates clamitans*) is diverse, but consists primarily of invertebrates (Hamilton 1948; Jenssen and Klimstra 1966; Stewart and Sandison 1972; Werner *et al.* 1995); consumption of vertebrates is rare (Jenssen and Klimstra 1966; DeGraaf and Nein 2010). Further, Green Frogs typically consume smaller prey items compared with American Bullfrog (*Lithobates catesbeianus*; Werner *et al.* 1995), which are known to predate opportunistically on vertebrates and especially other frogs (Werner *et al.* 1995; Cross and Gerstenberger 2002; Jancowski and Orchard 2013; Gibson and Hoffman 2019). An important difference between these species is that Green Frogs prefer more terrestrial habitat than bullfrogs and consume a higher ratio of terrestrial prey items compared with other sympatric frog species (Stewart and Sandison 1972; Werner *et al.* 1995). The predation of vertebrates by bullfrogs is common (Werner *et al.* 1995; Jancowski and Orchard 2013; Gibson and Hoffman 2019); however, predation of bats by any species of anuran is rare (Kirkpatrick 1982; Filho *et al.* 2014; Mikula 2015; Mancina *et al.* 2016).

On 31 July 2019, we observed the apparent predation of a bat (Vespertilionidae) by a Green Frog in Meux Creek near Neustadt, Ontario, Canada (44.458°N, 81.018°W, elevation 280 m above sea level). Meux Creek is a perennial stream that is ~15 m wide at this location. The near-stream riparian area was characterized by eroded banks, mowed grass, and cut banks with herbaceous and woody riparian cover. The channel itself consisted of a series of riffles, runs, and pools with some large instream woody debris. The observation occurred when a thrashing disturbance was noted on the riverbank, followed by an object tumbling from the bank into the water. We immediately identified a frog with a large prey item struggling in its mouth. On closer inspection we observed a Green Frog (later confirmed from photos using a dichotomous key) with black, membranous wings protruding from its mouth (Figure 1). The prey item was identified as a bat and likely a Big Brown Bat (*Eptesicus fuscus*) based on regional abundance in 2019 resulting from population declines of Little Brown Bat (*Myotis lucifugus*) related to white-nose syndrome (Frank *et al.* 2014). The frog remained near the bank, motionless, at a depth of ~30 cm, with the bat immobilized in its mouth for 5 min.

During this time, we were able to document the event with digital photographs and a short video. After the frog had consumed most of the bat, we captured the frog in a net to identify both species. We estimated the snout–vent length of the frog at 7.5–8.0 cm. Because the bat appeared to be similar in size,

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FIGURE 1. Green Frog (*Lithobates clamitans*) consuming a Big Brown Bat (*Eptesicus fuscus*), 31 July 2019, Meux Creek, Neustadt, Ontario, Canada. Photo: Fabio Vilella.

we estimated its length at 8–10 cm, which would give it an approximate mass of 11–25 g (NCC 2021). After release, the frog remained underwater near the bank where it took another 90 min to completely consume the bat.

Predation of bats by anurans is known, particularly in the tropics (Gouveia *et al.* 2009; Mikula 2015; Mancina *et al.* 2016), but as far as we know there is no documented evidence of a Green Frog depredating bats in Canada (Mikula 2015). Big Brown Bats (especially solitary males in summer) are known to roost in various crevices (Kurta and Baker 1990), but foliage roosting of vespertilionids appears to be rare in Canada (Davey and Fraser 2007; Huynh 2009). The bank where the frog and bat appeared was ~2 m high with a severe undercut of ~0.75 m. Herbaceous vegetation overhanging the bank was near total and created a dark, shaded undercut that would protect a roosting bat from wind and precipitation. Based on the lack of observations in the literature, this is likely an opportunistic predation of a roosting bat that is unlikely to occur with any frequency.

Our observation represents the first record of a Green Frog consuming any bat species in Canada, and the northernmost record of any frog species predating bats in North America (Mikula 2015). This record confirms *L. clamitans* as an opportunistic predator that will eat prey items larger than those making up the bulk of its diet. Some frog species will wait at bat roosting sites for falling bats (Gouveia *et al.* 2009); however, our discovery yielded no other bats under the cut bank, further reinforcing the conclusion that this was an opportunistic event and unlikely to be a widely distributed behaviour. This observation further expands the knowledge of opportunistic feeding behaviour of amphibians on large prey items and represents a first for a non-bullfrog species in North America.

Author Contributions

Writing – Original Draft: J.J.W.; Writing – Review & Editing: J.J.W., C.M.B., B.J., and F.V.; Investigation: J.J.W., C.M.B., B.J., and F.V.

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Use of Whitebark Pine (*Pinus albicaulis*) seeds by GPS-collared Grizzly Bears (*Ursus arctos*) in Banff National Park, Alberta

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Abstract

Seeds of Whitebark Pine (*Pinus albicaulis*) are a major food for Grizzly Bears (*Ursus arctos*) in the Yellowstone ecosystem. In Canada, Grizzly Bears are known to eat Whitebark Pine seeds, but little additional information, such as the extent of such use and habitat characteristics of feeding sites, is available. Because Grizzly Bears almost always obtain Whitebark Pine seeds by excavating cones from persistent caching sites (middens) made by Red Squirrels (*Tamiasciurus hudsonicus*), it is possible to infer Whitebark Pine feeding when bears are located near excavated middens in Whitebark Pine stands. During 2013–2018, I conducted a retrospective study in Banff National Park using data from 23 Grizzly Bears equipped by Parks Canada staff with global positioning system (GPS) collars. My objectives were to use GPS fixes to determine the percentage of these bears that had been located in close proximity to excavated middens containing Whitebark Pine seeds and to describe the habitat at these excavated middens. I linked 15 bears (65%) to excavated middens and, by inference, consumption of Whitebark Pine seeds. Excavated middens occurred on high-elevation (mean 2103 ± 101 [SD] m), steep (mean 26° ± 8°) slopes facing mostly (96%) north through west (0–270°). Use of Whitebark Pine seeds by at least 65% of the 23 studied Grizzly Bears suggests that conservation of Whitebark Pine in Banff National Park would concomitantly benefit the at-risk population of Grizzly Bears.

Key words: Banff National Park; Grizzly Bear; midden; *Pinus albicaulis*; Red Squirrel; seeds; *Tamiasciurus hudsonicus*; *Ursus arctos*; Whitebark Pine

Introduction

The large seeds of Whitebark Pine (*Pinus albicaulis* Engelmann) are an important seasonal food for Grizzly Bears (*Ursus arctos*) in the Yellowstone ecosystem, Wyoming and Montana, USA (Kendall 1983; Mattson *et al.* 1991). Whitebark Pine seeds weigh about 175 mg, or ~35 times those of Lodgepole Pine (*Pinus contorta* Douglas ex Laudon), and contain ~50% lipid and ~20% protein—a ratio close to that identified as an optimal autumn Grizzly Bear diet (Lanner and Gilbert 1994; Erlenbach *et al.* 2014). Grizzly Bears typically obtain Whitebark Pine seeds by excavating the persistent cone-caching sites (middens) of Red Squirrels (*Tamiasciurus hudsonicus*; Kendall 1983; Mattson and Reinhart 1997; Costello *et al.* 2016).

Although Mattson and Reinhart (1997) stated that Yellowstone Grizzly Bears fed almost exclusively on Whitebark Pine seeds when cones were available, an analysis of movement data from 72 individual global positioning system (GPS)-collared Grizzly Bears recorded in Yellowstone during 2000–2011 revealed that about a quarter of the autumn home ranges used by these bears did not contain Whitebark Pine habitat (Costello *et al.* 2014). Overall, a third of the sampled Grizzly Bears made little or no use of habitat with Whitebark Pine, even though the data were about equally divided between males and females and between years with good and poor cone production and came from areas and years showing variable amounts of Whitebark Pine mortality caused by Mountain Pine Beetle (*Dendroctonus ponderosae*).

Recent study has shown that Grizzly Bears in the Canadian Rocky Mountains also excavate Red Squirrel middens to obtain seeds of Whitebark Pine (Raine and Riddell 1991; Hamer and Pengelly 2015). However, beyond confirmation of use, little additional information is available on the importance of Whitebark Pine seeds to Grizzly Bears outside the Yellowstone ecosystem (Ciarniello 2018). Because Red Squirrel middens tend to be persistent and conspicuous features on the landscape and because evidence of excavation by bears tends to persist, I used available locations of GPS-collared Grizzly Bears in Banff National Park to retrospectively investigate these bears' use of Whitebark Pine seeds cached in squirrel middens. My

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objectives were to determine the percentage of collared Grizzly Bears that could be linked to excavated middens containing Whitebark Pine seeds and to describe habitat characteristics associated with these putative feeding sites. I assumed that Grizzly Bears located during August–November at sites containing excavated Red Squirrel middens in Whitebark Pine habitat could be categorized as having most likely fed on Whitebark Pine seeds.

Study Area

My study area was defined by the home ranges of GPS-collared bears ($n = 26$) that fell within Banff National Park. I also included some GPS locations to the south and west, in Kootenay and Yoho national parks, within 2 km of the Banff National Park boundary. Because bears were GPS-collared for a study of mortality associated with train strikes (Hopkins *et al.* 2014), most bears were captured in the Trans-Canada Highway–Canadian Pacific Railway transportation corridor running through the centre of Banff and Yoho national parks. The home ranges of the collared bears were mainly in the Bow Valley and adjacent watersheds, in the central portion of Banff National Park. The Bow Valley transportation corridor runs 70 km northwest–southeast, from the eastern boundary of Banff National Park in the Front Ranges of the Rocky Mountains to the British Columbia–Alberta boundary on the Continental Divide, in the Main Ranges of the Rocky Mountains.

There is a diminishing moisture gradient between the Continental Divide, which intercepts moist air moving inland from the Pacific Ocean, and the more arid rain-shadow of the Front Ranges. Subalpine forests in Banff National Park are dominated by Interior Spruce (*Picea engelmannii* Parry ex Engelmann var. *engelmannii* × *Picea glauca* (Moench) Voss), Subalpine Fir (*Abies lasiocarpa* (Hooker) Nutall), and Lodgepole Pine. Subalpine Larch (*Larix lyallii* Parlatore) and Whitebark Pine occur in some upper subalpine stands (Achuff 1982; Corns and Achuff 1982). Limber Pine (*Pinus flexilis* E. James), a species normally found in wind-swept, arid sites at lower elevations, occasionally occurs in the upper subalpine with Whitebark Pine on some steep, south- and west-facing Front Range sites exposed to solar insolation and desiccating foehn (Chinook) southwesterly winds (Hamer 2016). Whitebark Pine has greater abundance in the Main Ranges of Banff National Park, and is less common in more arid, eastern portions of the Front Ranges (Hamer and Pengelly 2015; Hamer 2016; I. Pengelly and A. Buckingham unpubl. data 2010).

Methods

I conducted fieldwork during 2013–2018 using data from 21 of 26 Grizzly Bears equipped with GPS collars as part of a 2010–2016 study of Grizzly Bear mortality in Banff and Yoho national parks (Whittington *et al.* 2018). Preliminary results from three of these collared bears (Bears 72, 128, 138) were reported by Hamer and Pengelly (2015); I have included these data here, given that my study is an extension of that previous work. I excluded two of the 26 bears (Bears 140, 149) because their collars provided only four GPS fixes from late summer–autumn (when pine seeds are eaten; Kendall 1983), and I was unable to study the GPS fixes of Bear 161 because unseasonal snowfalls in September 2018 prohibited data collection. In addition, based on an aerial survey for five-needle pines (I. Pengelly and A. Buckingham unpubl. data 2010), I judged that home ranges of four bears, located in the arid, eastern slopes of the Front Ranges, likely lacked Whitebark Pine stands; for two of these bears (Bears 135, 155), I found Limber Pine in the home ranges but no Whitebark Pine, and I, therefore, excluded the other two bears (Bears 131, 134) from the study.

For the 21 studied bears, I considered GPS fixes dating from August through November. Of this subset of date-constrained GPS fixes, I selected a smaller subset for field inspection based on knowledge of five-needle pine distribution in Banff National Park (Hamer and Pengelly 2015; Hamer 2016) and on habitat determined from the geographical information system, QGIS (v. 2.14; QGIS Development Team 2018) with topographic and Google Satellite layers. I selected fixes in habitat where Whitebark Pine was likely to occur: forest and open forest at higher elevations (~1800–2300 m) above valley bottoms. Finally, I also attempted to select GPS fixes for field inspection that were within 5 km of motor vehicle access, although three excavated middens and six other sites checked for middens were 5–14 km from the nearest road.

As in a concurrent study (Hamer 2016), I attributed all excavations found in middens to bears, and all excavated middens I observed contained either Whitebark Pine or Limber Pine cones or cone scales; only one of these excavated middens contained both Whitebark Pine and Limber Pine cones (Hamer 2016), and it was not possible to quantify the five-needle pine cones or cone scales in the middens. Bears also excavate middens found at valley-bottom beside the Canadian Pacific Railway in Banff National Park to obtain anthropogenic seeds gathered by Red Squirrels from railway car spillage (Put *et al.* 2017); these excavations, being distant from Whitebark Pine and Limber Pine, are not pertinent to my study. If I found an excavated Red Squirrel midden containing Whitebark Pine cones or cone scales, I classified this location as a putative Whitebark Pine feeding site, and I inferred that bears with GPS fixes (see Table 1) near this site had consumed Whitebark Pine seeds. It is possible that some of the excavated middens were a result of activity by American Black Bears (*Ursus americanus*); however, my study addressed Grizzly Bear proximity to excavated middens with the inference being that a Grizzly Bear near an excavated midden was seeking five-needle pine seeds at the midden.

To reduce the likelihood of obtaining false positives from coincidental overlap of GPS fixes with excavated middens, I attempted to obtain, for each bear, two instances of GPS locations near excavated middens (hereafter referred to as links) indicating possible consumption of Whitebark Pine seeds. Once two links were achieved, I shifted field effort to other bears. To reduce the likelihood of obtaining false negatives when bears lacked evidence of feeding on Whitebark Pine seeds, I spent 5.3 ± 3.6 (SD; range 2–9) field days searching their GPS fixes. This field effort was not quantifiable in terms of GPS fixes investigated on the ground because some bears had low fix rates (e.g., one fix/4 h) whereas other bears had up to one fix/min; the number of fixes at accessed sites varied from one to many, and some sites, when field-checked, proved to lack Whitebark Pine.

When an excavated midden was found near a GPS location fix, I recorded midden size, slope aspect, slope steepness, basal area of trees using a 2 m^2/ha prism, distance to nearest Whitebark Pine tree, and distance between the nearest GPS location fix and midden using a hand-held GPS unit (Garmin GPSMap 60, Olathe, Kansas, USA). I also checked for presence of Whitebark Pine cones and cone scales (Hamer and Pengelly 2015). Middens were recorded only once when calculating summary statistics of site parameters, regardless of the number of linked GPS fixes whether from the same bear on different dates or from different GPS-collared bears.

I established one paired plot with each excavated midden using a hand-held GPS unit to place the plots 50 m map distance from the midden and on the same elevational contour. Comparisons between excavated middens and plots were made using the non-parametric Wilcoxon paired-sample test in R (Wilcox.test, two-sided, v. 3.4.3; R Core Team 2014). Comparisons were not made for either slope aspect (which will usually remain essentially unchanged over 50 m) or elevation (which was identical for midden and matched plot given the methods used).

Results

Fifteen of the 21 studied Grizzly Bears (71%) were linked to excavated middens containing Whitebark Pine seeds. More conservatively, 15 of 23 bears (65%) were linked to these feeding sites when including the two bears (Bears 131, 134) omitted from analyses because their home ranges did not appear to include Whitebark Pine. The field signs linking bears to Whitebark Pine seeds were located a mean distance of 12 ± 14 (SD) m (range 0–49 m) from the associated Grizzly Bears' GPS locations. Observations with substantial (22–49 m) distances between fix and midden were viewed as putative links between collared bears and Whitebark Pine feeding sites when corroborated by additional, supporting field evidence

TABLE 1. Field evidence linking locations of GPS-collared Grizzly Bears (*Ursus arctos*) to 29 excavated Red Squirrel (*Tamiasciurus hudsonicus*) middens in Banff National Park, Alberta, 2013–2018.

Grizzly Bear	Distance from excavated midden,* m	Corroborating field evidence
Bear 122 Bear 122	22 36	Bear 122 had eight fixes within ~0.1 ha; two excavated middens were adjacent, one on contour to the right and one on contour to the left of the 0.1-ha site.
Bear 125	29	Bear 125's GPS fix fell 29 m from a 50 m^2 excavated midden but 4 m from an adjacent, undug, 11 m^2 satellite midden (Hamer and Pengelly 2015); Bear 125 was also located 6 m from an excavated midden at another site.
Bear 160	35	Bear 160 was also located 3–11 m from excavated middens at three other sites.
Bear 64	39	Four excavated middens occurred within 4 ha; Bear 64 was also located 9 m from an excavated midden at another site.
Bear 141	45	Two excavated middens occurred 45 m apart; Bear 141's GPS fix was 12 m from one and 45 m from the other.
Bear 130	49	This excavated midden plus four others occurred along ~300 m linear distance of a forested ridge proximal to Bear 130's GPS fix; Bear 130 was also located 6 m from an excavated midden at another site.

Note: GPS = global positioning system.
*In 22 cases, bears were located <14 m from an excavated midden (mean 5 m, range 1–13 m). A proximity of ≤13 m establishes a strong link between GPS-collared bears and feeding sites where bears obtain Whitebark Pine seeds.

(Table 1). Twelve of the 15 bears were linked to at least two excavated middens. Three bears (Bears 136, 143, 144) were linked to single excavated middens, although Bear 136 was also linked to scats containing >90% pine seeds, found in a bedding site and dating to three GPS fixes made 20 days before my field investigation; this site was 2.2 km from an excavated midden where Bear 136 had been located one day before his presence at the bedding site (D.H. pers. obs.). All excavated middens contained Whitebark Pine cones or cone scales; one midden contained both Limber Pine and Whitebark Pine cones (Bear 130; Hamer 2016). Mean midden size was 76 ± 47 m^2 (range 18–181 m^2, $n = 26$).

Excavated middens occurred on all slope aspects, although only one midden occurred on a slope facing northwest (270–359°); midden locations are determined by Red Squirrels. The observed frequency of slope aspects did not differ from that expected if the four cardinal directions (315–44° north, 45–134° east, 135–224° south, 225–314° west) were equally represented ($\chi^2_3 = 3.8$, $P = 0.28$, $n = 26$). Excavated middens were on steep slopes (mean 26 ± 8°, range 6–38°, $n = 26$) in upper subalpine habitat (elevation mean 2103 ± 101 m, range 1860–2280 m, $n = 28$).

Compared with surrounding habitat as measured at paired plots 50 m distant, excavated middens were on slopes that were significantly less steep and in stands with significantly greater basal area of both Subalpine Fir and all coniferous trees (Table 2).

Discussion

The main finding of this study was that most GPS-collared Grizzly Bears (15 of 21, 71%) were linked to excavated middens containing Whitebark Pine seeds. Of the remaining six bears, some may be false negatives because time and difficult access limited ground-checking to a small subset of each bear's GPS fixes. In addition, my conclusion that four bears (Bears 131, 134, 135, 155) did not have Whitebark Pine stands in their home ranges remains to be confirmed with further field observation. The Front Ranges north of the Bow Valley in Banff National Park do not appear to contain Whitebark Pine stands, and feeding on Whitebark Pine seeds was not reported in earlier work along the eastern slopes of this portion of Alberta (Russell *et al.* 1979; Hamer and Herrero 1987; Munro *et al.* 2006).

My study had several limitations and caveats. First, the mean separation between fixes and excavated middens was 12 m but ranged up to 49 m. The larger separations were accepted as valid links to Whitebark Pine when other evidence, as reported in Table 1, supported this conclusion. One bear (Bear 158) was separated by 23 m from an excavated midden, but had no other links. Furthermore, this fix dated to 10 August, a time when bears normally feed on fleshy fruits. For all other bears, fixes linking to Whitebark Pine dated from September (65%), October (28%), and November (7%). I classified Bear 158 as lacking a link to a Whitebark Pine feeding site. Second, some separation between fix and midden may reflect GPS error of both collar and my hand-held unit, especially

TABLE 2. Habitat characteristics at 22 excavated Red Squirrel (*Tamiasciurus hudsonicus*) middens compared with 22 random plots 50 m distant from excavated middens near location fixes from GPS-collared Grizzly Bears (*Ursus arctos*) in Banff National Park, Alberta, 2013–2018.

	Excavated middens			Paired plots			Wilcoxon paired-sample test	
Site variable	Mean	SD	Range	Mean	SD	Range	Wilcoxon *V*	*P*
Distance to GPS fix, m	10	11	1–36	—	—	—	—	—
Elevation, m*	2102	105	1861–2281	—	—	—	—	—
Slope steepness, °	26	7	6–38	32	6	23–48	19.5	< 0.01
Distance to nearest Whitebark Pine, m	8	12	1–42	12	19	1–80	55.5	0.20
Basal area, m^2/ha								
Whitebark Pine (*Pinus albicaulis*)	9	13	0–54	7	7	0–24	83	0.45
Interior Spruce (*Picea engelmannii* var. *engelmannii* × *Picea glauca*)	17	13	0–24	11	10	0–30	185.5	0.06
Subalpine Fir (*Abies lasiocarpa*)	19	16	0–52	9	11	0–44	126.5	0.02
All conifer species	47	11	28–68	29	17	0–78	201	< 0.01

Note: GPS = global positioning system, SD = standard deviation.
*Plots have the same elevation as paired middens; see Methods.

in narrow, steep-walled, or heavily-forested valleys. Even in flat and relatively open terrain, mean location errors of 8–12 m are found from GPS collars (D'Eon and Delparte 2005). Finally, for the two bears that had only single links to Whitebark Pine, there is an increased chance that I obtained a false positive result, compared with the 13 bears with two or more links. Weighing against this possible error is the chance of failing to detect seed use because of the intermittent fixes obtained by GPS collars. The collars used on Banff Grizzly Bears typically obtained fixes every four hours and thus could have obtained locations before and after, but not while, a bear was at a midden.

I did not find evidence that Grizzly Bears in Banff National Park harvested pine cones directly from trees in this or a related Limber Pine study (Hamer 2016). A similar conclusion was reached in the Yellowstone ecosystem where claw marks on tree trunks or broken branches were not observed (Kendall 1983). However, bears do climb for cones (Kuhn and Vander Wall 2007), including Grizzly Bears (D. McIntyre pers. comm. 31 March 2014; C.R. McLellan pers. comm. 18 September 2018). My study also did not address the extent of annual use of Whitebark Pine seeds by GPS-collared bears.

Some middens were thoroughly excavated and, in some cases, an animal trail was visible on the forest floor, leading into the midden. Learned behaviour may contribute to habitual use: one excavated midden had GPS fixes from a female Grizzly Bear (Bear 64) dating to 25 September 2012, as well as fixes from three of her offspring on 6 September 2014 (Bear 144), 20 September 2014 (Bear 148), and 10 September 2015 (Bear 160). Conversely, a second female Grizzly Bear (Bear 72) and two of her offspring (Bears 142, 143) had just one link to Whitebark Pine (Bear 143). These bears focussed on fruits of *Vaccinium* spp. and Black Crowberry (*Empetrum nigrum* L.) and roots of Yellow Hedysarum (*Hedysarum sulphurescens* Rydberg) during late summer and early autumn at the GPS fixes I investigated. Dietary differences among individual Grizzly Bears have been documented in other populations (Christensen *et al.* 2005; Edwards *et al.* 2011).

Grizzly Bears in the Yellowstone ecosystem tend to experience lower mortality rates in years when Whitebark Pine cones are abundant, a result attributed to at least two factors. First, Whitebark Pine feeding sites typically occur in high-elevation sites remote from high levels of human activity. Second, human–bear conflicts (which predictably occur in less-secure habitat) are a common cause of Grizzly Bear mortality (Mattson *et al.* 1992). Whitebark Pine cone abundance was the highest-ranked habitat covariate in models explaining the survival of Grizzly Bears in the Yellowstone ecosystem for 1993–2001 (Haroldson *et al.* 2006). In Banff National Park, Grizzly Bear mortality is largely human caused: 75% for females and 86% for males (Garshelis *et al.* 2005). Thus, Grizzly Bears that feed on Whitebark Pine seeds, if they occupy habitat that is remote from the Bow Valley transportation corridor and other foci of human activity, may experience lower risk of mortality. Further, the results of my study—where roughly two-thirds of the 21 studied Grizzly Bears were linked to Whitebark Pine feeding sites—suggest that a substantial portion of the Banff Grizzly Bear population may so benefit.

In Yellowstone, Whitebark Pine has been subject to high mortality, and use of this secure habitat by Yellowstone Grizzly Bears may be diminishing (Costello *et al.* 2014). Whitebark Pine surveys in the Canadian Rocky Mountains during 1996–2004 found high levels of infection (60–73%) by White Pine Blister Rust (*Cronartium ribicola*) both south (Waterton Lakes National Park) and north (Jasper National Park) of Banff National Park, but Banff had relatively low levels of infection (16%; Smith *et al.* 2008). Reassessment in 2009 found that infection and mortality were increasing, but, again, levels remained lower in Banff National Park (Smith *et al.* 2013). The predicted loss of Whitebark Pine from the effects of White Pine Blister Rust was one of the reasons for the Committee on the Status of Endangered Wildlife in Canada to assess the species as Endangered (COSEWIC 2010), which led to its listing as Endangered under the Canadian *Species at Risk Act* (SARA Registry 2019). Hence, managers may be able to provide for two at-risk species by conserving Whitebark Pine in a region that currently experiences lower than expected mortality from White Pine Blister Rust, at the same time providing secure feeding habitat for, according to my results, a substantial portion of Banff National Park's Grizzly Bear population.

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A tribute to Arthur T. Bergerud, 1930–2019

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Dr. Arthur T. (Tom) Bergerud (Figure 1), aged 89, passed away on 27 November 2019. He left us to mourn the loss of the "Caribou biologist" who was also a provocative thinker on animal behaviour and population dynamics in wildlife, an activist for the specific causes he knew needed to be heard, and a respected professional to those who were blessed with time to get to know him as naturalist, scholar, peer, friend, and mentor. Tom was born on 11 November 1930 in Minneapolis, Minnesota, to Alf and Marjorie Bergerud. Alf was a lawyer and popular state politician for 30 years, and General Counsel and President of the midwestern grocery store chain, Red Owl. At its peak, the Red Owl chain had over 400 stores. Alf served a week shy of 11 000 days in public office.

Tom found little of interest in his father's pursuits, instead spending much of his youth in outdoor adventures. Always enamoured of nature, Tom recounted to many the story of his first visit to the Bell Museum of Natural History on the St. Paul campus of the University of Minnesota. There, he saw a diorama depicting a cranberry bog on the Red Lake Peatland, about 100 km south of the Manitoba–Ontario border; the diorama featured taxidermy mounts of among the last Caribou (*Rangifer tarandus*) seen alive from this location in the state of Minnesota (Figure 2). It was on seeing this magnificent display that Tom convinced himself to be that "Caribou biologist" who could fight for the conservation of the species so emblematic of the boreal forest and much of the tundra of Canada and Alaska.

Tom's academic and professional career started in 1953 with a B.Sc. in Wildlife Management from Oregon State University, after which he began work as a Fish and Wildlife Specialist at the Delta Waterfowl Research Station in Minnedosa, Manitoba. His friendship there with Hans Albert (Al) Hochbaum almost led to M.Sc. research on ducks, but Tom knew that his two years of U.S. Army service was imminent, so this plan was put aside. After his army service, Tom was hired in 1956 as a District Wildlife Biologist in St. John's, Newfoundland and Labrador, and by 1960 became Director of the Province's Game Division.

While in Newfoundland and Labrador, Tom became familiar with parts of Canada that always remained dear to him. He published well into the

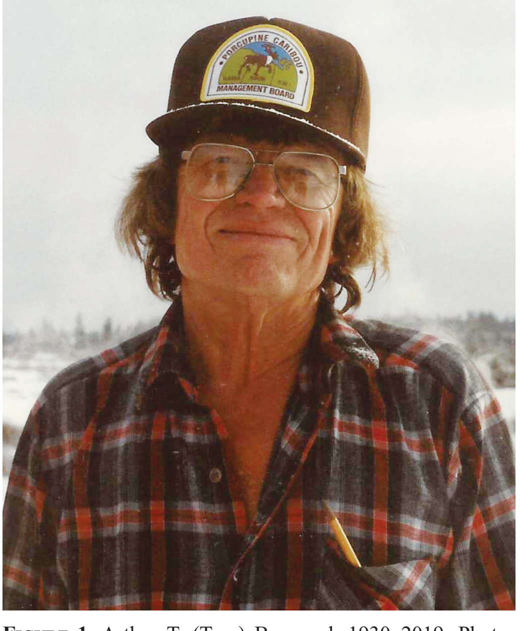

Figure 1. Arthur T. (Tom) Bergerud, 1930–2019. Photograph taken near the Kluane Lake Research Station *en route* to the Third North American Caribou Workshop held in Chena Hot Springs, Alaska, in November 1987. Photo: H. Butler.

FIGURE 2. Woodland Caribou (*Rangifer tarandus*) diorama in the original Bell Museum of Natural History, St. Paul, Minnesota, with famed painted backdrops by Francis Lee Jaques, ca. 1940. The diorama was viewed by visitors until renovation of the museum in 2016. Photo: P. Carroll, Wikimedia Commons.

1970s on some of the basics in monitoring Caribou and on the unique Caribou dynamics on the island of Newfoundland. Tom also used this time to embark on an M.Sc. degree in Wildlife Management from the University of Wisconsin in Madison (Bergerud 1961a) and a Ph.D. degree from the University of British Columbia (Bergerud 1969a). By 1971 he had published a summary on what he knew about Caribou in Newfoundland in No. 25 of the widely read *Wildlife Monograph* series (Bergerud 1971a). During this first part of his career, Tom also found time to help raise his first young children who all experienced rural life on the Avalon Peninsula.

Tom's publishing career spanned seven decades and over 100 published papers, and in the weeks before his passing, he did not arrest his passion for science. He could be found working on improvements to an earlier draft of his last manuscript, which documents the demise of the Caribou population on the Slate Islands, Ontario. It was published in the previous issue of *The Canadian Field-Naturalist* (Bergerud *et al.* 2020) and completes a part of Tom's career that started in the early 1970s, testing his hypothesis that Caribou in North America are limited by Gray Wolf (*Canis lupus*) predation (Bergerud 1974a). Regrettably, illustration of this hypothesis along the north shore of Lake Superior includes the near extirpation of Caribou from this part of their range, even in protected areas like Pukaskwa National Park (Bergerud *et al.* 2014). Tom made early alarm calls for this region (Bergerud *et al.* 2007), and pleas for wolf management in many other areas where Caribou were threatened (Bergerud 2007).

Tom assisted wildlife conservation and management in Newfoundland and Labrador's pioneering years far beyond the work on Caribou in Newfoundland, by conducting research on Caribou in Labrador (Bergerud 1967a), and on Willow Ptarmigan (*Lagopus lagopus*; Bergerud and Mercer 1966, 1972; Bergerud and Huxter 1969a,b; Bergerud 1970a,b, 1971c, 1972a), Arctic Hare (*Lepus arcticus*; Bergerud 1967b), Moose (*Alces americanus*; Bergerud *et al.* 1962, 1968; Bergerud and Manuel 1969), American Marten (*Martes americana*; Bergerud 1969b), and American Beaver (*Castor canadensis*; Bergerud and Miller 1977) in Newfoundland. His last paper specific to Newfoundland (Bergerud 1983a) popularized in *Scientific American* the story of a unique predator, Canada Lynx (*Lynx canadensis*), which contributed to Caribou calf mortality at levels that could account for population decline in a 'simple ecosystem' driven by declines in Snowshoe Hare (*Lepus americanus*). The beauty of that paper was in demonstrating the role of prey switching.

Perhaps it was his use of the word "simple" in the title of the *Scientific American* paper that set Tom up for later criticism. It was almost two decades later that Coyotes (*Canis latrans*) became established in Newfoundland and played the role of the Gray Wolf in increasing calf mortality, as well as raising the vulnerability of Caribou in this part of the world. Tom's hypothesis of the predator's role for Caribou decline was illustrated once again, this time by a new set of researchers who confirmed not just the likelihood of Tom's hypothesis involving canids, but also the importance of the bear and lynx as sources of calf mortality in Caribou (Mahoney *et al.* 2016; Lewis *et al.* 2017). Tom's tradition for good wildlife research in Newfoundland and Labrador continues.

Tom knew of the two main controversial elements to his career, and stick-handled them well. The first came with his publication of a paper with a title that named Caribou "buffalo of the North" (Bergerud *et al.* 1984b), a reference to their vulnerability to overharvest or poaching that can push a species to extirpation, like what happened earlier to Bison (*Bison bison*). The 1984 paper was motivated by the need for responsible construction of pipelines and highways in the north of Canada, in part to reduce access by hunters, but also by concerns about logging and other developments in the south of Canada. It was in this paper that the idea first surfaced that higher alternate prey abundance and subsequent high wolf densities in the southern and more disturbed portion of British Columbia (BC) were the proximate cause for Caribou declines. Tom recognized that logging *per se* was not detrimental but that it led to a cascade of changes in interactions with Caribou and their predators. Logging increased access by wolves and humans, increased density of predators with increases in alternate prey, and reduced the area of large predator-free habitat refuges for Caribou calving.

The "buffalo of the North" paper, published in *Arctic*, came at a controversial time in Canadian history, when the repercussions of Justice Thomas Berger's report on the potential effects of developing the Mackenzie Valley pipeline were resounding in the media. Bergerud *et al.* (1984b) twice cautioned about interpreting correlations of events in the population dynamics of Caribou as causes for effects. In addition, the authors attest agreement with the warning by C.C. Shank (1979, of the Arctic Institute of North America, University of Calgary, who wrote one of the industry-led reviews of effects of pipelines on northern mammals, as cited in Bergerud *et al.* 1984b: 8) that:

> there is a potentially infinite universe of manners in which human activity can influence animal populations and merely demonstrating that one factor is not operative does not negate the influence of the remainder of possible factors.

Nevertheless, the sweeping review that encompassed Tom's experience with Caribou and their conservation at this time led some critics to believe that he and his co-authors (1) surrendered themselves to industry, (2) disregarded the potential that individual effects of disturbance on Caribou may translate to cause-and-effect relationships at the population level, (3) filled their paper with inaccuracies in citation and omission of examples of documented effects of disturbance on *Rangifer tarandus*—for some reason, largely on Reindeer in Eurasia—and (4) referenced the literature selectively to make their points. These charges, in the form of letters to the Editor of *Arctic*, were humbly corrected by Bergerud *et al.* (1984c) and not so humbly confronted by Bergerud and Jakimchuk (1985). In the second response, Tom and consulting biologist Ronald Jakimchuk dryly extolled the virtues of Tom's having established 18 new Caribou populations, and of his helping to illustrate, largely in Newfoundland, that curtailing of regulated and unregulated hunting can restore Caribou populations. We suggest that a call for curtailing overharvest from all sources was the ultimate purpose of the Bergerud *et al.* (1984b) paper.

The second controversy arose a year later, when Tom and BC Ministry of Environment biologist John Elliott co-wrote the most memorable paper in Tom's bibliography (Bergerud and Elliott 1986). In it, they reviewed Caribou populations in northwestern BC, using reports of provincial biologists over approximately six decades on the harvest of Gray Wolves, Moose, and Caribou, including a period during 1949–1962 when wolves were controlled not only by bounty, but also by poisoned bait. They reviewed Gray Wolf and Caribou census data collected during their own experimental wolf control measures in 1977–1982 on one of the populations and compared to other areas without wolf control. The outcome matched Bergerud's (1974a) hypothesis on wolves limiting Caribou, although the work was criticized for rather coarse measures of demographics that spanned so many decades. What was undeniable was that during the experimental wolf control, populations increased predictably by 6% per year when no such increases occurred for the adjacent reference populations.

Figure 10 in Bergerud and Elliott (1986) increased the scope of the five Caribou populations it described to an additional 17 populations where Caribou calf counts were previously published, plus an additional 13 populations where Caribou mortality was estimated, in eight cases by some of the first radio-collared Caribou studies. Drawing on work from 1968 to 1985 in Caribou populations spanning Alaska and Canada, where Gray Wolf densities were also estimated, Bergerud and Elliott (1986) showed—Tom's graphics were always comprehensive—that mortality balanced recruitment at a point corresponding to 12% calves in a survey. This point matched a threshold density of 6.5 wolves per 1000 km^2. The figure was reproduced at the beginning of Tom's "open letter" written 20 years later and calling for management of wolves as an urgent conservation measure (Bergerud *et al.* 2007); it is still frequently referenced by those urging for or implementing wolf control.

Part of what made Bergerud and Elliott's (1986) paper so elegant was how they showed that the expansion of Moose southward and westward in BC was correlated with increases in the threshold density of wolves that then corresponded to periods of Caribou decline. Moose were bigger prey at higher densities and could support more wolves than Caribou alone. The argument, while not a 'smoking gun', was a hypothesis on an indirect interaction between Moose and Caribou, mediated by their common predator, and based in Robert Holt's (1977) idea that 'apparent competition' could structure ecological communities. Indeed, there was cause for less controversy: calls for management of wolves could include reducing populations of Moose or other ungulates more abundant than Caribou, an argument that could be inferred from Bergerud and Elliott's (1998) second paper reviewing a similar geography in BC. Apparent competition was later identified by Tom, and accepted by most biologists, as a driver in the evolution of Boreal populations of Caribou; Tom adopted "rareness as an antipredator strategy to reduce predation risk" as a defining phrase for this ecotype in the title of his chapter in the *Wildlife 2001* series (Bergerud 1992).

What was controversial in Bergerud and Elliott's (1986) paper was that it supported wolf control. Tom later described wolf predation as the driver in Caribou evolution (Bergerud 1996), and the suggestion that predation by Gray Wolves could be the deciding factor in the decline of Caribou populations was not well received. Some readers found it alarming that 'top-down' effects could be so easily described in wildlife research. Tom caused disbelief in some other readers by further describing Caribou, where limited by food supply, as on the Slate Islands, Ontario, to be conforming to a "maintenance phenotype", a term coined by Valerius Geist (1998, in his book on deer evolution, as cited by Bergerud *et al.* 2007). It took time for biologists who previously had almost universally thought that food limitation was the driver of Caribou population dynamics to accept the norm of top-down control by wolves in most of Caribou range. Wolf control can immediately 'buy time', before other Caribou conservation measures, such as habitat restoration, take effect (Hervieux *et al.* 2015). But as Mech (2012) has pointed out, too many biologists wish to paint the wolf as a 'saint'.

Despite later support from Seip (1992) and Wittmer *et al.* (2005) from radio-tracking data on Caribou in southern BC, and despite continued tests of the hypothesis that declines in Caribou in northern BC were due to top-down control by wolves and apparent competition (Serrouya *et al.* 2019), Bergerud's (1974a) and Bergerud and Elliott's (1986) hypotheses remain controversial to this day. The recent work of Serrouya *et al.* (2019) in BC and Alberta received the same sort of criticism about data precision that Tom often experienced (Harding *et al.* 2020); similarly, the work by Wittmer *et al.* (2005) received charges of methodological limitations (Brown *et al.* 2007). Ultimately, the criticism arises because a 'smoking gun' is difficult to find to justify cause-and-effect in ecology (Boertje *et al.* 2017).

The smoking gun is elusive for the ecological complexities that Tom in fact knew well. The examples involving Caribou declines that Tom witnessed and acknowledged include complexities not only in bear and lynx as additional predators in Newfoundland (Lewis *et al.* 2017), but also in variable effects of predation in Newfoundland that depend on weather (Bastille-Rousseau *et al.* 2015), on Caribou population dynamics (Mahoney *et al.* 2016), and on changes to their behaviour with food limitation (Schaefer *et al.* 2016). Variable Caribou population dynamics also occur with changing snow and freezing rain conditions in Labrador (Schmeltzer *et al.* 2020) and, as shown for the mountain populations in Alberta and BC, with human disturbance that can shift both Caribou behaviour (MacNearney *et al.* 2016) and Gray Wolf hunting efficiency (Pigeon *et al.* 2020). Caribou are also often not given enough space, and the space they are given as "critical habitat" continues to be fragmented; Palm *et al.* (2020) recently reiterated this point for the BC populations that were so often top of Tom's mind: fragmentation reduces or eliminates the value of the shrinking space for Caribou as a refuge from predation.

There is much irony in the fact that Tom listed the potential, and very often acknowledged the reality, of every one of the other contributing factors to Caribou decline listed above, yet could never completely win the argument for predation as the driving factor in shaping the behaviour of Caribou, and wolf control as a likely opportunity for Caribou rescue. Just one example to support Tom's case of careful consideration of multiple factors comes from his observations of the George River Caribou on the Ungava Peninsula (Bergerud and Luttich 2003). Indeed, in their book, *The Return of the Caribou to Ungava*, Bergerud *et al.* (2007) made the argument that limitations to the abundance of the George River population were due to nutritional effects caused by overgrazing of limited summer range, i.e., bottom-up and not top-down structuring of the ecosystem. Layne Adams (2009: 166) called Bergerud *et al.*'s (2007) work "an important reference for those interested in *Rangifer* populations throughout the world and … for anyone interested in ungulate ecology or northern ecosystems". Ironies aside, there is much sadness in the very large number of Caribou declines themselves.

Part of the success in Tom's career as a naturalist and biologist is owing to the alliances he made with steadfast colleagues and field personnel, in particular people who excelled in their own right. The collaboration with John Elliott co-occurred with an important study on Caribou calf mortality by R.P., at the time another BC biologist. Earlier, Newfoundland and Labrador biologist W.E. (Gene) Mercer collaborated with Tom on Caribou (Bergerud and Mercer 1968, 1989) and Willow Ptarmigan (Bergerud and Mercer 1966, 1972); later, biologist Stu (S.N.) Luttich, of the same provincial Wildlife Division, co-wrote *The Return of the Caribou to Ungava* (Bergerud *et al.* 2007) with Lo Camps, another long-time collaborator. A special kind of alliance in Newfoundland and Labrador was with two of this province's Conservation Officers, Mike (M.J.) Nolan (Bergerud *et al.* 1968; Bergerud and Nolan 1970) and Lloyd (L.R.) Russell (Bergerud *et al.* 1964; Bergerud and Russell 1964, 1966). These officers are among the most celebrated people throughout the province's Wildlife Division, and a credit to Newfoundland and Labrador's continued and unique recognition of Conservation Officers not just as enforcers of the law, but also as active participants in supporting research, should they choose this route. In the case of Mike Nolan, his recognition that poaching was a foremost barrier to recovery of the Avalon Caribou population, an idea that Tom helped reinforce, earned him an Honorary Doctor of Philosophy from Memorial University. The recognition was specific to his on-the-ground recovery efforts of the Avalon Caribou, efforts that Tom so kindly extolled (Figure 3), efforts that took this herd from a few hundred remaining individuals to a few thousand in three decades.

Throughout all the studies since 1974, Tom was accompanied and assisted by his wife, Heather Butler, who is also a biologist studying Caribou behaviour. Dave Mossop of Yukon College in Yellowknife and the late Michael Gratson assisted Tom in many studies on grouse. In Ontario, Tom's work on the Slate Islands and in Pukaskwa was assisted by many biologists, including Lo Camps from Salt Spring Island, but also Thunder Bay based H.R. (Tim) Timmermann, Terrace Bay District Biologist Barry Snider, Roger Ferguson also from Terrace Bay, Wawa based Gord Eason, and Sault Ste. Marie based W. (Bill) Dalton. Bill would be ready for any task on the Slate Islands, even though the trip was several hours away. He helped collect countless bones and antlers from deceased Caribou for Tom and Heather to return to Salt Spring Island, where Tom resided through most of his career. Gord's favourite story was Tom calling from a pay phone on the highway after he had just seen a Caribou and thought a local biologist should know about it because it was one that had been translocated to Lake Superior Provincial Park and had now moved south. Tom was not much for long phone calls, so Gord managed to say, "Yes, Tom, you just saw the southernmost mainland Caribou in the world". Tom replied "Okay, bye".

FIGURE 3. Woodland Caribou (*Rangifer tarandus*) calf held by Tom Bergerud in Newfoundland. Photo: source and date unknown.

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The Canadian Field-Naturalist

Changes to the Book Reviews and New Titles Sections

As of the publication of Issue 135, Volume 2, our Book Review Editor will be stepping down. We have been unable to find a replacement to date; thus, this section will undergo several changes. Until we find a new editor, William Halliday (wdhalliday@gmail.com), our Online Journal Manager, will take over the New Titles list and Amanda Martin (canadianfieldnaturalistae@gmail.com), the Assistant Editor, will manage the Book Reviews. William Halliday will focus on titles of books that are available for review. Readers of this journal are invited to request titles they are willing to review from the list from William and, if still available, copies will be sent directly to them by the publisher. Readers will still be able to submit reviews of books they have on hand, provided that reviewed books have a Canadian connection, including those on any species (native or non-native) that inhabits Canada, as well as books covering topics of global relevance, including climate change, biodiversity, species extinction, habitat loss, evolution, and field research experiences. Book reviews will be submitted through the online submission system https://www.canadianfieldnaturalist.ca/index.php/cfn/about/submissions. All received reviews will undergo editing, and prospective reviewers are encouraged to check our book review guidelines at https://www.canadianfieldnaturalist.ca/index.php/cfn/about/submissions. These changes will be fully in place as of Issue 135, Volume 3 and continue until a new Book Reviewer Editor is found.

We wish to thank each of you who has provided reviews in the past, and encourage all of you to continue to keep this section going. Lastly, are there any volunteers willing to assume the full role of the Book Reviewer Editor? If so, please contact the Editor-in-Chief (editor@canadianfieldnaturalist.ca) for more information.

Book Reviews

Book Review Editor's Note: *The Canadian Field-Naturalist* is a peer-reviewed scientific journal publishing papers on ecology, behaviour, taxonomy, conservation, and other topics relevant to Canadian natural history. In line with this mandate, we review books with a Canadian connection, including those on any species (native or non-native) that inhabits Canada, as well as books covering topics of global relevance, including climate change, biodiversity, species extinction, habitat loss, evolution, and field research experiences.

Currency Codes: CAD Canadian Dollars, USD United States Dollars, EUR Euros, AUD Australian Dollars, GBP British Pounds.

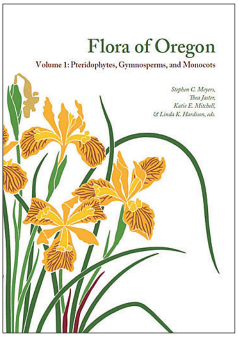
Botany

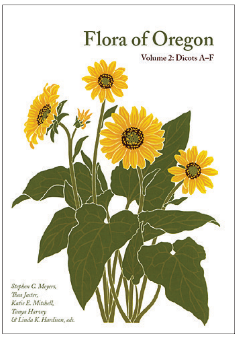
Flora of Oregon. Volume 1: Pteridophytes, Gymnosperms, and Monocots

Edited by Stephen C. Myers, Thea Jaster, Katie E. Mitchell, and Linda K. Hardiston. 2015. OregonFlora, Oregon State University, and Botanical Research Institute of Texas. 608 pages, 520 black and white figures and maps, and 73 landscape colour photos, 75.00 USD, Cloth.

Flora of Oregon. Volume 2: Dicots Aizoaceae - Fagaceae

Edited by Stephen C. Myers, Thea Jaster, Katie E. Mitchell, Tanya Harvey, and Linda K. Hardiston. 2020. OregonFlora, Oregon State University, and Botanical Research Institute of Texas. 880 pages, 785 black and white figures and maps, and 96 landscape colour photos, 85.00 USD, Cloth.





The two volumes of the three-volume *Flora of Oregon* that have been published to date are beautiful books to own, filled to bursting with floristic information of importance to the whole Pacific Northwest including southern British Columbia (BC). They cover 1054 pteridophyte, gymnosperm, and monocot taxa in Volume 1 and 1668 dicot taxa (Aizoaceae to Fagaceae) in Volume 2, with full floristic treatments. An additional 206 native, naturalized, non-naturalized, and hybrid taxa are noted in Volume 2. Volume 3 will cover the remainder of dicot families found in the remarkably diverse Oregon flora, which consists of 4653 terminal taxa (native, naturalized, non-naturalized, and sporadic taxa).

Introductory materials in the two volumes are fantastic. Volume 1 contains valuable sections on the history of the Oregon Flora Project, notable Oregon botanists, and the ecology and the botanical diversity of Oregon, constituting a whopping 64 pages of great information. In Volume 2, introductory sections include chapters on landscaping with native plants, insects as plant taxonomists, and a both important and timely discussion of the importance of herbaria to our understanding of contemporary flora. These interesting topics all likely appeal to a wide range of readers. The editors acknowledge that the flora itself is inclusive, built on the hard work of academics, graduate students, and skilled amateur botanists. Generating interest in different aspects of the flora and being readable and accessible are obviously important goals of this publication.

Introducing the landscapes of Oregon through the work of notable botanists commencing in the early 1800s sets the scene for subsequent chapters on the ecology and botanical diversity of the state. Colourful maps of the ecoregions are found not only in a standalone chapter but on the front cover of the book and on the front page. They are valuable in helping the reader visualize where notable field botanists spent their time, and where plants noted in the chapters are found within the state.

The Flora of Oregon Project has been a highly organized effort from its beginning in 1994, constituting a huge, collaborative effort involving project leaders, taxonomic specialists, an advisory board, taxonomic and ecological contributors, student assistants, and volunteers. Other important aspects of the project include a commitment to documenting the flora on the basis of specimens preserved in major regional herbaria and the digitization of the information both in an online atlas in the mid-1990s and later in an online photo gallery. The checklist has been an important online resource for years to many in the Pacific Northwest prior to the publication of the flora.

The core significance of any flora is its species treatments. Clear and informative representative line drawings are included for each group in the *Flora of Oregon*, although many of the taxa are not illustrated. To make up for this, key features are highlighted, including a valuable montage of illustrations of the taxonomically informative nutlets of the 17 *Plagiobothrys* (popcorn flowers; Boraginaceae) taxa (Volume 2, p. 427), and, it appears, a figure for each native species of the taxonomically challenging *Carex* (sedges), including numerous illustrations of perigynia. The range maps are remarkable. Despite their small size they clearly illustrate collection locations overlaid upon base maps that depict the counties and ecoregions represented by occurrences of each taxon. What a terrific way to immediately indicate environmentally-directed versus random-distribution patterns! Accordingly, a bit more discussion and explanation of these patterns would have been valuable additions to the end notes provided with many treatments, particularly for distributions apparently displaying natural discontinuities. The nomenclature employed by the various contributors appears to reflect a modern but restrained taxonomy. While a more liberal contribution of synonyms would have been appreciated, the limited numbers provided are adequate in most cases. Importantly, the language employed in the economical descriptions and in the keys is technically precise but not so academic as to require overly frequent reference to the (excellent) glossary provided in both volumes. Quite simply, the *Flora of Oregon* species treatments are impressive.

Information on the taxa of conservation concern is highlighted throughout. This is provided both in notes in the main text and in specialized appendices. Endemic species (a remarkable 115 taxa) are also flagged throughout.

The appendices in the *Flora of Oregon* are unusually rich sources of information. Several in Volume 1 highlight different aspects of taxa of conservation concern. Appendices on native/wildlife gardening are interesting additions to Volume 2. (Indeed, Landscaping with Native Plants represents a stand-alone introductory chapter in this volume.) An annotated listing of the 159 taxa not supported by voucher specimens obtained in the last 50 years is another infrequently seen but instructive data set. Appendix 1 in Volume 1 contains three tables of taxa not fully treated: excluded taxa with a confirmed voucher, those reported for the state but lacking vouchers, and misapplied names. In the excluded list are many introduced but not established taxa: recent or historical waifs, occasional hybrids, ballast plants, and escapees. In addition, species only recorded once from Oregon are listed, some of which could be conceivably considered native. It can be a challenge to determine whether a very rare entity, native or introduced, should be treated as established or, in some cases, how to determine provenance. The *Flora of Oregon* addresses this on a case-by-case basis in that appendix in Volume 1, but curiously not in Volume 2. We hope Volume 3 will include a comprehensive and updated version of this valuable data set. Similarly, we feel a single appendix combining the four conservation-oriented appendices would have made it easier for readers to understand and use these data. A single appendix with species annotated by 1, not collected for 50 years (i.e., extirpated, or possibly so); 2, rare and threatened (i.e., state-, or federal-listed); 3, endemic; 4, known from a single occurrence in an ecoregion; and 5, known from only a single occurrence in the state (and native in adjacent jurisdictions), would perhaps have been clearer. That might have given more insights into plant rarity, endemism, threats, protected areas, and hotspots by ecoregion, and thus the state of conservation of Oregon's vascular plant biodiversity.

This review from a Canadian perspective has a particular interest in the affinities between the floras of BC and Oregon and in the phytogeographical implication of those affinities in the northwestern North America region. A large number of species are shared between Oregon and BC (although the flora is larger than the latter by ca. 1200 taxa). These include some taxa whose ranges almost or completely exclude intervening Washington state. Indeed, some of BC's most interesting and significant plants of conservation concern are shared with Oregon. The *Flora of Oregon* has done a fairly good job of noting the Canadian occurrence of each taxon also found in BC, although some (inevitably) were missed, including *Astragalus spaldingii* (Spalding's Milk-vetch), a number of *Boechera* (rockcress) species, *Cardionema ramosissima* (Sandmat), *Elatine brachysperma* (Short-seeded Waterwort), *Lasthenia glaberrima* (Rayless Goldfields), *Pellaea breweri* (Brewer's Cliffbrake), *Pinus flexilis* (Limber Pine), *Plagiobothrys cognatus* (Sleeping Popcornflower), *Plagiobothrys cusickii* (Cusick's Popcornflower), *Soliva sessilis* (Carpet Burweed), and *Thelypodium milleflorum* (Many-flower Thelypody). Canadian distributional data for most of these are available online at the University of British Columbia's herbarium database or on the BC Conservation Data web tools.

One notable species shared between BC and Oregon is *Oxypolis occidentalis* (Western Cowbane), a monotypic genus currently only known from the Cascades and Sierra Nevada in Oregon and California, and disjunct to BC (Haida Gwaii and Vancouver Island). This begs the question of why it is absent from Washington. Many other species show similar geographic discontinuities that have not been adequately explained to date.

These two well-bound, attractive, and user-friendly publications contain an immense amount of valuable floristic and conservation information that is applicable far beyond their home state. From start (fascinating introductory materials) to finish (information-rich appendices) and everything in between (inspired treatments), this is a winner. We can only hope Volume 3 is not far off so *Flora of Oregon* can assume its position as the new standard of excellence for the production of regional North American floras.

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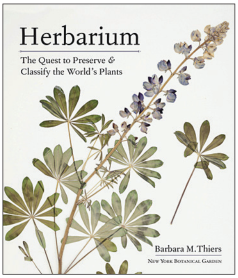
Herbarium: The Quest to Preserve & Classify the World's Plants

By Barbara M. Thiers. 2020. Timber Press. 304 pages, 40.00 USD, Cloth, 30.05 USD, E-book.



An herbarium is simply a collection of dried plants. They may be glued into a book or mounted after flattening onto separate sheets of light cardboard with labels. They have been, and still are, especially useful, let us say absolutely essential, to the processes of identification and classification of plants.

In the Preface Dr. Theirs, Director of the William and Lynda Steere Herbarium of the New York Botanical Garden, notes that she was impressed that formal botanical training in the mid- to late-20th century included so little in the way of background about herbaria. We are now well into the 21st century and not much has changed in this respect. Thiers further notes:

> At a time when we seem to be bombarded daily by negative aspects of human nature, herbaria highlight one of our better human impulses: to save things for the future, not just for ourselves but for generations to come … As much as our modern lives tend to separate us from the rest of earth's biodiversity, we cannot exist without it, and these preserved organisms give us information about our world and clues to its future that we cannot learn any other way. (p. 11)

Thiers is kindly apologetic about focussing attention on herbaria in Europe and the United States, and hopes that the stories of herbaria in other countries will be written. In Canada we have the nineth largest herbarium in North America (acronym DAO, at Agriculture and Agri-Food Canada in Ottawa) with over 1.55 million specimens. It is the 43rd largest collection in the world (Thiers 2021b: 8). I had the great pleasure of serving as Chief Curator of this remarkable collection for several decades. Perhaps, with the encouragement from Thiers, the story of this and many other Canadian herbaria will be told. I hope that Thiers does not worry too much about what was left out. It is a very large subject that she treated remarkably well. The challenge is there for any of us to expand a chapter or a section into another book.

This book contains five chapters. To give the reader a better idea of the content, I have paraphrased some of the fascinating information provided by Theirs, sometimes adding a little of my own with references that can be pursued further.

The Origin of Herbaria draws attention to some of the first herbaria. Botany was once a minor subdiscipline of medicine, but the development of herbaria allowed the study of plant classification and evolution to become a separate endeavour. It is suggested that herbaria may have developed in Europe earlier because the longer winter season when plants were not available for observation made a dry collection particularly advantageous and the flourish of science, new ideas, and innovations during the Renaissance brought the herbarium with it. Italian physician Luca Ghini created the first herbarium in the early 1500s, and the herbaria of his students exist to this day. As well as the origins of vascular plant collections, Thiers considers the origin of cryptogamic collections.

In Herbaria and the Age of Botanical Exploration, Thiers explains that in the 18th and 19th centuries many European countries undertook explorations around the world to obtain materials for trade, some of which were plant derived, including spices, drugs, food, and horticultural plants. As this became more popular and the need to know more about plants increased, collecting specimens and putting them in herbaria also increased.

The stories that are part of this period are very entertaining, some written by the plant collectors themselves. William Drapier was the first to be charged with collecting herbarium specimens. He was a pirate (a privateer in the proper British vocabulary of the time) working for the Royal Navy. He wrote a book published in 1697 that became very popular with the public. This led to a position with the Royal Navy as a botanical explorer. Unfortunately, he "went south". His ship sank but some of his specimens and his notes were saved. When he returned to England he was court-martialed and retired as a pirate. His specimens and notes, however, lived on and were used by later explorers, including Banks, Humboldt, Darwin, and Wallace (also discussed in this chapter).

During this time, women, disguised as sea-faring men, illegally joined exploratory expeditions. Some of them (perhaps all) were smarter than men, worked harder than men, and became more well known for their contributions to botany. Jeanne Baret, aka "Jean", had *Solanum baretiae* named in her honour and received a pension from the French navy in 1785. *Ce n'est pas une surprise, … juste un fait intéressant.* I cannot remember the name of her male colleague.

The difficulties, sacrifices, labours, dangers, and costs of building plant collections in those early times are hard to imagine. Many plant collectors died, were wounded, or sickened and never completely recovered; plant science suffered huge tragedies. In a concluding section on later development, we learn about the destruction by Allied bombing on 1 March 1943 during World War II of the Berlin Herbarium (Herbarium Berolinense, acronym B). Fortunately, the herbarium of Carl Ludwig Willdenow, the founder of Phytogeography, as well as 20 000 types of specimens had been recently moved out to off-site storage in a protective mine shaft. Three and one half million specimens were destroyed, including 30 000 specimens on loan from other herbaria. Considering the remarkable effort to create the Berlin Herbarium, founded in 1815 (Hiepko 1987: 1), and its potential for future contributions to science, this was a "a catastrophe of major proportions to world botany" (Merrill 1943: 490), although a minor event in the many tragedies of that war. What was lost was priceless and irreplaceable world heritage, but luckily photographs of 40 000 specimens, including many destroyed, were obtained in 1929 by the Field Museum in Chicago. The Berlin Herbarium was rebuilt and restored to its former accession level by 1979, with help from around the world. For much more information on Herbarium Berolinense, see Hiepko (1987).

In Development of Herbaria in the United States, I particularly liked Thiers's text on the French scholar, Constantine Samuel Rafinesque. It is kind, balanced, and informative, perhaps the best I have read about this unreliable and erratic figure. It seems that all groups possess destructive forces. Rafinesque was the destructive force in North American classification of flora and fauna. He was desperate to name (not describe) new species. There is sometimes a humorous side. We have heard people say "you have to laugh … or you'll cry". There is the story of how he broke Audubon's violin trying to knock down a new species of bat (everything was a new species to him). This lack of sensitivity upset Audubon, who subsequently supplied Rafinesque with a series of sketches of mammals (all imaginary) that Rafinesque promptly named. He even named some of these imaginary mammals accidentally twice (using different names of course)!

One does not have to be an herbarium practitioner to find interesting information here. Alice Eastwood, who did so much to document the flora of California, was born in Toronto. She made the California Academy of Science Herbarium the most complete record of western plant life. She became well known for her heroic efforts to protect the herbarium during the San Francisco earthquake in 1906. She was there because The California Academy of Sciences was one of the first institutions in the world to recognize and encourage women scientists.

With his large personal herbarium of 100 000 species, George Engelmann began the herbarium of the Missouri Botanical Garden. With his extensive herbarium-based knowledge of plants, and his special interest in grapes, he saved the French grape industry by providing a North American rootstock, resistant to a damaging pest. These are just a few of the interesting stories of herbaria. This fascinating chapter concludes with a valuable overview of herbarium digitization, the exciting interface of plant collections and modern computerized analysis.

In Development of Herbaria Around the World we learn that many of the stories about the development of herbaria around the rest of the world are similar to those of Europe and the United States, but they are also unique in a number of ways because they took on the flavour of the country. After Joseph Banks made such a valuable contribution to the study of Australian botany through the collection of herbarium specimens, Linnaeus wanted Australia to be named "Banksia". Prisons were popular in England at the time, and Banks suggested that Australia could be used as a penal colony to reduce overcrowding in England. People were unlikely to come back in those days! A penal colony was established in the botanical paradise of Botany Bay in 1788. The city of Sydney grew up nearby, but luckily some of the remarkable landscape was protected in Kamay Botany Bay National Park.

A recurrent theme is the fluctuating good times and bad times which changed with the political climate. Following the Boxer Rebellion in 1901, China had to pay foreign powers for losses. However, the United States allowed money paid to them to be used to assist Chinese students to come to the United States for advanced studies. Many of these students went back to China to build significant herbaria and did valuable work on Chinese biodiversity, at least for a while. A cultural revolution in China beginning in 1966 halted scientific research and prominent botanists were starved, beaten, and forced to write confessions, and some were lost. The light at the end of the tunnel was reached in the mid 1970s and Chinese herbaria again began to grow with associated large contributions to botanical science.

There was a tendency for Chinese research to be relocated further south during World War II to avoid Japanese occupation. This brought Chinese scholars into under-explored territory in Hubei province and this led to the discovery of living trees of Dawn Redwood (*Metasequoia glyptostoboides*). The plant had been known as a fossil since 1941, but by 1948 seeds from a limited region of China had been sent around the world, thus ensuring its preservation. This living fossil can be seen in several Canadian botanical gardens, and there are other similar examples, also from China. This chapter also contains sections on the development of herbaria in Brazil and South Africa.

The Future of Herbaria stresses that herbaria are vast storehouses of information that is available directly and also through analysis. They have been used to study and predict: harmful heavy metals in the environment; atmospheric conditions; distributions, tolerances, and productivity of plants; the changing timing of important events; the spread of pathogens and invasives; and to facilitate conservation and protection. (In addition to the text and references provided by Thiers, the reader may find useful information on the value of herbaria in references provided below, including: Prather *et al.* 2004; Nualert *et al.* 2007; Ellis 2008; Bebber *et al.* 2010; Mitrow and Catling 2011; Eisenman *et al.* 2012; Culley 2013; Guerin 2013; Lavoie 2013; Kuzima *et al.* 2017).

A section on educational opportunities in herbaria explains that "plant blindness" (p. 232) is the phenomenon wherein we see plants not as living organisms that are key to our existence but merely as background scenery to our lives. A section on threats to herbaria suggests (very correctly) that a major threat is misperception that herbaria are part of the past descriptive science rather than the future unified science. As a result of the late 20th century shift to interest in subcellular processes, funding declined for biodiversity research. Actually, herbaria play a huge role in modern molecular science, but "we are still in a period where general impressions of value lag behind reality, and many herbaria lack sufficient infrastructure and basic curatorial staff" (p. 239). However, the situation is changing. The US National Science Foundation has commissioned a study by the National Academy of Sciences to recommend a strategy to safeguard and sustain these irreplaceable research and educational resources.

> Publications using herbarium data have increased exponentially over the last century. As we enter the Anthropocene, herbaria have likewise entered a new era with enhanced scientific, educational, and societal relevance. (Heberling *et al.* 2019: 812)

This chapter concludes with a section entitled How You Can Help. It reminded me of a time when we arranged with a group of disabled people to mount plants in their homes and to come into the herbarium prep room to do similar mounting and recording work. It was unbelievably successful, as was another volunteer program which attracted the attention and awards from upper management, providing a valuable opportunity to explain herbarium value.

A more specific and interesting application of community science to increase the value of herbarium specimens was recently described by Heberling and Isaac (2018). It involves associating photographs in iNaturalist with QR (quick response) codes on herbarium specimen labels (produced in iNaturalist) which can be read by smartphones and tablets to enable immediate access to field images, a mapped location, and other information. The label data are also stored in appropriate databases in Darwin Core format. This procedure takes advantage of the fact that very good quality photographs are much easier to obtain now than in the past. There is still a great deal of work to do, and millions of specimens are needed by herbaria. This means that community science help in collecting the best specimens that we have ever had is very important and exciting.

One of the basic tools for herbarium researchers and staff over decades has been Index Herbariorum (Thiers 2021a), produced since 1935 by the New York Botanical Garden. It is a guide to the herbaria of the world, providing addresses, staff and specialties, contents, and other details. The most recent iteration of this very valuable work is that of Thiers (2021b). Her book reviewed here is like a companion to Index Herbariorum that gives an idea of how herbaria came to be, of their great importance, the character of the people involved, their remarkable contributions, and the whereabouts of their specimens. This makes it a very important reference. It is so well written that it serves also as a source that can be enjoyed by the public and provides a compelling record of botanical science for anyone just looking for a good read.

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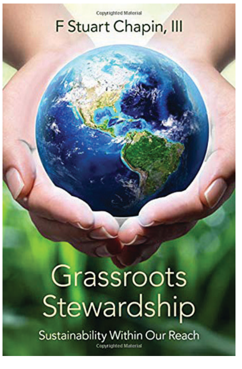
CONSERVATION AND WILDLIFE

Grassroots Stewardship: Sustainability Within Our Reach

By F. Stuart Chapin, III. 2020. Oxford University Press. 240 pages, 34.95 USD, Cloth. Also available as an E-book.



How does one write and publish a book about current events right now? Our reality is shifting so quickly that everything feels dated within weeks. Chapin writes with a hopefulness and trust in the world that has escaped me in recent months (or years?). In reading this book, I was reminded of the tension between patiently picking away at what we can do to make the world around us better versus the feelings of rage and sadness that arise from the futility of individual action. I eventually forced myself to slow down and consider what Chapin is trying to achieve with this book.

Chapin defines the book's audience early on as a specific selection of four practitioner types: managers of private and public lands, Indigenous people with strong cultural connections to their lands, city residents who encounter and shape nature in their neighbourhoods, and people who tinker with nature or volunteer for community or conservation efforts (p. 14). By defining the audience, he's able to skim over a lot of preliminary information that seems to bog down other books in the Climate Change genre, such as the history of the agricultural revolution or how the greenhouse effect works.

The first half of the book establishes the problems—disconnection with nature and disintegration of community and social networks—that lead to ecological problems including habitat loss and behaviours that contribute to climate change. He is resolute about tying each idea to a set of recommended actions, usually relevant for the intended audience of the book, and ends each chapter with a section entitled "What Can We Do?" containing ideas such as "join efforts to improve the well-being of less fortunate people" (p. 78) and "observe and record local ecological changes" (p. 36).

The second half of the book provides different types of actions to address the problem: individual, collaborative, and political. The chapter on individual actions fell flat for me. Consuming less, driving less, taking fewer flights, eating more locally, getting out into nature … these are all 'Good Things To Do' but just not enough. Chapin argues that:

> although environmentalists often blame environmental damage on companies that extract fossil fuels, mine minerals and clear land for agriculture, these activities are profitable largely because of public demand for products that we consume. (p. 90)

This seems unfair when we consider government subsidies for unsustainable industries and unrelenting corporate greed. The emphasis on individual responsibility comes across as sanctimonious and unoriginal; this unfortunately tainted my view of the rest of the book.

Although the rest of Chapin's recommendations did not resonate with me, his expertise and perspective really shine when he celebrates collaborators. He devotes a significant amount of time discussing the value and practice of dialogue, collaborative work, and effective communication:

> This loading-dock model of communication, in which knowledgeable people produce and

> deliver knowledge for others to use, is insufficient … most of the public know a lot about their local systems and often have strong opinions about what information would be useful. (p. 111)

Chapin clearly feels inspired by the work being done around him, and it shows.

Considering the length of this book (<200 pages when you remove notes and references), Chapin tries to pack a lot in. It is a somewhat confusing mix of practical frameworks and tables for conservation and stewardship practitioners (e.g., what makes a novel species invasive; types of ecosystem services; how to best collaborate with different stakeholders), anecdotes from his long career, and sweeping generalizations about how the world works. He makes a lot of effort to extend his optimism to the political and corporate worlds; unfortunately, I think this optimism is generally unfounded. At one point he uses the example of ranchers unlikely to overgraze lands or community members unlikely to pollute their own watershed, to suggest that a hypothetical resource extraction company is unlikely to deplete the resource it is extracting to ensure there are resources for future extraction (p. 137). Unfortunately, corporations are not people—except on paper. In practice, they tend to extract until they are told by regulators that they cannot. He argues that "individuals ultimately determine whether market forces promote or undermine sustainability" (p. 172). If by individuals he means large collective movements that force governments to implement more strict regulations, I would tend to agree. I would not, however, if he means me making the individual choice to buy recycled toilet paper.

Chapin is a well-respected ecologist, and I would love to see more ecologists writing about politics. They bring a balanced, practical, and holistic approach to a world that is otherwise polarized and harsh, and at the end of the day this is a hopeful book. But what about when the proposed solutions (read: individual actions) have been tried and are clearly not enough? Is that hope or willful naivety? I ultimately left this book feeling frustrated. A lovely hopeful book about collaboration and communication is nice. But maybe what we need now is rage. I'm angry about the state of the world. I'm angry that corporations are stealing our planet's future. I'm angry that there is so much entrenched systemic inequality. We need urgent voices for these urgent times, but I keep coming back to Chapin's words:

> Understanding without emotional connection is sterile. Passion without understanding bypasses critical thinking and can trigger knee-jerk reactions with unintended consequences. Empathy without action creates more frustration than solutions. (p. 85)

Perhaps I just need to stop reading the never-ending ticker tape of bad news, and start acting—starting, as Chapin would no doubt recommend, in my own community.

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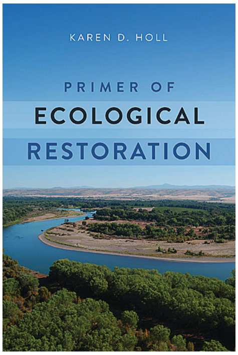
Primer of Ecological Restoration

By Karen D. Holl. 2020. Island Press. 224 pages, 35.00 USD, Paper or E-book.



Primer of Ecological Restoration is a textbook-style book written by the well-published primary researcher Dr. Karen Holl. The author's stated goal is to create a broad but succinct introductory text that would be useful as a textbook for restoration ecology courses where more detailed case readings are assigned in tandem, one of several resources for a conservation biology or resource management course, or as an introduction to the field of restoration for resource managers or a general audience.

In the Preface, Holl is very clear about what the book is not—it is not an in-depth comprehensive guide nor a "how to" for restoring particular ecosystem types. As you would expect from a primer, this book provides more breadth than depth. That being said, it introduces the principal questions, debates, and complexity that characterize the discipline. As a primer it largely meets its stated goals: the glossary is excellent, it boasts a clearly cited references section, and the index is intuitive and well executed. Each of the short chapters (6–19 pages) ends with an annotated "recommended reading" list of a few additional sources, with a brief sentence from Holl describing their content.

While Holl achieves the goal of creating an introductory text chock full of jumping off points, there are certain areas where more direction would be helpful. Several controversial topics in the discipline that would have benefitted from more depth include novel ecosystems, conflicting restoration goals (specifically strategies on how to resolve them, or examples of success), and anticipatory/climate shifted restoration. Similarly, Traditional Ecological Knowledge (TEK) and collaborations with First Nations stakeholders receive two brief mentions; the book would benefit from addressing these topics in a more deliberate way and providing additional resources as it does so effectively for other topics.

Appropriate emphasis is placed on the need for long-term planning, monitoring, and clear, actionable goals—all significant and common stumbling blocks for successful restoration initiatives. Much of the book is prescriptive—what should be considered. What is sometimes lacking, however, is the "how"—provisioning budget and personnel for long-term monitoring is important, yes, but successful examples to follow are not provided. Chapters 6 (Landform Hydrology), 7 (Soil and Water), 8 (Invasive Species), 9 (Revegetation), and 10 (Fauna) are the most fleshed out, providing various examples and specifics of successful interventions and techniques. Chapter 6 is particularly detailed, with several excellent supporting diagrams to explain major concepts. Holl's definitions of invasive and non-native species used in Chapter 8 (Invasive Species) are one of the few elements in the text that are both controversial and uncited—considering the widespread and ongoing debate on this topic, not every reader will agree with the resulting recommendations of the chapter. The book may also have benefitted from a short conclusion section; the text's final topic-based chapter ends with the glossary on the facing page.

To keep costs low, the author has chosen to use primarily diagrams and tables; colour photos are instead included in the accompanying materials on the Island Press website. The diagrams included in the text are well chosen, especially those explaining key spatial concepts (e.g., habitat connectivity, soil layers). The accompanying resources at https://islandpress.org/restoration-primer include short case studies mentioned in the text (downloadable PDFs, one per case study), downloadable PowerPoint slides with high resolution copies of figures used in the text, discussion and reflection questions for each chapter, and a document listing additional resources (videos, books, example restoration plans, and websites). Although not necessarily of interest to a casual reader, these resources are good quality and valuable for instructors looking to use this text as a learning tool.

Overall, this book is a successfully executed primer that meets its stated goals admirably for such a short text. Combined with the online resources, it is likely most useful for instructors who assign additional readings to expand on different concepts pertinent to their courses. As it is well written and generally free of jargon (and fashioned with an excellent glossary), the primer would also be a valuable introduction for junior practitioners or interested members of the public. If you are new to ecological restoration, this is a solid introductory text.

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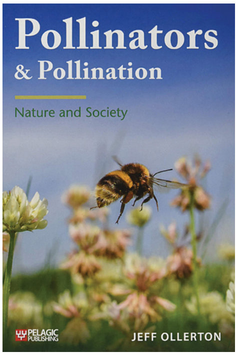
ENTOMOLOGY

Pollinators & Pollination: Nature and Society

By Jeff Ollerton. 2021. Pelagic Publishing. 300 pages and 78 colour illustrations, 43.54 CAD, Paper.



The title of this wonderful book has four key words—and author Jeff Ollerton nails them all. He achieves this in several ways: by outlining his four aims for the book; addressing those aims clearly; incorporating up-to-date research while providing historical insights; and communicating in a way that successfully bridges the all-too-frequent gulf between scientist and interested lay reader. As well, the book is studded with manageable graphs and charts as well as photographs, frequently based on Ollerton's own observations, whether taken during his international research trips or—appropriately in a book exploring community science—in his own backyard in Northampton, a town in England's East Midlands region.

Ollerton covers a lot of time and space (i.e., ground, literally!) in the exploration of these themes. The book has 14 chapters, beginning with an outline of The Importance of Pollinators and Pollination. Readers will tend to be people who already buy into the concept but, as he does throughout, Ollerton debunks—a process I took to calling 'myth-busting'—some of the commonly-held views on the topic. These include such oft-stated notions as honeybees are the most important pollinators, every species of orchid has its own specialized species of pollinator (pp. 87–88) and every fig its own specialized wasp (p. 100), "one third of all food [is] owing to pollinators" (p. 107), urban zones are bereft of nature, the overemphasis on the virtues of native plants as best for pollinators—and the list goes on. This is, by the way, one of the many things I enjoyed about the book. Ollerton looks at the research behind the claims (see p. 7 on percentage of flowering "plants needing pollinators") and exercises some valid scepticism about the political side of the debates around conservation. In a world inundated with 'information' via social media, proponents of conflicting views often aim for effective sound bites rather than trying to explain complexities. Ollerton admits readily the points at which the science parts company with the sound bites or is too incomplete to fully support one side or the other. In fact, his insights into the limitations of what we know, and the vastness of the unknown, provide valuable and cautionary commentary throughout the book. Throughout, he inspires many questions and suggests research that needs to be done.

The 'nature' side of the book covers the evolution of the process of pollination, the rich diversity of pollinators—which include far more animals than bees—and natural factors affecting the process, "from daily cycles to climate change" (p. 90) to quote the subtitle of Chapter 6. The 'society' aspects receive increasing treatment in Chapters 7 through 10, beginning with modern Agricultural Perspectives (Chapter 7). Ollerton notes that diversity of pollinators is important for seed set and yield, but intensive agriculture results in a decline in both. He is critical of the acceptance of increasingly technological approaches to agriculture, which create problems requiring increasingly technical 'solutions'—robobees, to cite just one exotic example, are not the answer (p. 122). Urban Environments (Chapter 8) provide more hope than many of us might realize. Nature is everywhere in cities if we take the time to see it (p. 141). Managed well and imaginatively, urban settings such as brownfield sites and roadway verges can contribute greatly to the health of diverse populations of pollinators. Even the smallest gardens, planted for the purpose, contribute. Readers can glean techniques for increasing pollinator habitat at home (Chapter 9). And the plants do not need to be native—another myth busted! The key is to find plants that pollinators will use, native or not, and avoid those they cannot use, such as multi-floral cultivars so laden with petals as to be inaccessible. These points made, however, we still need to realize that while gardens are helpful, they are not sufficient—in the United Kingdom, for example, only 2% of the land is garden, 70% is agriculture (p. 157).

The "four main aims" (p. 228) that Ollerton set out to achieve are reiterated in the final chapter, Studying Pollinators and Pollination. Sharing his fascination with the topic is the first and the myth-busting noted above is the second. The third, to inform on how much there is to discover, motivates this chapter, full of tips, techniques, and resources—from apps, books, and the latest field guides to the vast information available online—for community scientists. If enough of us make the effort, then Ollerton's fourth aim—to encourage the preservation of pollinators and pollination—could yet be fulfilled. This is a book that deserves to be read by anyone interested in the topic. Given the amount of research in the pipeline, it's easy to imagine a second edition someday. One little suggestion: add a fifth word—Science—to the title. In the meantime, we can always keep up through his blog, https://jeffollerton.co.uk/blog/.

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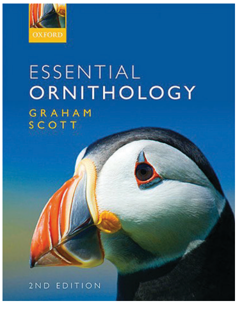
ORNITHOLOGY

Essential Ornithology. Second Edition

By Graham Scott. 2020. Oxford University Press. 224 pages, 45.95 CAD, Cloth. Also available as an E-book.



Graham Scott's *Essential Ornithology* is designed as an introduction to the scientific study of birds. It delivers on this objective, covering the fundamental elements of bird life: evolution, feathers and flight, migration and navigation, eggs and nesting, reproduction, foraging, and populations.

The book is, on the whole, accessible to the amateur ornithologist. It is written in clear if sometimes scientific language, made more personable by anecdotes from the author. Moreover, it includes plentiful diagrams and colour pictures to support and complement the text. The geographic diversity of species used as evidence and examples means that any reader is likely to encounter familiar names.

One useful feature of the book is the inclusion of frequent boxes to explain important concepts, provide key citations, cross-reference other sections of the text, or dive deeper into particular areas. One such box (pp. 16–17) explains the ecological impact of hybridization. It recounts how the North American Ruddy Duck (*Oxyura jamaicensis*), upon its introduction to Europe, promptly interbred with the indigenous White-headed Duck (*Oxyura leucocephala*). The genetic viability of the native species was threatened until concerted international conservation measures stemmed the Ruddy Duck's expansion. The box draws an analogy to the inverse case of American Black Ducks (*Anas rubripes*) and Mallards (*Anas platyrhynchos*) in North America, where the spread of Mallards may have been supported by the introduction of European stock by early settlers. Although still quite common, Black Duck is now on a genetic precipice in its native range owing to interbreeding with the more dominant Mallard. Case studies such as these help make the book interesting and intelligible to a diverse audience.

As an introduction, *Essential Ornithology* understandably leaves some intellectual avenues not fully pursued. One example is a discussion of feather pigmentation (p. 26), in which it is noted that red and yellow colours are solely acquired from diet. The author adds that these colours feature prominently in the breeding plumage of males, suggesting that this may be a signal of virility. The connection is left for the reader to make, that colours acquired through feeding indicate an ability to feed oneself—and therefore to feed a mate and young.

Yet these very implications and omissions also serve to underline just how much remains unknown in the avian world. The frequent references to limited data and outstanding questions should certainly intrigue and inspire anyone curious about the life of birds. The author draws on a wide body of literature from across many decades, including initial reports on ongoing research. Students and casual readers alike will find potential dissertations and investigations in these pages.

There was a small but surprising number of typographical and grammatical errors in the text. These did not interfere significantly with legibility but should have been caught in the review process. The graphs would also have benefited from greater editorial attention: while helpful overall, some are quite unintuitive, particularly for the non-scientist reader.

Regardless, there is a great deal of information collected here in a slender volume. To be at once introductory and scientific is not easy; for succeeding in this endeavour, *Essential Ornithology* deserves our interest and appreciation.

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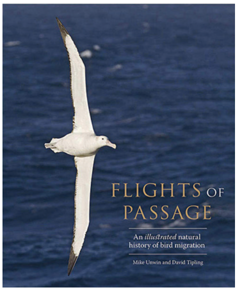
Flights of Passage: An Illustrated Natural History of Bird Migration

By Mike Unwin and David Tipling. 2020. Yale University Press. 288 pages and 220 colour illustrations, 40.00 USD, Cloth.



As a bird bander, whenever I recapture a migrant that I banded in the same location in a previous year, I marvel at this tiny being's ability to travel vast distances and unerringly return to its previous breeding site. How do they do it? This book did not give me an in-depth explanation of why and how birds migrate, but that isn't really its intent: while Unwin and Tipling's book does provide an introduction to all aspects of avian migration, it is mainly a celebration of the wonder of flight and the drama of migration, as told through the stories and images of 67 species.

The book begins with a 12-page introduction to bird migration, of which only a few paragraphs focus on why birds migrate and how they find their way; both are fascinating topics and more detail would have been welcome. This is followed by five sections that, rather than being taxonomic groupings, are loose associations of species—wildfowl and diving birds, seabirds, shorebirds, songbirds, raptors and owls—that showcase a spectrum of migratory behaviour. A final section discusses "misfits" and other species that tell a compelling story but do not fit into the five main groupings. Each section starts with a one-page introduction to the group. Each species account then follows a similar template: thumbnail description of size, appearance, lifestyle, range and migration, and status. A map (scale depending on species) shows general breeding, non-breeding, and year-round residency areas, with arrows indicating general migration route(s) and direction. One or two pages of text highlight unique aspects of the species' life history and migration strategy.

The authors have a very Northern Hemisphere focus, with 62 of the 67 highlighted species being ones that breed there and migrate varying distances south. Of the other five species, two are Australian and three are African. There are no Western Hemisphere austral migrants, those that breed in the temperate areas of South America and migrate north to Amazonia in the non-breeding season (see review by Chesser 1994). I think this was a missed opportunity to broaden the reader's concept of bird migration by highlighting a couple of these species.

Species' status is apparently based on the IUCN Red List of Threatened Species, although this is not explicitly stated in the introduction, and should be explained for those unaware of it. The status of many species was given as Least Concern, but then in the details there is mention of severe declines in certain populations: I would have liked to have seen at least a mention in the introduction of 'shifting baseline syndrome', the concept that people's accepted threshold for environmental degradation (or species decline, in this case) is continually lowered in the absence of historical information or past experience. I thought there could have been a little more emphasis put on conservation of important stop-over sites, the threat of hunting—particularly along the Mediterranean islands—and the threat of climate change (changes in rainfall, wind patterns, temperature changes, storms, phenology of prey, etc.). While these were all mentioned in the context of individual species, they could have been explored more in the introduction.

The maps are generally effective at locating where the species lives throughout the year, scaled depending on its range. However, I noticed a couple of errors: the legend in the map of principal migratory flyways does not match the text exactly; the map for Baltimore Oriole (*Icterus galbula*) breeding range does not extend nearly far enough west, even though Montana is mentioned in the text; and, while the text for Northern Wheatear (*Oenanthe oenanthe*) mentions birds breeding in eastern Canada, this is not shown on the map. There are also a few errors in the text: the Pink-footed Goose (*Anser brachyrhynchus*) account states that the tail is white with a black tip, but the photograph shows it is black with a white tip, as does my field guide; the Tundra Swan (*Cygnus columbianus*) account states that the species is called Whistling Swan in North America, but that is an old common name; and, in the title of the species account, Snow Goose is correctly given as *Anser caerulescens*, but the text retains the now superseded genus *Chen* for the two subspecies. As well, after stating that Lesser Snow Goose (*A. c. caerulescens*) is found westward from central northern Canada, the text incorrectly states that it is responsible for habitat degradation on breeding grounds on Hudson's Bay, caused, in fact, by Greater Snow Goose (*A. c. atlanticus*).

The poster child of long-distance migration used to be Wandering Albatross (*Diomedea exulans*), which has been known to circumnavigate the Southern Ocean three times in one year (about 120 000 km). But it may have been supplanted by Bar-tailed Godwit (*Limosa lapponica*), which recent satellite telemetry tracking has been shown to fly from Alaska to New Zealand (11 680 km) in just nine days of nonstop flight

(p. 136)! I enjoyed reading about the many fascinating migration facts like this throughout this book.

Then there are the stunning photographs, which are really the focus of the book, many of which feature unique angles. All but 38 of the 154 photographs were taken by the award-winning wildlife photographer David Tipling. These are mostly one- or two-page action shots, but many show habitat too, especially with larger species. This is a book that can sit on your coffee table, waiting for you to pick it up and randomly choose a species to spend 5–10 min reading about and be amazed and inspired by the diversity and beauty of migratory birds.

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Literature Cited

Chesser, R.T. 1994. Migration in South America: an overview of the austral system. Bird Conservation International 4: 91–107. https://doi.org/10.1017/S0959270900002690

The Biology of Moult in Birds

By Lukas Jenni and Raffael Winkler. 2020. Helm. 320 pages and 151 illustrations, 76.50 USD, Cloth, PDF E-book, or EPUB/MOBI E-book.

Every bird does it … replaces all of its feathers, that is, usually once a year for smaller birds and longer for larger birds. The process of doing so is called "moult". There are two main reasons this is done: (1) worn, damaged, or lost feathers must be replaced to maintain plumage function, such as insulation and flight, and (2) feathers are replaced to adjust to changing requirements, such as the need for colourful plumage to attract mates. This sounds simple but is anything but. For instance, a hummingbird has some 1000 contour (body) feathers, and a swan has 25 000! And, with the exception of most waterfowl and a few other species, a bird still needs to fly while moulting its wing feathers. Fitting moult into a bird's annual cycle of breeding and migration (for temperate-breeding species) usually requires trade-offs, some at the behavioural level and others at the physiological level. While there is usually some overlap of moult with breeding and/or migration, Common Murre (*Uria aalge*) overlaps all three life history stages by feeding its chicks at sea, while migrating by swimming because it has simultaneously moulted all of its flight feathers. Talk about multi-tasking! A behavioural example is that of Rock Ptarmigan (*Lagopus muta*), which moults its plumage to match its Arctic environment; however, the male keeps his white winter plumage longer than the female does to attract mates, then when the female starts laying eggs he purposely soils his plumage to be more cryptic until he moults into his brown summer plumage.

The Biology of Moult in Birds is a textbook on the what, why, where, when, and how of moult, with some fascinating examples such as the two above. The book is organised into five chapters: (1) functions of plumage, (2) plumage maintenance and need for renewal, (3) processes of moult, such as feather growth and physiology, (4) effects of environmental conditions during moult on plumage quality, and (5) moult strategies, or fitting moult into the annual cycle. Each chapter is divided into sub-sections, each of which has a plain language summary, plus a summary and concluding remarks at the end of the chapter. The text is superbly complemented by 151 figures, all with clear and informative captions. Many of the figures include multiple photographs, from microscopic detail of feathers to stages of moult in different species, and the coloured illustrations include a variety of styles of graphs, 3-D drawings, and flow charts. Most of the examples, whether in the text or the figures, are of European species, which reflects where Jenni and Winkler are based, but also where much of the research on moult has been undertaken. However, it is reasonably easy to think of a similar species in North America. I confess to skimming over some of the details, such as those on physiology, but felt that I understood the basics by reading the summaries and studying the figures. The book ends with 41 pages of small-print references and an 18-page detailed index.

The onset, duration, extent, and speed of moult at the individual level are governed largely by a genetically determined (innate) schedule, which interacts with day length (photoperiod), and is modified by breeding activity and social cues (e.g., number of nestlings, parental care), and environmental factors such as food availability, temperature, and parasite load. At the species level, moult is governed by the size and morphology of the bird, its lifestyle, and annual cycle needs. It is common to read about the "costs" of moult: reduced insulation may require more fuel to maintain metabolic functions, flight costs increase when there are gaps in the flight feathers, hunting success is reduced for raptors, reluctance to fly may increase predation risk. However, I was surprised to read that some of these costs may be compensated for by changing the wingbeat to maintain flight, adapting the resting metabolic rate, and reducing body weight yet increasing muscle mass. And these costs may actually be less than during the breeding season, when birds are laying eggs, feeding young, and defending territories.

I found the final chapter, on fitting moult into the annual cycle, the most interesting. As a bird bander, an understanding of a species' moult strategy—the timing, place, extent, speed, and sequence of moult—is critical to being able to determine the age of a bird, a key demographic parameter in scientific studies. Moult strategy is determined by (1) the length of the longest primaries, which impacts the time required to grow new ones, (2) the degree of flight capability needed during moult, (3) the timing of breeding and/or migration, and (4) the ease of obtaining food during moult.

Moult studies have been difficult to undertake, but the authors have done a good job of synthesizing the data. Most were undertaken with captive birds, which raises the question of how representative these are of free-living birds. There have not been as many studies on large birds, such as raptors or herons, because they are difficult to keep in captivity. As a result, there is still a lack of studies on many aspects of moult, and the section summaries often raise questions for which more research is required. As Jenni and Winkler state in their concluding remarks:

> Many studies of annual cycles by default give a premium role to reproduction and migration, rather than moult. However, while breeding can be skipped, moult is a life-history stage essential for survival by maintaining flight and feather function. (p. 238)

It is a fascinating topic.

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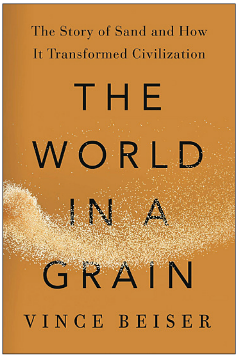
OTHER

The World in a Grain: The Story of Sand and How It Transformed Civilization

By Vince Beiser. 2018. Riverhead Books. 294 pages, 37.00 CAD, Cloth, 17.00 CAD, Paper.



An entry in the noble genre of "a lot more information about something you thought was boring", *The World in a Grain* is an exploration of sand and its foundational role in our society. If, like me, you were surprised and mystified by the news stories over the last decade or so heralding the fact that we are, as a global civilization, running out of sand, this book is for you. Written with a broad audience in mind, it is nonetheless lovingly referenced with in-text citations described further in a 20-page Notes section organized by chapter. Additionally, the author provides a Bibliography of published books and important documents used in their research, and a detailed Index.

Following an introductory chapter (The Most Important Solid Substance on Earth), the book is organized into two main parts: the past and the present/future. Part 1 covers the history of how sand built our 20th century world, including its fundamental role in cities (cement), interconnected nations (pavement), and everything from simple windows to high-tech innovations which let us peer into the inner workings of microscopic and interstellar worlds (glass). Part 2 explains how sand is building our globalized, digital world. From the rare and precious high-silicon Iota quartz required to make halogen lamps and photovoltaic cells to the ultra-pure (80 molecules of impurities per one billion molecules of silicon dioxide) quartz necessary for computer chips, our online world requires sand, and there are more types than I could have imagined. Each of our seemingly infinite uses for sand requires very specific grains. Desert sand? Too rounded to be used in construction. Sand used for fracking? Requires specific properties: high quartz content, small grained, and semi-rounded edges.

Not to be confused with a treatise on sand engineering, *The World in a Grain* also addresses the human and environmental cost of our global relationship with sand. Bricklayer associations versus concrete proponents. Land creation via destructive ocean bed dredging. Critically eroding beaches and the sand mining required to maintain the classic 'beach' look. The simple fact that we need more and more concrete but have not figured out how to recycle it. The ecological consequences of dredging, trawling, and mining for a dwindling resource. Sand heists and corruption with deadly consequences for activists and anyone who opposes.

This book is well researched and delivers on its promise. Each chapter focusses on a new, distinct piece of the narrative while building on what came before to create a coherent whole. If you are looking for a work primarily focussed on the environmental consequences of sand mining, this is not the book for you. If you also want to learn about the history and context, the complexity and socioeconomic dimensions, *The World in a Grain* is written for you.

HEATHER A. CRAY
Halifax, NS, Canada

New Titles

Prepared by Barry Cottam

Please note: Only books marked † or * have been received from publishers. All other titles are listed as books of potential interest to subscribers. Please send notice of new books—or copies for review—to the Book Review Editor.

†Available for review *Assigned

Currency Codes: CAD Canadian Dollars, AUD Australian Dollars, USD United States Dollars, EUR Euros, GBP British Pounds.

Biology

The First Cell: The Mystery Surrounding the Beginning of Life. By Ulrich Schreiber and Christian Mayer. 2020. Springer International Publishing. 195 pages, 47 colour illustrations, and one black and white illustration, 49.99 USD, Cloth, 34.99 USD, E-book.

Microbiomes of Soils, Plants and Animals: An Integrated Approach. Edited by Rachael E. Antwis, Xavier A. Harrison, and Michael J. Cox. 2020. Cambridge University Press. 248 pages, 115.00 USD, Cloth, 44.99 USD, Paper.

New World Monkeys: The Evolutionary Odyssey. By Alfred L. Rosenberger. 2020. Princeton University Press. 368 pages and 16-page colour insert, 39.95 USD, Cloth. Also available as an E-book.

The Science of Animal Welfare: Understanding What Animals Want. By Marian Stamp Dawkins. 2021. Oxford University Press. 160 pages, 75.00 CAD, Cloth, 35.95 CAD, Paper. Also available as an E-book.

Secretive Slime Moulds: Myxomycetes of Australia. By Steven Stephenson. 2021. CSIRO Publishing. 382 pages, 180.00 AUD, Cloth.

†**Squid**. By Martin Wallen. 2021. Reaktion Books. 216 pages, 19.95 USD, Paper.

Botany

Ash. By Edward Parker. 2021. Reaktion Books. 224 pages, 80 colour plates, and 70 halftones, 27.00 USD, Cloth.

***In Defense of Plants: An Exploration Into the Wonder of Plants**. By Matt Candeias. 2021. Mango Media. 280 pages, 18.95 USD, Cloth.

Extraordinary Orchids. By Sandra Knapp. Foreword by Mark W. Chase. 2021. University of Chicago Press. 160 pages and 140 colour plates, 30.00 USD, Cloth or E-book.

Field Guide to the Grasses of Oregon and Washington. By Cindy Talbott Roché, Richard E. Brainerd, Barbara L. Wilson, Nick Otting, and Robert C. Korfhage. 2019. Oregon State University Press. 472 pages, 49.95 CAD, Paper.

Finding the Mother Tree: Discovering the Wisdom of the Forest. By Suzanne Simard. 2021. Allen Lane. 368 pages, 34.95 CAD, Cloth, 15.99 CAD, E-book.

Florapedia: A Brief Compendium of Floral Lore. Pedia Books Series. By Carol Gracie. Illustrated by Amy Jean Porter. 2021. Princeton University Press. 200 pages, 16.95 USD, Cloth. Also available as an E-book.

A Naturalist's Book of Wildflowers: Celebrating 85 Native Plants in North America. By Laura Martin. 2021. Countryman Press. 240 pages, 22.95 USD, Paper.

A Naturalist's Guide to Plant Communities of Pacific Northwest Dune Forests and Wetlands. By George Poinar, Jr. 2019. BRIT – Botanical Research Institute of Texas. 329 pages and 500 colour photos, 25.00 USD, Paper.

The Nature of Oaks: The Rich Ecology of Our Most Essential Native Trees. By Douglas W. Tallamy. 2021. Workman Publishing. 200 pages, 27.95 USD, Cloth, 21.95 USD, E-book.

Wildflowers of New York City. By Andrew Garn. 2021. Cornell University Press. 208 pages and 185 colour photos, 32.95 USD, Cloth.

Yungcautnguuq Nunam Qainga Tamarmi / The Entire Surface of the Land is Medicine: Edible and Medicinal Plants of Southwest Alaska. By Ann Fienup-Riordan, with contributions by Alice Rearden, Marie Meade, and Kevin Jernigan. Photography by Kevin Jernigan and Jacqueline Cleveland. Plant portraits by Sharon Birzer and Richard W. Tyler. 2021. University of Alaska Press. Distributed by University of Chicago Press. 300 pages and 124 colour plates, 28.95 USD, Paper or E-book.

CLIMATE CHANGE

The Contamination of the Earth: A History of Pollutions in the Industrial Age. By Francois Jarrige and Thomas Le Roux. Translated by Janice Egan and Michael Egan. 2020. MIT Press. 480 pages, 39.95 USD, Cloth, 19.95 USD, Paper.

Environmental Offsets. Edited by Shelley Burgin and Tor Hundloe. 2021. CSIRO Publishing. 140 pages, 69.99 AUD, Paper.

Grasslands and Climate Change. Ecological Reviews Series. Edited by David J. Gibson and Jonathan A. Newman. 2019. Cambridge University Press. 372 pages, 102.95 CAD, Cloth, 51.95 CAD, Paper.

ECOLOGY & CONSERVATION

100 Plants to Feed the Monarch. By The Xerces Society. 2021. Storey Publishing. 288 pages, 57.00 USD, Paper.

†**Adaptation and the Brain**. Oxford Series in Ecology and Evolution. By Susan D. Healy. 2021. Oxford University Press. 176 pages, 95.00 CAD, Cloth, 45.95 CAD, Paper.

Animals' Best Friends: Putting Compassion to Work for Animals in Captivity and in the Wild. By Barbara J. King. 2021. University of Chicago Press. 280 pages, 25.00 USD, Cloth or E-book.

Avatimik Kamattiarniq: Arctic Ecology and Environmental Stewardship. By Jordan Hoffman. 2017. Nunavut Arctic College Media. 261 pages, 74.95 CAD, Cloth.

Beloved Beasts: Fighting for Life in an Age of Extinction. By Michelle Nijhuis. 2021. W.W. Norton. 352 pages, 27.95 USD, Cloth.

The Biological Survey of Canada: A Personal History. Biological Survey of Canada Monograph Series No. 8. By H.V. Danks. 2016. Biological Survey of Canada. Open access at https://biologicalsurvey.ca/public/Bsc/Controller/Page/Danks2016_BSCHistory.pdf.

Catastrophic Thinking: Extinction and the Value of Diversity from Darwin to the Anthropocene. By David Sepkoski. 2020. University of Chicago Press. 360 pages, 35.00 USD, Cloth. Also available as an E-book.

Community-Based Monitoring in the Arctic. By Finn Danielsen, Noor Johnson, Olivia Lee, Maryann Fidel, Lisbeth Iversen, Michael K. Poulsen, Hajo Eicken, Ania Albin, Simone G. Hansen, Peter L. Pulsifer, Peter Thorne, and Martin Enghoff. 2021. University of Alaska Press. Distributed by University of Chicago Press. 116 pages, 11 halftones, and 11 tables, 29.95 USD, Paper or E-book.

†**Dead Zones: The Loss of Oxygen from Rivers, Lakes, Seas, and the Ocean**. By David L. Kirchman. 2021. Oxford University Press. 228 pages, 39.95 CAD, Cloth. Also available as an E-book.

†**Ecology of Coastal Marine Sediments: Form, Function, and Change in the Anthropocene**. By Simon F. Thrush, Judi E. Hewitt, Conrad A. Pilditch, and Alf Norkko. 2021. Oxford University Press. 224 pages, 100.00 CAD, Cloth, 49.95 CAD, Paper. Also available as an E-book.

†**Exuberant Life: An Evolutionary Approach to Conservation in Galápagos**. By William H. Durham. 2021. Oxford University Press. 408 pages, 49.95 CAD, Cloth. Also available as an E-book.

Flames of Extinction: The Race to Save Australia's Threatened Wildlife. By John Pickrell. 2021. Island Press. 228 pages, 28.00 USD, Cloth or E-book.

Future Sea: How to Rescue and Protect the World's Oceans. By Deborah Rowan Wright. 2020. University of Chicago Press. 200 pages, 22.50 USD, Cloth or E-book.

Moving Water: The Everglades and Big Sugar. By Amy Green. 2021. Johns Hopkins University Press. 272 pages, 24.95 USD, Cloth or E-book.

Plant Conservation: The Role of Habitat Restoration. By Sergei Volis. 2019. Cambridge University Press. 494 pages, 131.95 CAD, Cloth, 56.95 CAD, Paper. Also available as an E-book.

Recovering Lost Species in the Modern Age: Histories of Longing and Belonging. By Dolly Jørgensen. 2019. The MIT Press. 256 pages, 30.00 USD, Paper.

†**Rewilding Agricultural Landscapes: A California Study in Rebalancing the Needs of People and Nature**. Edited by H. Scott Butterfield, T. Rodd Kelsey, and Abigail K. Hart. 2021. Island Press. 288 pages, 39.00 USD, Paper or E-book.

Rewilding: The Radical New Science of Ecological Recovery. By Paul Jepson and Cain Blythe. 2020. Icon Books. 176 pages, 5.82 GBP, Paper. Also available as an E-book.

Scientific Foundations of Zoos and Aquariums: Their Role in Conservation and Research. Edited by Allison B. Kaufman, Meredith J. Bashaw, and Terry L. Maple. 2019. Cambridge University Press.

684 pages, 114.95 CAD, Cloth, 56.95 CAD, Paper. Also available as an E-book.

Something Hidden in the Ranges: The Secret Life of Mountain Ecosystems. By Ellen Wohl. 2021. Oregon State University Press. 176 pages, 28.95 CAD, Paper.

Start to Identify Composite Flowers: Daisy, Dandelion, Thistle. By Faith Anstey. 2021. Wildflower Study. 38 pages and 125 colour plates, 8.50 GBP, Paper.

The Synthetic Age: Outdesigning Evolution, Resurrecting Species, and Reengineering Our World. By Christopher J. Preston. 2018. MIT Press. 224 pages, 26.95 USD, Cloth, 15.95 USD, Paper.

Thirteen Paces by Four: Backyard Biophilia and the Emerging Earth Ethic. By Joe Gray. 2021. Dixi Books (UK). 192 pages, 17.99 GBP, Paper.

Urban Ecology: Its Nature and Challenges. Edited by Pedro Barbosa. 2020. CABI. 248 pages, 120.00 USD, Cloth or E-book.

Wildlife Disease Ecology: Linking Theory to Data and Application. Edited by Kenneth Wilson, Andy Fenton, and Dan Tompkins. 2019. Cambridge University Press. 690 pages and 284 black and white illustrations, 115.00 USD, Cloth, 59.99 USD, Paper.

Ecology

50 Ways to Help Save the Bees. By Sally Coulthard. 2021. Countryman Press. 136 pages, 14.95 USD, Paper.

The Complete Field Guide to Dragonflies of Australia. Second Edition. By Günther Theischinger, John Hawking, and Albert Orr. 2021. CSIRO Publishing. 424 pages, 49.99 AUD, Paper.

Empire of Ants: The Hidden Worlds and Extraordinary Lives of Earth's Tiny Conquerors. By Susanne Foitzik and Olaf Fritsche. 2021. Workman Publishing. 352 pages, 27.95 USD, Cloth, 21.95 USD, E-book.

Encyclopedia of Social Insects. Edited by Christopher K. Starr. Foreword by Raghavendra Gadagkar. 2021. Springer International Publishing. 1075 pages, 749.99 USD, Cloth or E-book; 1099.99 for both.

Guide d'identification des vers fil-de-fer dans les grandes cultures au Québec. Par J. Saguez. 2017. Centre de recherche sur les grains. 44 pages. Disponible à https://cerom.qc.ca/vffqc/documents/Saguez_2017-Guide-d-identification-VFF-ISBN_978-2-9813604-5-8.pdf.

Leafminers of North America. By Charley Eiseman. 2019. Self-published E-book. 2009 pages, 90.00 USD covers first addition plus all future updates. Available from http://charleyeiseman.com/leafminers/.

A Natural History of Insects in 100 Limericks. By Richard Jones and Calvin Ure-Jones. 2021. Pelagic Publishing. 120 pages, 17.33 CAD, Paper.

Stingless Bees: Their Behaviour, Ecology and Evolution. Fascinating Life Sciences Series. By Christoph Grüter. 2020. Springer International Publishing. 399 pages, 86 colour illustrations, and 11 black and white illustrations, 139.99 USD, Cloth, 109.99 USD, E-book.

Super Fly: The Unexpected Lives of the World's Most Successful Insects. By Jonathan Balcombe. 2021. Penguin Books. 352 pages, 24.00 CAD, Paper, 13.99 CAD, E-book.

Wasps: The Astonishing Diversity of a Misunderstood Insect. By Eric R. Eaton. 2021. Princeton University Press. 256 pages and 150 colour photos, 29.95 USD, Cloth. Also available as an E-book.

Periodical Cicadas: The Brood X Edition. By Gene Kritsky. 2021. Ohio Biological Survey. 154 pages, 24.99 USD, full-colour Paper, 12.99 USD, black-and-white Paper, 9.99 USD, E-book.

Plant Galls of the Western United States. By Ronald A. Russo. 2021. Princeton University Press. 400 pages, 29.95 USD, Paper. Also available as an E-book.

Herpetology

Lizards of the World: A Guide to Every Family. By Mark O'Shea. 2021. Princeton University Press. 240 pages, 29.95 USD, Cloth.

Ornithology

The Bedside Book of Birds: An Avian Miscellany. By Graeme Gibson. Foreword by Margaret Atwood. 2021. Doubleday Canada. 384 pages, 48.00 CAD, Cloth.

The Evolution of Feathers from Their Origin to the Present. Fascinating Life Sciences Series. Edited by Christian Foth and Oliver W.M. Rauhut. 2020. Springer International Publishing. 256 pages, 71 colour illustrations, and nine black and white illustrations, 119.99 USD, Cloth, 79.99 USD, E-book.

Florida Scrub-jay: Field Notes on a Vanishing Bird. By Mark Jerome Walters. 2021. University of Florida Press. 176 pages, 24.95 USD, Cloth. Also available as an E-book.

A World on the Wing: The Global Odyssey of Migratory Birds. By Scott Weidensaul. 2021. W.W. Norton. 400 pages, 32.00 USD, Cloth.

ZOOLOGY

Water Mites of the World with Keys to the Families, Subfamilies, Genera and Subgenera. By Harry Smit. 2020. Nederlandse Entomologische Vereniging. 774 pages and 3087 line drawings, 90.00 EUR, Cloth.

50 Years of Bat Research Foundations and New Frontiers. Fascinating Life Sciences Series. Edited by Burton K. Lim, M. Brock Fenton, R. Mark Brigham, Shahroukh Mistry, Allen Kurta, Erin H. Gillam, Amy Russell, and Jorge Ortega. Foreword by Paul A. Racey. 2021. Springer Nature. 387 pages, 52 colour illustrations, and 11 black and white illustrations, 109.99 USD, Cloth, 84.99 USD, E-book.

The Atlantic Walrus: Biological, Historical, and Indigenous Insights into Species-Human Interactions. Edited by Xenia Keighley, Morten Tange Olsen, Peter Jordan, and Sean P.A. Desjardins. 2021. Academic Press. 344 pages, 102.00 CAD, Paper.

The Bears of Brooks Falls: Wildlife and Survival on Alaska's Brooks River. By Michael Fitz. 2021. Countryman Press. 288 pages, 18.95 USD, Paper.

†**Coywolf: Eastern Coyote Genetics, Ecology, Management, and Politics**. By Jonathan (Jon) Way. 2021. Eastern Coyote/Coywolf Research, Barnstable, MA. 277 pages, Open Access E-book. Available from http://www.easterncoyoteresearch.com/CoywolfBook/.

Crab. By Cynthia Chris. 2021. Reaktion Books. 176 pages, 85 colour plates, and 15 halftones, 19.95 USD, Paper.

Ethology and Behavioral Ecology of Sea Otters and Polar Bear. Ethology and Behavioral Ecology of Marine Mammals Series. Edited by Randall Davis and Anthony Pagano. 2021. Springer International Publishing. 200 pages, 87 colour illustrations, and 20 black and white illustrations, 169.99 USD, Cloth, 129.99 USD, E-book.

†**Opossums: An Adaptive Radiation of New World Marsupials**. By Robert S. Voss and Sharon A. Jansa. 2021. Johns Hopkins University Press. 328 pages, 59.95 USD, Cloth or E-book.

OTHER

The Bears Ears: A Human History of America's Most Endangered Wilderness. By David Roberts. 2021. W.W. Norton. 336 pages, 27.95 USD, Cloth.

On Being a Bear: Face to Face with Our Wild Sibling. By Rémy Marion. Foreword by Lambert Wilson. Translated by David Warriner. 2021. Greystone Books. 240 pages, 29.95 CAD, Cloth. Also available as an E-book.

Bicycling with Butterflies: My 10,201-Mile Journey Following the Monarch Migration. By Sara Dykman. 2021. Timber Press. 280 pages, 37.95 CAD, Cloth.

Billion-Dollar Fish: The Untold Story of the Alaska Pollock. By Kevin M. Bailey. 2021. University of Chicago Press. 300 pages, 18.00 USD, Paper.

†**Driven by Nature: A Personal Journey from Shanghai to Botany and Global Sustainability**. By Peter H. Raven. Edited by Eric Engles. Foreword by E.O. Wilson. 2021. Missouri Botanical Garden Press. Distributed by University of Chicago Press. 450 pages and 50 colour plates, 35.00 USD, Cloth.

How to Be Animal: A New History of What It Means to Be Human. By Melanie Challenger. 2021. Allen Lane. 272 pages, 22.95 CAD, Paper, 13.99 CAD, E-book.

†**The Government of Natural Resources: Science, Territory, and State Power in Quebec, 1867–1939**. By Stéphane Castonguay. Translated by Käthe Roth. 2021. University of British Columbia Press. 208 pages, 75.00 CAD, Cloth.

†**Insights from Data with R: An Introduction for the Life and Environmental Sciences**. By Owen L. Petchey, Andrew P. Beckerman, Natalie Cooper, and Dylan Z. Childs. 2021. Oxford University Press. 320 pages, 75.00 CAD, Cloth, 36.95 CAD, Paper. Also available as an E-book.

Maria Martin's World: Art and Science, Faith and Family in Audubon's America. By Debra J. Lindsay. Illustrations by Maria Martin. 2018. University of Alabama Press. 328 pages, 50 colour illustrations, and six black and white illustrations, 49.95 USD, Cloth or E-book.

Nature Fast and Slow: How Life Works, from Fractions of a Second to Billions of Years. 2021. Reaktion Books. 224 pages, 22.50 USD, Cloth.

Nunakun-gguq Ciutengqertut / They Say They Have Ears Through the Ground: Animal Essays from Southwest Alaska. By Ann Fienup-Riordan. Translated by Alice Rearden, Marie Meade, David Chanar, Rebecca Nayamin, and Corey Joseph. 2020. University of Alaska Press. Distributed by University of Chicago Press. 400 pages and 50 halftones, 39.95 USD, Paper or E-book.

***The Object's the Thing: The Writings of Yorke Edwards, a Pioneer of Heritage Interpretation in Canada**. Edited by Richard Kool and Robert A. Cannings. Foreword by Bob Peart. 2021. Royal British Columbia Museum. 336 pages, 24.95 CAD, Paper.

†Population Genetics with R: An Introduction for Life Scientists. By Áki Jarl Láruson and Floyd Allan Reed. 2021. Oxford University Press. 224 pages, 95.00 CAD, Cloth, 45.95 CAD, Paper. Also available as an E-book.

†Reflections on the Making of the Modern Law of the Sea. By Satya N. Nandan and Kristine E. Dalaker. 2021. National University of Singapore Press. 320 pages, 32.00 USD, Paper.

†Science in the Forest, Science in the Past. Edited by Geoffrey E.R. Lloyd and Aparecida Vilaça. 2020. HAU Books. 290 pages, 30.00 USD, Paper.

Science on a Mission: How Military Funding Shaped What We Do and Don't Know About the Ocean. By Naomi Oreskes. 2021. University of Chicago Press. 744 pages, 40.00 USD, Cloth or E-book.

†Southwood's Ecological Methods. Fifth Edition. By Peter A. Henderson. 2021. Oxford University Press. 528 pages and 176 illustrations, 120.00 CAD, Cloth, 60.00 CAD, Paper. Also available as an E-book.

†Temple of Science: The Pre-Raphaelites and Oxford University Museum of Natural History. By John Holmes. 2021. University of Chicago Press. 184 pages and 100 colour plates, 55.00 USD, Cloth.

†Vanished Giants: The Lost World of the Ice Age. By Anthony J. Stuart. 2021. University of Chicago Press. 288 pages, 45.00 USD, Cloth. Also available as an E-book.

Wild Neighbours: Portraits of London's Magnificent Creatures. By Sarah Cheesbrough. 2020. Unicorn Publishing Group. 192 pages, 37.95 USD, Cloth.

E.O. Wilson: Biophilia, The Diversity of Life, Naturalist. Collected Edition. By Edward O. Wilson. Edited by David Quammen. 2021. Library of America. 1150 pages, 60.00 USD, Cloth.

Writing Effective Ecological Reports: A Guide to Principles and Practice. By Mike Dean. Foreword by Mike Oxford. 2021. Pelagic Publishing. 228 pages, 61.22 CAD, Paper.

A Year in the Wilderness: Bearing Witness in the Boundary Waters. By Amy Freeman and Dave Freeman. 2018. Milkweed. 320 pages, 35.00 USD, Cloth, 25.00 USD, Paper.

The Canadian Field-Naturalist

News and Comment

Compiled by Amanda E. Martin

Upcoming Meetings and Workshops

Entomological Society of America, North Central Branch Meeting

The annual North Central Branch Meeting of the Entomological Society of America to be held as an online meeting 21–23 June 2021. Registration for this event is free for members. More information is available at https://www.entsoc.org/northcentral/branch-meeting.

World Conference on Ecological Restoration

The 9th World Conference on Ecological Restoration to be held as an online meeting 21–24 June 2021. The theme of the conference is: 'A New Global Trajectory: Catalyzing Change Through the UN Decade on Ecosystem Restoration'. Registration is currently open. More information is available at http://www.ser2021.org/.

Entomological Society of America, Southwestern Branch Meeting

The annual Southwestern Branch Meeting of the Entomological Society of America to be held as an online meeting 28–29 June 2021. Registration for this event is free for members. More information is available at https://www.entsoc.org/southwestern/branch-meeting.

BL2021

The Québec B(ryophytes) and L(ichens) conference—or BL2021—of the Canadian Botanical Association/L'association botanique du Canada, International Association of Bryologists, American Bryological and Lichenological Society, and the Societé québécoise de bryologie to be held as an online meeting 6–9 July 2021. The theme of the meeting is: 'Bryophytes, Lichens and Northern Ecosystems in a Changing World'. Registration is currently open. More information is available at http://bl2021.org/.

Botany 2021

Botany 2021 to be held as an online meeting 18–23 July 2021. Registration is currently open. More information is available at http://2021.botanyconference.org/.

Ecological Society of America Annual Meeting

The annual meeting of the Ecological Society of America to be held as an online meeting 2–6 August 2021. The theme of the conference is: 'Vital Connections in Ecology'. Registration is currently open. More information is available at https://www.esa.org/longbeach/.

Annual Conference of the Animal Behavior Society

The 58th Annual Conference of the Animal Behavior Society to be held as an online meeting 3–6 August 2021. Registration is currently open. More information is available at https://www.animalbehaviorsociety.org/2021/index.php.

Joint meeting of the American Ornithological Society and Society of Canadian Ornithologists - Société des ornithologistes du Canada

The joint meeting of the American Ornithological Society and Society of Canadian Ornithologists - Société des ornithologistes du Canada to be held as an online meeting 9–14 August 2021. The theme of the conference is: 'Birds of Many Feathers Flock Together'. Registration is currently open. More information is available at https://meeting.americanornithology.org/.

Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles

The 19th Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles to be held as an online meeting 10–31 August 2021. Registration is currently open. More information is available at https://turtlesurvival.org/2021-symposium/

James Fletcher Award for *The Canadian Field-Naturalist* Volume 134

The James Fletcher Award is awarded to the authors of the "best" paper published in a volume of *The Canadian Field-Naturalist* (CFN). The award is in its fifth year. The award honours James Fletcher, founder of the Ottawa Field-Naturalists' Club (OFNC) and the first editor of CFN's earliest iteration, *Transactions of the Ottawa Field-Naturalists' Club*. The editorial team of CFN sifted through all papers in Volume 134 of CFN, and came up with a list of the top four papers. From these top four, the committee selected the top paper. The award for Volume 134 of CFN goes to:

Daniel F. Brunton, Margaret A. Krichbaum, Randall S. Krichbaum, and Paul C. Sokoloff. Distribution and status of Howell's Quillwort (*Isoetes howellii*, Isoetaceae) in Canada and its relation to Bolander's Quillwort (*Isoetes bolanderi*). Canadian Field-Naturalist 134(3): 252–264. https://doi.org/10.22621/cfn.v134i3.2509

– A study of rare and at-risk quillworts in British Columbia using a combination of field surveys and morphological examination, including scanning electron microscope images of spores.
– Important results for the conservation of this rare species.

Congratulations to Dan Brunton and co-authors for their excellent paper.

Honourable Mentions

Pamela H. Sinclair, Marty D. Mossop, and Shannon A. Stotyn. Nesting ecology and reuse of nest burrows by Bank Swallow (*Riparia riparia*) in southern Yukon. Canadian Field-Naturalist 134(4): 329–341. https://doi.org/10.22621/cfn.v134i4.2427

– Quite an extensive study of nesting ecology of a Threatened bird species in a region where it has been relatively understudied (boreal).
– Results have implications for recovery of this listed species.

Véronique Lesage, Stéphane Lair, Samuel Turgeon, and Pierre Béland. Diet of St. Lawrence Estuary Beluga (*Delphinapterus leucas*) in a changing ecosystem. Canadian Field-Naturalist 134(1): 21–35. https://doi.org/10.22621/cfn.v134i1.2421

– A comparative study of St. Lawrence Beluga diet from carcass examination over the past 30 years with that of a previous diet study from a hunting site over 80 years ago.
– A change in diet reflects a change in the marine ecosystem.

Stephanie K. Archer, Glen Dennison, Lora Tryon, Sheila Byers, and Anya Dunham. Invertebrate settlement and diversity on a glass sponge reef. Canadian Field-Naturalist 134(1): 1–15. https://doi.org/10.22621/cfn.v134i1.2297

– The assessment of invertebrate diversity on a glass sponge reef in Halkett Bay Provincial Marine Park, British Columbia, using settlement plates.
– This study provides further evidence that glass sponge reefs are an important component of the marine ecosystem.

Congratulations to these finalists. We would also like to voice our appreciation to all authors who chose to share their interesting and valuable field-based studies with the readers of Volume 134 of CFN.

WILLIAM HALLIDAY, AMANDA E. MARTIN, and DWAYNE LEPITZKI
OFNC Publication Committee

Writing for Conservation: an Online Resource for Science Communication

Fisher, M. 2019. Writing for Conservation. Fauna & Flora International, Cambridge, United Kingdom. Accessed 30 May 2021. https://www.oryxthejournal.org/writing-for-conservation-guide.

In 2019 Fauna & Flora International, with the support of The Rufford Foundation and the John Spedan Lewis Foundation, published a free online guide to *Writing for Conservation*, with the goal to provide guidance to those wanting to report research findings and results of conservation actions in ways that are informative and interesting to the audience. Fisher suggests that *Writing for Conservation* will be useful no matter the writing venue, from blogs to reports to articles for publication in peer-reviewed journals. In my opinion, however, the advice given in *Writing for Conservation* will be much more useful in more formal situations (e.g., writing for a peer-reviewed journal) than in informal ones (e.g., writing a blog post).

This online resource is formatted in the same manner as a traditional book, with chapters further subdivided into sections. These chapters and sections are easily accessible via a drop-down menu located at the top right of each webpage. After a brief Preface and Introduction, the next two chapters—Structure your Writing and Present your Data—focus on an overview of the elements a writer needs to consider when preparing a manuscript, with advice on writing each of the typical sections found in a scientific article (Title, Abstract, Introduction, etc.) and preparing figures and tables. This is followed by a series of chapters focussed on providing more specific guidance on (1) how to ensure a complete and accurate bibliography or reference section; (2) how to write clearly and concisely; and (3) how to produce visually appealing maps and figures that convey a clear message to readers. In addition to providing design tips and illustrative examples of maps and figures, Fisher provides recommendations for free software packages that writers could use, with examples and links to video tutorials. The guide also includes a chapter with advice on how to promote your writing through things like blog posts and social media.

Overall, I found this to be a well-organized resource, peppered with useful pieces of advice. Things that I "had to learn the hard way". For example, Fisher recommends that if you plan to publish in a peer-reviewed journal you should choose the target journal before you start writing. I whole-heartedly agree. Different journals have different formatting requirements and different limits on the lengths of article sections and/or the full article. You can save a lot of time if you write to satisfy these requirements, rather than revising your manuscript to satisfy them after a full draft is completed. Another time-saver is the recommendation to use a reference manager (e.g., Mendeley or Zotero) to insert citations into the manuscript and produce the references section. I manually inserted citations and wrote and formatted references sections for years before I finally tried a reference manager and realized how much time it could save me! Note that some peer-reviewed journals do not allow submission of manuscripts with the linked fields inserted by the reference manager; in these cases, the links must be converted to regular text before submission.

Individuals with experience writing and publishing articles in peer-reviewed journals may or may not find something new in this guide. However, I think those who are just starting out will find *Writing for Conservation* to be a valuable resource.

AMANDA E. MARTIN
Assistant Editor

Correction: Carolyn Callaghan—stop stepping down!

In the News & Comments piece "Carolyn Callaghan—stop stepping down!" (134: 404 https://doi.org/10.22621/cfn.v134i4.2753), Carolyn's position as Senior Conservation Biologist was misprinted; Carolyn works for the Canadian Wildlife Federation, not the Canadian Nature Federation.

The Canadian Field-Naturalist

Draft Minutes of the 142nd Annual Business Meeting (ABM) of the Ottawa Field-Naturalists' Club, 12 January 2021

Held by Zoom meeting during COVID-19 pandemic.
Chairperson: Diane Lepage, President

The Zoom meeting was attended by 65 participants. The minutes of the previous ABM, the financial statements, Treasurer's Report, and Annual Reports of the Ottawa Field-Naturalists' Club (OFNC) Committees for 2019–2020 had previously been available on the Club's website. During the meeting, relevant documents were projected on the screen for the audience's reference.

Diane Lepage called the meeting to order at 7:35 pm and welcomed the participants.

The Zoom host, Ken Young, explained how the Zoom meeting and voting would work.

1. Approval of the Agenda

It was moved by Elizabeth Moore, seconded by Jakob Mueller, that the Agenda be accepted as distributed.

Carried

It was noted that, for the report following the conclusion of the business meeting on rare birds seen in the Ottawa area in the past year, Michelle Martin would replace Bruce Di Labio as joint presenter with Bernie Ladouceur.

2. Minutes of the Previous Annual Business Meeting

It was moved by Elizabeth Moore, seconded by Ted Farnworth, that the minutes of the 141st ABM be accepted as distributed and published in *The Canadian Field-Naturalist* (CFN).

Carried

3. Business Arising from the Minutes

a) Colacem L'Orignal Cement Plant

Gord Robertson had drawn the attention of the last ABM to the approval by the Ontario Municipal Board of the construction of a cement plant by Colacem Canada Inc. in L'Orignal, Ontario. The site is 2 km from the Ottawa River and 9 km from the Alfred Bog. The Vankleek Hill and District Nature Society (VKHDNS) were very concerned about emissions from the plant and had requested assistance from OFNC in opposing the necessary zoning change. OFNC had donated $1000 to employ an expert to calculate likely emissions. Diane Lepage reported that she had attended a virtual hearing in December 2020 where it was shown that the emissions projected by Colacem were substantially underestimated. The case is awaiting judgement.

b) Burnt Lands Alvar

Diane Lepage had reported at the last ABM that the Mississippi Valley Field-Naturalists' Club (MVFNC) had sought assistance in promoting protection of the Alvar. OFNC had donated $800 towards the development of a website to promote understanding of the importance of the Alvar. Diane reported that MVFNC had advised that, due to COVID restrictions, they had been unable to make much progress with the website which they felt required face-to-face planning. OFNC will continue to monitor this initiative.

4. Treasurer's Report by Ann Mackenzie

Ann MacKenzie, Treasurer, presented the Financial Statements for the year ended 30 September 2020 as prepared and reviewed by the accounting firm Welch LLP. The complete statements as well as the Treasurer's Report for 2019–2020 were available to members on the Club website in advance of the meeting.

There were four key observations relative to the financial statements. The Club had a surplus of $22 000 in the year but this is not seen as indicative of a trend, but rather specific circumstances. Revenues were higher than the previous year, 2018–2019, as a result of higher donation levels and greater income from author's charges. Expenses were only slightly lower because of decreased activity. The necessary cancellation of the Fletcher Wildlife Garden Plant Sale meant that little revenue was received from plants.

Looking back over the last 10 years showed the spike in revenues and surpluses in 2014 and 2015 as a result of the Czasak bequest. As programs and projects were implemented as a consequence of this bequest the next couple of years had marked losses. It appears as if revenues and expenses are becoming more balanced as they had been before the bequest with just the normal annual variations.

A question was raised about whether the Club had ethical guidelines for investments. Investments are primarily in provincial bonds which does not pose ethical issues. However it was acknowledged that guidelines might be prudent, regardless.

It was moved by Ann MacKenzie, seconded by Ken Young, that the Financial Statements be accepted as a fair representation of the financial position of the Club as of 30 September 2020.

Carried

5. Nomination of the Accounting Firm

It was moved by Ann MacKenzie, seconded by Ken Young, that the accounting firm of Welch LLP be contracted to conduct a review of the OFNC's accounts for the fiscal year ending 30 September 2021.

Carried

6. Committee Annual Reports

It was moved by Elizabeth Moore, seconded by Gordon Robertson, that the Committee Annual Reports be accepted as distributed.

Carried

Highlights from 2020

a) Fletcher Wildlife Garden (FWG)

Ted Farnworth discussed some of the challenges and some of the successes experienced during the year. At the beginning of the COVID-19 pandemic, Agriculture and Agri-Food Canada (AAFC) had blocked off access to FWG, delaying the start of the volunteer year. The annual plant sale had to be cancelled. Some plants were sold through other channels but there was substantially reduced revenue. Once volunteer activity was able to start, with appropriate COVID precautions, a large number of new volunteers turned out, many having learned about FWG through Volunteer Ottawa. The new volunteers included a significant number of young people which is a very welcome development.

COVID restrictions left many families trying to find local areas to explore and FWG saw a considerable increase in the number of visitors, many coming for the first time. The FWG Facebook Group has also experienced a significant increase in followers. Although the increased interest is welcome, the large number of visitors resulted in some issues with social distancing. Appropriate signs were erected in the garden. Increased problems with dogs off-leash were also noted with some unpleasant confrontations resulting. Ted warned that AAFC is now enforcing parking restrictions.

In closing, Ted brought the attention of the meeting to the two extensive developments that are planned adjacent to FWG. To the east, the new hospital is expected to be "the largest medical campus in Canada" and to the south, the planned botanical garden expects to draw "hundreds of thousands of visitors" a year. These developments will undoubtedly have a significant impact on FWG.

b) Conservation

Owen Clarkin summarized the work of the committee with accompanying photographs.

The committee has been involved in a Multi-Year Red Spruce Project. In February, in partnership with Janet Mason from the Ottawa Stewardship Council, they met with Norbert Lussier, a career technician partner of Alan Gordon (the discoverer of Red Spruce in Ontario circa 1950). They discussed what is, and isn't, known about the species in the province. Following this meeting, in the winter and spring they performed extensive surveys and Google Street View searching for the species and approximately doubled the known populations in Ontario east of Ottawa, including a large population at the edge of Voyageur Provincial Park (PP). They subsequently proposed a survey of Voyageur PP and turned up three new populations of Red Spruce in the Park from July to December 2020, in addition to a number of other new plant and animal records.

Other notable activities included:

i) Establishing new amphibian records for local areas such as Spotted Salamander near Vars and Two-lined Salamander at Voyageur PP.

ii) Finding a population of critically endangered Greater Purple Fringed Orchid near Vars.

iii) Confirmation, via flowers, of the presence of *Euonymus nanus* at Gillies Grove, the first provincial record and second in North America.

iv) (Late 2019) Finding a population of American Hazelnut at Torbolton Forest, an apparently isolated northern population of the species.

v) (Late 2019) Finding a probable new population of Southern Arrowwood near Vars, near or at its northern limit, a species considered absent from Quebec north of the Ottawa River.

7. Report of the Nominating Committee by Fenja Brodo (Chair)

Fenja advised that the Board is very stable with only a few changes. The most notable change is that Diane Lepage is stepping down from the position of President and will become Past President. Jakob Mueller has accepted the nomination for President.

Relevant Excerpts from the OFNC Constitution (revised February 2000)

Article 8 – The Council shall consist of the officers of the Club and up to eighteen additional members, all members of the Club.

Article 12 – The officers of the Club and other members of the Council shall be elected annually at the Annual Business Meeting. The nomination of sufficient persons for election to the various offices and membership of the Council shall be the responsibility of the Nominating Committee, which shall act in the manner prescribed in the By-Laws.

The Council shall, at the earliest possible date, appoint chairs and members of Standing and ad hoc committees and Editor and Business Managers, as required for club publications.

Nominated Officers	Official Duty
Jakob Mueller	President
Owen Clarkin	1st Vice President
(vacant)	2nd Vice President
Elizabeth Moore	Recording Secretary
Ann MacKenzie	Treasurer
Diane Lepage	Past President

Nominated Members of the Board of Directors (alphabetical order)

Robert Cermak	Janette Niwa
Edward Farnworth	Gordon Robertson
Catherin Hessian	Jeff Saarela
Diane Kitching	Henry Steger
Diane Lepage	Ken Young
Ann MacKenzie	Eleanor Zurbrigg

It was moved by Fenja Brodo, seconded by Bev McBride, that this slate of nominees for Officers and other Members of the Board of Directors of the OFNC for 2021 be accepted.

Carried

Nominating Committee suggestions to the Board Members for Chairs of Committees and other positions in the OFNC

Awards Committee	Eleanor Zurbrigg
Birds Committee	Robert Cermak
Conservation Committee	Owen Clarkin
Education & Publicity Committee	Gordon Robertson
Events Committee	Jakob Mueller
Fletcher Wildlife	Edward Farnworth, Representative
Finance Committee	Ann MacKenzie
Investment Manager	Catherine Hessian
Macoun Field Club	Diane Kitching, Representative
Membership Committee	Henry Steger
Publications Committee	Annie Bélair, Representative
Editor, *Canadian Field-Naturalist*	Dwayne Lepitzki
Editor, *Trail & Landscape*	Annie Bélair

Chairs not on the Board of Directors

Macoun Field Club	Rob Lee
Safe Wings Ottawa	Anouk Hoedeman
Webmaster	Sandra Garland
Ontario Nature Representative	Diane Holmes

Fenja advised that several of the Committees need more members and appealed to attendees to consider volunteering as committee members. The Education and Publicity Committee and the Events Committee are in particular need of new members.

8. New Business and General Discussion

Celebrating Fenja Brodo's 30 years on the OFNC Board

On the occasion of Fenja's retirement from the Board, several members of the Board spoke to her contributions to the Club.

Eleanor Zurbrigg noted that Fenja has been a member of the Club for 54 years. During that time, she has served in various positions including:

10 years as Editor of *Trail & Landscape*,
10 years on the Education and Publicity Committee,
10 years on the Events Committee, and
10 years on the Executive Committee.

In 2001, Fenja was awarded the George McGee Service Award for her contribution as an outstanding Editor of *Trail & Landscape*.

In 2009, Fenja was elected to Honorary Membership in the Club.

Annie Bélair noted that, during her tenure as Editor of *Trail & Landscape* from 1991 to 2001, Fenja had worked on 38 issues of *Trail & Landscape*, contributing to a major part of the Club's work. Working initially with paper copy, Fenja was the first Editor to introduce use of a computer.

Jakob Mueller noted that Fenja had chaired the Events Committee for five of the 10 years that she was on the committee. The position involves a great deal of work, arranging field trips and speakers among other responsibilities. Fenja has also been involved in co-ordinating Awards Night and the Pelee trip over the years.

Diane Lepage noted that Fenja had served as Vice President, President, and Past President of the Club. She described Fenja as very interested in other people, very positive, and very welcoming towards new ideas. Diane remarked that Fenja will be missed on the Board and looked forward to her continued participation in the Club.

All the speakers expressed their thanks for Fenja's contributions to the Club. They also noted her remarkably persuasive talent for recruiting members into positions of responsibility within the Club which will be sorely missed.

Fenja thanked the speakers and told the meeting that she had enjoyed it all!

10. Adjournment

It was moved by Elizabeth Moore, seconded by Eleanor Zurbrigg, that the meeting be adjourned.

Carried

ELIZABETH MOORE
Recording Secretary

After the meeting was adjourned, Diane Lepage presented a multiple choice identification quiz of some of the wildlife captured in her beautiful photographs.

Bernie Ladouceur and Michelle Martin then reported on some of the rare birds seen in the Ottawa area over the past year and some of the changing trends that have been documented in recent years.

The Canadian Field-Naturalist

Annual Reports of OFNC Committees for October 2019–September 2020

Awards Committee

The Awards Committee manages the process to annually recognize and thank those Ottawa Field-Naturalists' Club (OFNC) members and other qualified persons who, by virtue of their efforts and talents, are deserving of special recognition. In late 2019, nominations were received and evaluated (see awards criteria at http://ofnc.ca/about-ofnc/awards), resulting in nominees for four awards being recommended to the Board of Directors for approval. Biographies were written for each award recipient for inclusion in the Club's publications and posting on the website. The awards were presented at the annual Awards Night in February 2020. The recipients' names, type of award, and short rationale for recognition follow below.

- Martha Farkas—Member of the Year Award. For outstanding coordination of the Point Pelee bus excursion.
- Barry Cottam—George McGee Service Award. For contributions in many areas of the Club including *The Canadian Field-Naturalist* and Fletcher Wildlife Garden.
- Owen J. Clarkin—Conservation Award for a Member. For revitalizing the Conservation Committee and promoting the appreciation and conservation of regional forests.
- Mississippi Madawaska Land Trust— Conservation Award for a Non-member. For their land preservation initiatives.

Eleanor Zurbrigg, Chair

Birds Committee

Birds Committee (11 members), Bird Records Sub-committee (12 members), and Bird Feeders Sub-committee (Chair coordinates and fills in when needed and five volunteers) coordinated OFNC bird-related activities and directed and encouraged interest in birds within and outside the OFNC area.

A committee member, Nina Stavlund, administered the Ottawa Field-Naturalists' Club's Facebook group (2257 members in November 2020) which is a place for OFNC members and non-members to discuss ideas and exchange information relating to all aspects of natural history, club outings, and club initiatives, as well as for prospective members to get a feel for what OFNC is about.

A committee member, Derek Dunnett, provided weekly provincial (Birdnews) reports of OFNC area (Ottawa–Gatineau) bird sightings which, with photos by local photographers, was also provided on OFNC Facebook and the OFNC website.

Committee members provided articles on a variety of subjects in *Trail & Landscape*, led OFNC field trips, participated in the OFNC Website Working Group, improved Birds content on the website, and responded to bird related enquires from members and the public. The Bird Studies Group suspended workshops on topics of interest to birders such as the Chirps, Tweets & Trills workshops with the advent of COVID-19 just prior to spring birding season. Chris Traynor established policy with the Department of National Defense (DND) and coordinated updates to DND's Shirley's Bay causeway access list.

OFNC Birds Committee and the Club des ornithologues de l'Outaouais (COO) organized the 101st Ottawa–Gatineau Christmas Bird Count 15 December 2019. The day featured 30 kph winds (with gusts to 50 kph) and gradually dropping temperatures throughout the day. A total of 61 species were found by 139 field observers and 26 feeder watchers. The species total was the third lowest in the last 30 years. There were no real highlights, with one spectacular exception, a Northern Fulmar that appeared mid-afternoon over and on the Ottawa River, below the Deschênes Rapids.

Birds Committee organized and participated in the 2020 Seedathon "Big Day" on 30 August 2020. There were 15 participants who submitted 39 checklists. The tally of species was 121 this year; the record Seedathon tally is 134 species found by Bob Bracken, Bernie Ladouceur, and Chris Lewis in 2006

Bob Cermak, Chair

Conservation Committee

Intent to wrap up fieldwork on our multi-year Red Spruce survey project, we started 2020 activities via a late winter meeting with Norbert Lussier, an old colleague of Alan Gordon (the discoverer of the species in Ontario circa 1950). We met Norbert along with Janet Mason, of the Ottawa Stewardship

Council. Norbert was kind enough to discuss all he knows about Red Spruce in Ontario, including suggesting that we check the landscape north of Larose Forest in more detail. This inspired us to take several road trips in February and March and surf Google Streetview thoroughly, resulting in new populations being found near Rockland, near Plantagenet, near Alfred, in Larose Forest (first "wild" origin trees to our knowledge at Larose), and many trees found along the Highway 417 corridor bordering Voyageur Provincial Park, within 100 m west and south of the park (more on that later).

Given the challenges associated with the pandemic which emerged in March, we were initially concerned that we might be facing a "lost year" but ultimately we found ourselves to be no less busy than in a normal year, albeit with strict physical distancing from March onwards.

Our next major activity was a Rhodora survey at Alfred Bog during its flowering period in May. A rare (S1) eastern species, we had noted apparent habitat loss where Rhodora had previously been reported and that Rhodora had not been reported in recent years. So in collaboration with Ontario Parks and the Natural Heritage Information Centre, we surveyed and found large local populations of Rhodora persisting at the western edge of the bog. An interesting incidental finding was that we found the apparent culprit causing significant damage to Sheep Laurel leaves noted in previous years across eastern Ontario: Kalmia Leaf Beetle (*Tricholochmaea kalmiae*) was observed in high numbers consuming leaves of the evergreen Sheep Laurel.

In June our group, in cooperation with Ontario Nature, participated in a bioblitz survey at and near Gananoque Lake on a newly conserved property.

Following up on a hunch of committee member Greg Lutick, our group found a population of Greater Fringed Orchid (S1 species) near Vars during the summer.

Mid-summer, we confirmed (via observed flowers) the presence of wild-growth Dwarf Strawberry Bush (*Euonymus nanus*) at Gillies Grove making this perhaps only the second time the species has been observed to be escaped in North America.

Inspired by our late winter work finding Red Spruce, we proposed and were granted permission to conduct a six month survey (July–end of year) for Red Spruce at Voyageur Provincial Park. We ended up discovering three populations of the species at the park, making Voyageur one of a very few parks in the province with confirmed natural growth Red Spruce. Given the half-year duration of the project over repeated visits to the park, we found a number of other new species for the park and other interesting incidental findings such as what we think may be the largest Rock Elm on public property in Ontario.

In late summer we conducted a radio interview with Carleton University's CKCU, describing our group's work in recent years. We also participated in a number of conservation-related physically-distant activities, notably small in-person tours with the Friends of the Farm and livestreams with Ecology Ottawa.

For the autumn academic term, we participated in the design and evaluation of a 3rd-year environmental science course at Carleton University (with Professor Susan Aitken of Carleton University and Janet Mason of the Ottawa Stewardship Council).

We had intended for 2020 to be a year focussed on reptile / amphibian surveys: to some extent our activity was reduced due to the pandemic, but led by committee member Jakob Mueller our group made significant finds such as Milk Snake at Orleands, Spotted Salamander in Cumberland Forest near Vars, and Two-lined Salamander at Voyageur Provincial Park. We intend to carry on with this focus in 2021.

Along with community partners, our group is planning biodiversity monitoring projects at Lavigne Natural Park project and Carp Barrens during 2021. Following our work at Voyageur Provincial Park and Alfred Bog in 2020, we are also planning additional work with Ontario Parks in 2021.

In addition to active work in the field, we also responded to several proposed changes to policy relevant to conservation, notably the provincial Bill 229 late in the year.

OWEN CLARKIN, Chair

Education and Publicity Committee

COVID-19 created a series of cancellations that severely limited the work of the Education and Publicity Committee. We did participate in the February Ottawa Wildlife Speaker Series. Sandy Garland, Catherine Shearer, Lynn Ovenden, and Gordon Robertson took a display to the event, which attracted a lot of interest. The presentation by the invited speaker on Coyotes was very informative and well attended.

The Committee has three new members: Dean Beeby, Lloyd Mayeda, and Sarah Wray. Emily Shearer also joined but later withdrew due to work demands. Dean Beeby has taken over the Twitter account and Gord added its link to the webpages. Gord was added as an Administrator for the webpages.

The Ottawa–Carleton District School Board's Science Fair was cancelled just as we were selecting judges. Kathy Conlan who judged at the fair for many years asked to be replaced. We thanked her for her many contributions to this event.

Lynn Ovenden registered the OFNC for a Jane's Walk on Sunday 3 May to coincide with our annual

Open House. Both events had to be cancelled.

Mark Brenchley constructed three more storyboard holders. Three posts were purchased and the holders installed at the Fletcher Wildlife Garden (FWG). Michelle St-Germain selected images of flowers for two of the storyboards. The third was placed in the new habitat called the Gully.

Gord has made five new wildlife quests for Strathcona Park, Riverain Park, the Bog Trail, the MacLaren Cemetery Trails in Wakefield, and a general one for Ottawa–Gatineau. More are to be planned and produced. Other quests were updated to include sections where unlisted wildlife may be added. These wildlife quests (formerly called hunts) are intended to assist parents taking their children on nature walks (see them at ofnc.ca/quests).

A fourth species trail map on vines has been added for walks at the FWG. All four may be found at ofnc.ca/maps. The committee is considering labelling some of the notable trees and shrubs on these trails with their common names in English and French, the species name, and possibly QR codes with URL links to our website. Expansion of descriptions on the webpages and links to other relevant scientific sites were also being considered.

A group of Brownies came to the FWG on 26 September. Only 11 girls showed up so Gord gave them a brief tour then sent them to do the Butterfly Meadow on their own. Social distancing and masks were mandatory. Rob Alvo led a tour at Mud Lake for an alternative school.

There were no applicants for the Youth Summit this year that was to be online. Macoun Club members were contacted but none responded. Greater outreach is necessary for this event to be successful.

Gord Robertson, Chair

Events Committee

The 2020 Events Committee faced an incredibly challenging year. The committee had started the year well-positioned, with speakers booked for most of the year's meetings and dozens of planned field trips in the works. In response to the COVID-19 pandemic, all monthly meetings and field trips after 15 March were cancelled. With restrictions and safety procedures, field trips resumed in September 2020, but few such events were scheduled as virus case counts climbed again in the "second wave".

The committee pivoted to creating digital events, primarily held on Zoom, with one digital "scavenger hunt" conducted on the OFNC Facebook group. Official monthly meetings resumed in December in an online format. Astronomer Howard Simkover presented at both the last in-person meeting and the first new digital meeting.

In total, the committee coordinated 23 events (not including those cancelled), including field trips, workshops, presentations for monthly meetings, and digital events. Topics included birding (five), mycology (five), conservation (two), astronomy (two), herpetology (one), and photography (one), with the remainder being general interest (seven).

The committee extends its sincere gratitude to all individuals who lead, presented, or assisted with events.

Jakob Mueller, Chair

Finance Committee

This report covers financial matters during fiscal year 2019–2020, which extended from 1 October 2019 through 30 September 2020.

The COVID-19 pandemic has affected the finances of the OFNC. Fundraising activities such as the Fletcher Wildlife Garden plant sale had to be cancelled. On the other hand, our expenses continue much as before. However, compared with many other small charities, we are fortunate. We have a sizeable reserve that enables us to continue our activities even though revenues are down, and to purchase things such as a Zoom licence to help us cope with the pandemic.

The Finance Committee monitors legislation that might affect the Club. The Club is incorporated in Ontario, so it is subject to Ontario's laws governing incorporated organizations. In 2010, the Government of Ontario passed legislation to update the governance of incorporated charities. The update is badly needed. Unfortunately, successive governments have failed to implement the new law and related regulations. Recently, the government postponed implementation for yet another year. The Finance Committee is currently examining what the Club can do to update our governance, without running afoul of either the existing law, or the new law, because it may someday be enacted.

The primary task of the Finance Committee is to prepare a draft budget for consideration by the Board of Directors. The committee receives suggestions, and estimates of committee revenues and expenses, from directors and committee chairs. Our process is that the Finance Committee presents a draft budget for discussion at the September meeting of the Board of Directors. After amendment, it is adopted at the October meeting.

The budget for FY2019–2020 was approved at the Board of Directors meeting of October 2019. The draft budget for FY2020–2021 was presented to the Board's September 2020 meeting and a revised version was approved at the October 2020 Board meeting. The budget forecasts revenues of $133 600 and expenses of $156 480, for a deficit of $22 880. A copy of the budget, as approved, is included as an appendix to the minutes of the October 2020 Board of Directors meeting. These minutes are posted on the OFNC website.

The question arises from time to time whether our spending is appropriate. Members have two concerns. On the one hand, will we exhaust our investment fund prematurely? Our current budgeted deficits are in the range of $20 000 to $25 000. We are currently earning interest of 2.5% to 3.0% on our investments. If we continue in this manner, our investment fund will be maintained for almost three decades. Even if our earned interest rate drops to 1% it would be two decades. Based on this, the Board feels that our deficits are reasonable.

The other concern is that we are not spending enough. The Board of Directors reviews proposals for spending, during the budget process and on an *ad hoc* basis during the year. Proposals are evaluated based on the Club's objectives, for example natural history education, and our policies, for example a focus on eastern Ontario and the Ottawa Valley. The Board is responsive to proposals, but also prudent.

The committee examined our accounting standards during the year. We consulted with our accountants concerning an accounting issue, how to match revenues and expenses in our financial statements. In the end we decided that we could not improve on the existing accounting standard that we use. We have made a change to the timing of sending invoices to authors of articles in *The Canadian Field-Naturalist*. It should have the effect of improving the matching, without changing the accounting standard.

The Treasurer continued her work to improve our systems for bookkeeping, donations, and payments.

For the past three years, Tanja Schueler has helped the Club with financial matters, in particular by keeping track of our PayPal account. Now she is returning home to Australia. I thank her for her help, and wish her well among the fascinating world of Australian flora and fauna.

KEN YOUNG, Chair

Fletcher Wildlife Garden

2020 has been a challenging year for the FWG group. All work, access, and activity at the Fletcher were carried out under COVID-19 restrictions and protocols. Thanks to the dedication and hard work of our volunteers, the Fletcher property was maintained and open to visitors in spite of a late start for our work teams. We welcomed more visitors than usual, as people, many for the first time, took advantage of the outdoor experience, and the peace and beauty offered at the Fletcher. Many visitors with children were particularly pleased with the story boards that have been put up around the property that provide information about the flora and fauna found at the Fletcher throughout the year.

To protect volunteers who continued to work as visitors toured the property, signage was put up reminding people about social distancing.

At the beginning of the year Sandy Garland and her team started the labour-intensive work to grow, pot, and repot plants for the FWG annual plant sale. However, restrictions imposed by the pandemic meant that the annual plant sale did not happen.

A new team comprising Chris Mark, Pam Johnston, and Barbara Riley have taken over running the Backyard Garden after Isabel Nicol stepped down. The pandemic delayed maintenance work, but the gardens have been well cared for thanks to the volunteers, including several high school students. Significant progress was made on the north bank of the ravine, and it has become a popular spot to stop, sit, and enjoy the view. A plan is being developed to slowly phase out non-native plants from the Back Yard Garden, and throughout the property.

The battle with invasive species continues in all parts of the property. Replanting White Snakeroot along the path to the baseball diamond has shown that Dog Strangling Vine (DSV) can be discouraged from regrowing. Several volunteers in the Tuesday group have taken up the battle against Buckthorn after our long-time Buckthorn expert Tony Denton decided it was time to slow down. Good progress was made eliminating Flowering Rush from the amphibian pond. Purple Comfrey along the entrance road and in the western part of the property was the target of several work parties, but it continues to spread. Following several years of work, DSV abundance has been reduced throughout the Butterfly Meadow, although continued vigilance is required. This has allowed increased focus on removal of other problem plants, notably honeysuckle, tansy, and comfrey, as well as increased attention to keeping high-value trees and shrubs free from encroaching vines and ground cover.

Using pandemic restrictions and guidelines, we were able to host small volunteer groups from the Canadian Wildlife Federation, Ottawa Police, and Health Canada.

Agriculture Canada and the City of Ottawa have now agreed that by-law enforcement, dogs on leash in particular, is the responsibility of the City of Ottawa.

Our Facebook page continues to be filled with spectacular photos of the wide variety of flora and fauna that call the Fletcher Wildlife Garden home.

TED FARNWORTH, Committee Member

Macoun Club

From September 2019 until March 2020, the

Macoun Field Club held meetings and field trips for children and young people (ages 8 to 18) every Saturday, except for public holidays. Committee members organized and oversaw 12 indoor meetings at the Fletcher Wildlife Garden's resource centre, with presentations and workshops, and led nine field trips.

For the fourth year running, the Macoun Club hosted the nature quiz at the OFNC's Awards Night event on 22 February.

A novel coronavirus had been detected in Canada in January. As the number of cases of the disease COVID-19 rose sharply in March, Ontario and Quebec went into a society-wide shutdown. The OFNC suspended all in-person activities, including those of the Macoun Field Club.

Trails in the Macoun Club Study Area remained open. To maintain Macoun Club members' special connection to the natural world, Club leaders began visiting the children's "Study Trees" weekly and reported on them on the Macoun Club website.

Committee members discussed the effects of extended restrictions on Macoun Club members, as reported by their parents: separation from their closest friends, confinement to their homes, physical inactivity, and being deprived of healthy experience in nature.

As OFNC approval was not given until 1 September, there were no Macoun Club field trips for the children during the last six months of the Club's year (March through August).

Publication of Issue No. 74 of the Club's annual magazine, *The Little Bear*, which normally happens in June, was deferred.

ROBERT E. LEE, Chair

Membership Committee

Club membership is divided into two groups. The first, defined as the "Membership", consists of those who pay Club fees, are "Honorary" members, or participate in the "Macoun Club". The other consists as the membership aggregate "Other" which represents mostly designated individuals and affiliate organizations that receive complimentary copies of the *Trail & Landscape* (T&L). This group, together with "T&L Subscriber", are reported separately.

The distribution of Club membership for 2020 on 30 September 2020 and on 30 September 2019 is shown below. There was a notable decrease in Membership of 64 for 2020. The Club did not hold monthly meetings or field events starting mid-March 2020 because of COVID-19 and this likely was a discouragement for members to renew or for new members to join. For example the renewal of memberships for July to September 2020 was about 33% less than in each of the previous six 3-month renewal periods. Also new memberships were about 30% lower than in the previous two years.

Members within 50 km of Ottawa comprised 695 of the total membership of 795.

	2020	2019
Individual	377	402
Family	309	339
Student	16	30
Honorary	23	24
Life	39	39
Macoun Club	20	17
U.S.A.	10	7
International	1	1
TOTAL	795	859

The distribution of "Other" for 2019 on 30 September 2020 and on 30 September 2019 is shown below. The slight increase in "Other" was due to a re-assignment of one type of membership to "Other".

	2020	2019
T&L Subscriber	3	3
Other	26	23
Total	29	26

HENRY STEGER, Chair

Publications Committee

The Publications Committee manages publication of *The Canadian Field-Naturalist* (CFN), T&L, and Special Publications. The committee also advises OFNC with respect to issues relating to research, including managing the research grants program.

Trail & Landscape

Four issues of T&L were published: 54(1–4). In collaboration with the Canadian Museum of Nature, the project to image and upload T&L back issue content to the Biodiversity Heritage Library (BHL) was completed. This content is available under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) licence at https://www.biodiversitylibrary.org/bibliography/115961#/summary. *Trail & Landscape* back issues, from Volume 51 (2017) onwards, are also available on the OFNC website, where the content is displayed in high resolution using a viewing tool that was installed during the last year.

The Canadian Field-Naturalist

Five issues of CFN were published, based on the mailing date: 133(1–4) and 134(1). Two papers published in the last year received media coverage, reflecting not only the important contributions to science published in the journal but also the importance and relevance of the journals content to broader society in Canada. The paper on the spiders of Prince Edward Island (https://doi.org/10.22621/cfn.v132i4.2017) that was the co-winner of the James Fletcher Award for the best paper of the year in the 2018 volume was reported on by CBC News (25 November 2019) and *The Guardian* [P.E.I.] (22 November 2019). A paper on the use of salmon by Brown Bears in and around Gates of the Arctic National Park and Preserve, Alaska (https://doi.org/10.22621/cfn.v133i2.2114) was reported on by *Hatch Magazine*, a publication about fly fishing (17 August 2020).

Ottawa Field-Naturalists' Club Research Grants

This was the sixth year of the Ottawa Field-Naturalists' Club Research Grants program. Research grants support field-based research activities that reflect and promote the Club's objectives within eastern Ontario and/or western Quebec, focussed particularly upon the Club's study area. A total of $15 000 is available each year to fund research proposals. The application deadline was 15 January 2020. A subcommittee convened and chaired by Dan Brunton reviewed all proposals and submitted funding recommendations to the OFNC Board of Directors. A list of recipients of 2020 Research Grants was published in T&L 54(3): 112. The research grant program was reported on by the *Ottawa Citizen* (8 May 2020). COVID-19 restrictions may have curtailed some field work during the summer of 2020.

JEFFERY M. SAARELA, Chair

Safe Wings Ottawa

Highlights

In 2019–2020, Safe Wings Ottawa (SWO) volunteers:

- Documented more than 3000 window collisions (exact number not yet available), a small decrease from the previous year due to volunteer availability / effort.
- Provided care to 1336 live birds representing 127 species (not including domestics), up 46% from the previous year. Of these, 853 (64%) were window collision victims. We admitted a record 45 live birds (all but one were window collision victims) on 11 September. Our previous one-day record, on 21 May 2019, was 26 live birds.
- Answered an estimated 5000 phone calls, up 40% from the previous year. We have recruited and trained more volunteers to answer the phone.
- Added eight new species to our list of collision victims, bringing our cumulative total to 140, including 15 Species at Risk. The cumulative total of species that have been in our care is 141.

COVID-19

The pandemic had a major impact on our operations. Our annual display and the official launch of the Ottawa Bird Strategy was to be held at the Canadian Museum of Nature in late March. The event was cancelled, as were a major fundraiser and all other events in which we planned to participate. Instead, the Ottawa Bird Strategy was released online in the spring, and the specimens that would have been displayed remain in storage.

After consulting with the Canadian Wildlife Health Cooperative, we decided to allow existing volunteers to patrol if they agreed to take precautions such as physical distancing. We did not train new volunteers for the spring season, but developed online orientation and training sessions for fall, and hosted several online events, including workshops and a Jane's Walk.

The Wild Bird Care Centre suspended its use of volunteers to assist with many tasks, which we felt might reduce the level of care that could be provided. Due to this change, Safe Wings began keeping window collision victims in its care for longer periods than in the past, and also transferred some high-needs birds directly to other rehabilitation facilities for care.

Also as a result of the pandemic, many more people became aware of bird collisions at residences. We received fewer calls about collisions at office buildings, but more calls from people working from home.

Outreach

An advocacy subcommittee was created to better oversee and organize outreach efforts to encourage bird-friendly measures. Outreach efforts yielded the following results:

An advocacy subcommittee was created to better oversee and organize outreach efforts to encourage bird-friendly measures. This includes contacting the property owners / managers of existing buildings to recommend corrective measures; reviewing development applications and encouraging members of the public to submit comments to project planners; and initiating discussions with government stakeholders (primarily federal but also municipal) about bird-safe initiatives.

The City of Ottawa and National Capital Commission (NCC) both released draft bird-safe building design guidelines, which are expected to be adopted by the end of 2020. Both agencies have begun specifying bird-friendly design for at least some of their projects. The NCC installed visual markers on the Gatineau Park Visitors Centre on Scott Road, and launched an initiative to assess all its buildings for collision risk.

Communications Security Establishment (CSE) Canada, which last year agreed to apply visual markers to a test area as a pilot project, unexpectedly promised to retrofit the entire building in stages over several years. CSE headquarters is currently estimated to kill thousands of birds per year, and is among the most lethal buildings in the region.

OC Transpo's pilot project to gauge public reaction to visual markers on three bus shelters, originally planned for 2019, finally moved forward this past spring. The ultimate goal is to make all future bus shelters bird-safe. Separately, Safe Wings launched a formal study of bird collisions at existing LRT stations in order to build a case for retrofitting some of these structures, and for the adoption of bird-safe design for the Stage 2 LRT stations.

In Kanata North, one of the worst areas for collisions, the property manager at 1001 Farrar Road accepted Safe Wings' offer to install visual markers on a smoking shelter for free. They are considering applying similar measures to the main building. KRP, which owns most properties in the Kanata Research Park, rejected our offer to apply visual markers to a smoking shelter at 2500 Solandt Drive, then hired a third party to do the job.

Safe Wings Ottawa gave presentations to staff from National Research Canada (NRCan) and BGIS (property management company for most federal buildings). Since then, BGIS applied visual markers to a glass railings at NRCan Head Quarters at 580 Booth Street, and is considering assessments and retrofit projects at other lethal buildings.

After reaching out to Safe Wings for advice, Via Rail applied visual markers on one façade of the Ottawa train station, and plans to treat other façades as budgets allow. The project manager hopes this pilot project will serve as an example to retrofit other train stations across Canada.

There has been enormous public support for bird-safe design for the new library on LeBreton Flats. While collision deterrent measures were promised early on, we were not satisfied with the lack of specific information, especially because the architecture firm is the same one that designed the National Arts Centre retrofit with ineffective bird-friendly measures. We have kept up the pressure and, with the help of the Glebe Community Association, continue to discuss improvements with the city design team.

ANOUK HOEDEMAN, Chair

Treasurer's Report

The Ottawa Field-Naturalists' Club continues to be on a solid financial footing. The fiscal year 2019–2020 showed a surplus of revenue over expenses of $22 035 in the General Fund. This is more related to specific circumstances rather than indicative of a trend. In the previous year (2018–2019) there had been a slight loss of about $3000 and the year before a larger loss of about $42 000. Looking over the past 10 years there has been year-over-year variability in the surplus or loss but no defining trend. Receipt of the Czasak bequest raised revenues significantly in 2014 and 2015. The start of programs and activities resulting from that bequest lead to apparent losses in the following years. We seem to now have settled back into more balanced revenues and expenses.

Looking more closely at 2019–2020, Total Revenue was higher by about $25K than the previous year if you remove the Pelee trip revenue from 2019. Donations were higher overall including a large single donation ($4K) to Safe Wings for rehabilitation equipment. Revenue from authors for publishing in the CFN were considerable higher ($18K) because we had an extra issue of CFN published and we started to send out invoices after the issue was published online rather than after it was published in print.

Expenses were slightly lower this year because some activities were curtailed as a result of pandemic restrictions. Our usual donation of $5000 to the Ottawa–Carleton District School Board for buses for students for outdoor education was deferred until the activity can safely resume. During the year the Club gave $5000 to Ontario Nature to help with the purchase of more land in the Frontenac Arch. The Vanleek Hill District Nature Society was given $1000 to conduct an emission study related to a proposed cement plant. The Mississippi Valley Field Naturalists were given $800 for Burnt Lands Alvar web development.

The Fletcher Wildlife Garden could not hold their annual native plant sale which is their major fundraiser. Some plants were sold directly raising $1255 compared with $6736 the previous year from plant sales. They did receive a grant of $5276 from the City of Ottawa for "Design your own Pollinator Garden" workshops which were held in the fall of 2020 by Elizabeth Gammell.

Looking ahead we are detecting some softening in membership and subscription renewals but it is hard to say how significant this will be financially. It may be a temporary problem resulting from decreased activities. Universities, who are our main subscribers and who pay many author's charges, are also being squeezed by the pandemic. Interest income will decrease as low interest rates continue. Fortunately we have a good cushion to enable us to keep our programs going regardless of these kind of changes.

ANN MACKENZIE, Treasurer

Approved financial statements available online at: https://www.canadianfieldnaturalist.ca/index.php/cfn/article/view/2825/2689

The Canadian Field-Naturalist

The Ottawa Field-Naturalists' Club Awards for 2020

Eleanor Zurbrigg, Irwin Brodo, Christine Hanrahan, Karen McLachlan Hamilton, and Lynn Ovenden

Due to COVID-19, the annual Awards Night ceremony was cancelled this year and awards were presented individually. Awards are given to members or non-members who have distinguished themselves by accomplishments in the field of natural history and conservation or by extraordinary activity within the Club. Five Club awards were conferred for 2020, for: (1) fostering the development of amateur mycology in the Club, (2) efforts to preserve the Champlain oaks, (3) outstanding contributions to Canada's mollusc fauna, (4) making the Fletcher Wildlife Garden (FWG) happen and service to the Club, and (5) a lifetime of natural history and conservation efforts in eastern Ontario and Canada.

Member of the Year: Joan Heyding and Ian Gough

In recognition of the member judged to have contributed the most to the Club in the previous year.

We are awarding Joan Heyding and Ian Gough Members of the Year, for fostering the development of amateur mycology in the Ottawa Field-Naturalists' Club (OFNC).

It's not easy to teach yourself mushrooms. For Joan, it started in 2014 when she photographed some mushrooms on her campsite and tried to identify them. She and Ian also found fungi flourishing in the forest near their cabin, studied field guides, and attended the annual Fabulous Fall Fungi workshops led by Richard Aaron at the Queens University Biological Station. In 2017, at Richard Aaron's suggestion, they reached out to local alumni of the workshops to ask if they wanted to foray occasionally. Joan invited everyone for a walk in Gatineau Park. About eight people showed up, enjoyed each other's company, and chatted about forming the Ottawa Mycology Circle. Ian created an online home for the new group to share photos and plans.

In the spring of 2018, Joan and Ian invited the group for a supper meeting at a friendly tavern to plan a few outings. Over the year, the circle grew to over 30 people and there was talk about how to share the group's enthusiasm with other naturalists in the region. Should they plant a foothold within the OFNC?

OFNC's directors welcomed the prospect of hosting more fungal events. So, in early 2019, Joan and Ian joined the Club and encouraged others in the Circle to do so. They rallied people to share their interests and lead an activity. A steady stream of fungal events ensued. Joan brought photos to OFNC's 2019 Photo Night. One member led a seminar on Beatrix Potter's watercolour paintings of fungi in February. Another gave a talk on mycorrhizal fungi in March. Joan co-led a workshop in April on wood-inhabiting fungi. In June, members forayed in a forest near Calabogie and identified their fungal finds at a member's cabin.

To prepare a fall fungal season, Joan and Ian convened another planning supper in August 2019. Members stepped up to lead forays in Calabogie and at the MacSkimming Outdoor Education Centre. The group hosted two workshops at the Fletcher Resource Centre: first, an introductory talk and review of participants' mystery mushrooms, and secondly, a seminar on Arctic fungi.

Joan and Ian continued to anchor and organize more fungal events in 2020. There was a dinner-and-movie night, a lichen walk at Dewberry Trail in January, and two joint lectures for the OFNC and the RA (Recreation Association of the Public Service of Canada) Canoe Camping Club on fungal themes. Joan, Ian, and a third member authored one of them, on Poisonous Mushrooms. In March 2020, Ian created a new online forum for OFNC's fungi fans: https://forum.mycoott.org/.

There were no forays during the COVID-19 lockdown in spring 2020. However, the forum could meet every few weeks for an evening of Shroom Zoom. During the cautious months of summer and early fall, the group remained active with six small socially-distanced walks and monthly chats on various fungal themes. Three members offered digital presentations to the OFNC membership: an Introduction to Fungi, a talk on Molds, and a talk on Ergot and Choke Disease Fungi.

Joan and Ian have enabled the fungal enthusiasts of OFNC to find and teach each other as they explore the fungal kingdom. With planning meetings, follow-up, encouragement, and communication tools, they have fostered the emergence of an active and growing community of shroomers. We're glad they did.

(Prepared by Lynn Ovenden)

Conservation Award—Non-Member: Daniel Buckles and Debra Huron

This award recognizes an outstanding contribution by a non-member in the cause of natural history conservation in the Ottawa Valley.

The 2020 award goes to two particularly deserving individuals, Daniel Buckles and Debra Huron, for their long dedication to the historic Bur Oak trees in the Champlain Park neighbourhood of Ottawa.

Bur Oaks are slow-growing and majestic trees, and those in Champlain Park are of a venerable age, with one confirmed to be more than 190 years old; they are descendants of an old-growth oak forest as indicated by the informative Champlain Oaks website (https://www.champlainoaks.net/).

The oaks are a source of pride in the area; however, recent development has seen the removal of several gigantic oaks, much against the wishes of the established neighbourhood. This motivated Daniel Buckles and Debra Huron to initiate and organize the Champlain Oaks Project in 2010, bringing together a volunteer group of neighbours to celebrate, preserve, and restore the historic oak forest in Ottawa's west end. Daniel and Debra, as the animators and catalysts, have ensured the engagement and momentum of the group.

Raising awareness of the heritage value and history of the old Bur Oaks and current threats to them is an important way to garner support for preserving the trees. Daniel and Debra conceived the idea for, and provided coordinated, effective leadership to complete, the informative oak display at the Champlain Park Field House: outside, a slice of a giant Bur Oak that was lost to development is displayed; and inside, a timeline of the tree history of the neighbourhood is presented. Daniel and Debra have tirelessly promoted the Champlain oaks directly to City of Ottawa forestry staff, on National Tree Day events, with the children from the local school, through their City Councillor, and in the media.

Thanks to Daniel's and Debra's efforts, in 2017 and 2018, seven ancient Bur Oaks were named Heritage Trees—complete with heritage plaques—by Forests Ontario. To gain this commemorative designation, Daniel and Debra had rallied support from neighbours and tree-lovers and environmentalists from across the city. In 2019, they organized a Jane's Walk to celebrate the Heritage Trees.

A crucial means of protection for mature trees is the City of Ottawa's *Tree Protection By-law*, recently consolidated and strengthened, and the updated Urban Forest Management Plan. Daniel coordinated community input to both of these initiatives to ensure that the needs of the Champlain oaks were considered. He also coordinated local comments on the City's tree planting plans in their neighbourhood.

Daniel spearheaded the Champlain Park community's adoption of Neighbour*woods*, a community-based tree inventory, monitoring, and stewardship planning program. Training of volunteers was provided, a good amount of tree inventory data were collected, and two educational infographics were produced.

Maintaining the unique genetic diversity of the heritage oak trees is important due to their adaptations to conditions in the area. To this end, Daniel and Debra maintain a backyard nursery of baby Bur Oaks grown from acorns of heritage trees. The saplings are available for tree planting in the neighbourhood. Daniel, Debra, and the local Environment Committee volunteers also produced a brochure, *Planting Trees in Small Spaces*, that was distributed throughout the community.

Mapping Ottawa's Lost Trees is another project initiated by Daniel and Debra. They piloted its precursor prior to the city-wide launch by partners in 2018. It is an interactive mapping tool that will help keep track of what is being lost from the urban forest and is planned to be linked to other mapping tools.

The OFNC is pleased to confer the Conservation Award for a Non-Member to Daniel Buckles and Debra Huron.

(Prepared by Eleanor Zurbrigg and Christine Hanrahan with input from Erwin Dreessen)

Honorary Member: Robert G. Forsyth

This award is presented in recognition of outstanding contributions by a member or non-member to Canadian natural history or to the successful operation of the Club. Usually, people awarded an honorary membership have made extensive contributions over many years.

Gastropods could be considered one of the world's misunderstood group of creatures. It was once said:

> Most people dismiss them as slimy, slow-moving creatures seldom worth a second thought. Because they are small and reclusive, we seldom notice them, unless they become pests in our gardens.

Historically this has been the situation in Canada. However, they include serious invasives, valuable prey, important predators, informative indicators, native species at risk, and potential sources of bio-products of great value to people.

Slugs or snails are not easy to identify, especially without experience. To successfully identify them, one must have the following: means to see the animal and its diagnostic structures (many are very small and difficult to see with the naked eye); an adult (diagnostic keys use adult characters and because juveniles do not have them, they cannot be identified); a steady hand when dissection is required for identification; literature; and, if you are lucky, some formal training. Because it takes a lot of work to master these organisms, it is understandable why so few people take on the task. Robert Forsyth found them fascinating and challenging. Without his interest, we would not have a dedicated Canadian expert on this very important group.

Robert's knowledge of these organisms is vast, and his contribution to expanding our understanding of the Canadian mollusc fauna is extensive. He has authored, or contributed to, many scientific papers, several technical reports, Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reports, species assessment summaries, numerous popular articles, as well as two books.

The bulk of his work initially involved collecting and identifying molluscs from British Columba. He has since worked on species in every province and territory. Throughout his studies, he has documented populations of native species, discovered new distributions and/or range extensions/contractions, compiled checklists, and reported on new non-native and potentially invasive species. He has cooperated with more than 100 people while doing this work. Two books, *Land Snails of British Columbia* and *Identifying Land Snails and Slugs in Canada*, are excellent identification tools because they include keys to genera and species, distribution data, habitat and ecology information, and lots of pictures and drawings. They have been proven so useful, that they are used routinely by federal inspectors when snails are found on imported and domestic goods. Many of his specimens can be found in the Royal British Columbia Museum and the New Brunswick Museum and serve as vouchers for mollusc research.

Robert was a member of Mollusc Species Specialist Subcommittee for COSEWIC from 2001 until 2020 and served as Co-chair from 2007 to 2010. COSEWIC is responsible for providing a science-based status assessment of species found in Canada to determine if a species is at risk of extinction and the threats to their continued existence. It was his in-depth knowledge of Canada's terrestrial mollusc fauna that made him a valuable member of this organization for so long. All of the 20 terrestrial snails and slugs so far assessed by COSEWIC have been dealt with while he was part of the subcommittee, including 17 species that are at risk or are no longer found living in Canada. A status report on another terrestrial snail, confined to Cypress Hills in Saskatchewan and Alberta, is scheduled to be assessed in April 2021. His knowledge on molluscs, however, extends far beyond just the terrestrials and includes freshwater as well as marine gastropods. Overall, Robert has made a very significant contribution to the conservation of molluscs in Canada.

Robert also developed and maintains the website www.mollus.ca where people can find information on 22 families of slugs and snails found in North America and 44 non-native species. To date there are 69 posts featuring various species, all of which contain fantastic images. The website also provides useful keys to genera and species in Canada, information on how to collect specimens, and where to donate samples collected.

He has been an OFNC member since 2000, but in 2019 he became the graphic artist/designer, responsible for the layout of *The Canadian Field-Naturalist* (CFN) starting with volume 133. His formal training as a graphic and visual artist as well as his self-taught expertise on molluscs has resulted in his doing layout and technical editing for not only CFN, but for several international malacological journals.

Robert's extensive knowledge has made him an authority on terrestrial molluscs of Canada, and one of the foremost experts of its western fauna. His achievements are especially noteworthy, considering the difficulty of the group. What may be more astonishing is that his knowledge was acquired without any formal training. It has been through Robert Forsyth's interest and dedication to these fascinating, often unnoticed creatures that we have come to know so much more about one of Canada's least known faunal groups in a short period of time.

It is with pleasure that the OFNC awards Robert Forsyth Honorary Membership for his outstanding contributions to Canada's mollusc fauna.

(Prepared by Karen McLachlan Hamilton with input from Dwayne Lepitzki and Paul Catling)

Honorary Member: Jeffery E. Harrison

This award is presented in recognition of outstanding contributions by a member or non-member to Canadian natural history or to the successful operation of the Club. Usually, people awarded an honorary membership have made extensive contributions over many years.

The FWG is without doubt, the public face of the OFNC. Many people first discover the club through visits to the garden. Jeff Harrison was intimately connected with the garden from its early days and even though no longer living in Ottawa, still maintains a keen interest in the site and is always ready to answer queries about the genesis of the garden or provide ideas.

The FWG was initially envisaged as a way for the OFNC to celebrate "Wildlife 87", an initiative of the Canadian Wildlife Service with the goal of emphasizing the conservation of wildlife and its habitat. Peter Hall conceived the idea of a wildlife garden and together with several other OFNC members, chose the location on the Central Experimental Farm. At that point, Jeff who was on the OFNC Council (now Board) and soon to become OFNC President, became chief promoter of the FWG. His enthusiasm for the project was contagious and profound. Working with members of the OFNC sub-committee responsible for the FWG, he threw himself into developing plans and guidelines for the garden, the ideas coming fast and furious. He enlisted numerous volunteers to help the project get underway and then to carry it forward. Once he became chair of the FWG, he kept enthusiasm high and inspired volunteers. He also focussed on developing various habitats for local wildlife in the garden, such as the Backyard Garden, with the aim of showing landowners how to manage sites for wildlife. His endless devotion to the project helped transform the site into the well-loved, well-visited site of today, a place for OFNC committees to meet, and where the Club can conduct its business.

Jeff has long been passionate about nature as evidenced by the column, The Urban Naturalist, he and his wife Victoria Dickenson wrote throughout the 1990's for *The Ottawa Citizen*. For their work promoting nature and the environment, they were awarded a City of Ottawa Whitton Award for Environment in 1996. He has also written extensively about the natural history of the Avalon Peninsula in Newfoundland, an area he knows well, having summered there for many years. For the last 20 years Jeff has been involved in researching and writing the history of ornithology in Canada, with a particular emphasis on Charles Fothergill, a Toronto politician who wrote many articles on the birds of southern Ontario between about 1820–1840.

Originally from Toronto where he became an avid birder, Jeff developed wanderlust as a young man and travelled the world for five years, including a lengthy stay in Australia. The travel bug continued for some time as he then went on to lead nature tours to many exotic parts of the world, although his specialty was the birds and nature of Belize.

In 1997, Jeff came up with the grand idea of holding a birding competition similar to ones south of the border that would "raise money for environmental projects and raise awareness of the great diversity and richness of wildlife habitats in eastern Ontario and western Quebec". He called it The Taverner Cup (after Percy Taverner, the early Canadian ornithologist) and convinced the OFNC to make it a Club activity. Jeff found a number of sponsors and volunteers for the event, promoted it enthusiastically, attracted numerous participants, and MC'd the event for each of the eight years the competition ran.

Jeff Harrison was OFNC President during 1989 and 1990. He also participated in local Christmas Bird Counts and wrote articles for the OFNC publication *Trail & Landscape*.

Jeff's interest in nature encompasses many areas. He was the founder and coordinator of the Newfoundland and Labrador Wilderness Society, served as Vice President Bird Protection Quebec, and was a member of the Board of Directors of the Ontario Field Ornithologists, Secretary for the Toronto Ornithological Club, and was the OFNC representative on the Board of Ontario Nature for several years.

For all these reasons it gives us great pleasure to award Jeff Harrison Honorary Membership in the Ottawa Field-Naturalists' Club.

(Prepared by Christine Hanrahan with Peter Hall)

Honorary Members: Fred Schueler and Aleta Karstad

This award is presented in recognition of outstanding contributions by a member or non-member to Canadian natural history or to the successful operation of the Club. Usually, people awarded an honorary membership have made extensive contributions over many years.

Fred Schueler and his wife, Aleta Karstad, are well known to naturalists and nature lovers in the Ottawa Region. They have been a team for over 47 years, documenting events and changes in the natural world here in the Valley and throughout Canada. Not only have they made observations, collected data and specimens, and made drawings and paintings all across the country, but in 2009, 30 years after their first survey trips, they returned to many of these areas to re-access the natural history, their "Thirty Years Later Expedition".

Fred became a member of the OFNC in 1971, soon after coming to Ottawa to work at the Canadian Museum of Nature. Although Fred's interests were primarily focused on reptiles and amphibians (his Ph.D. thesis was on Leopard Frog), he became expert in many other fields of natural history including malacology and botany. Being a talented and dedicated observer, Fred created a working database of observations on everything from road-kills to invasive plants and animals such as giant reedgrass and Zebra Mussels. Much of Fred's work has been done on contract with the Canadian Museum of Nature where he is the Museum's longest serving Research Associate. His research and other carefully documented observations have resulted in 32 publications, books, and reports.

Aleta Karstad is acknowledged as one of Canada's most talented wildlife artists. Her works of art adorn many homes and public spaces and have illustrated her popular books, including *Canadian Nature Notebook*, *Wild Season's Daybook*, and *A Place to Walk* as well as, more recently, a memory card game, *NatureMatch*. She has received several awards for her art and conservation work, including the Environmental Scientist of the Year (2010) from the Canadian Geographic Society and Robert Bateman Award (2018) from the Canadian Wildlife Federation.

Their conservation work has been far-reaching and influential, from Cumshewa Head on Haida Gwaii and the rivers crossed by the Energy East Pipeline from Alberta to New Brunswick, to northeastern Ontario and the Dumoine River in Quebec. They've also worked with citizen groups protesting habitat destruction throughout eastern Ontario, discovered or predicted most of the new Species at Risk mussel populations in eastern Ontario, and have worked with official bodies on the conservation of Kemptville Creek, the Limerick Forest, and New Brunswick's Protected Natural Areas. Especially notable is their on-going collaboration with the South Nation Conservation Authority's Fish and Wildlife Committee with regard to the South Nation River.

Fred and Aleta's conservation work was acknowledged in 2018 by their receiving the Glen Davis Conservation Leadership Prize from the Canadian Parks and Wilderness Society and the World Wildlife Fund-Canada. Aleta and Fred, with their typical generosity and selflessness, plan to use the $10 000 in prize money to upgrade their database and make it more accessible to the public and other researchers.

Mention must be made of Aleta and Fred's tireless efforts in nature education for which they received the 2011 OFNC Mary Stuart Education Award. Fred's "Mudpuppy Night" in Bishop's Mills has been a popular annual event for decades. They've also published popular natural history books and run the NatureList & OREGlist, e-mail list-serves for natural history and road ecology. In addition, Fred is a regular contributor to several Facebook groups, answering questions pertaining to nature, and he has written several articles for *Trail & Landscape*. Fred and Aleta were instrumental in the creation of the Eastern Ontario Biodiversity Museum in Kemptville, in part, to save the threatened collections at Carleton University. Although that project couldn't be sustained, they are presently operating the Bishop Mill's Natural History Centre to house their personal natural history collection of four to five million specimens.

In recognition of these impressive accomplishments over many years, the OFNC is proud to welcome Aleta Karstad and Frederick W. Schueler as Honorary Members.

(Prepared by Irwin M. Brodo, acknowledging an article by Paulina Hrebacka from InsideOttawaValley.com, the CPAWS citation for the Glen Davis Award, and a biographic sketch of Aleta Karstad by Nature Artists website, http://www.natureartists.com/artists/artist_biography.asp?ArtistID=40, accessed 25 December 2020.)

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Tributes

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