The Canadian Botanical Association Bulletin

Bulletin de l'Association Botanique du Canada

Volume 53 Number 3 - December/décembre 2020

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President's Message

Rouyn-Noranda, November 15th: It is snowing in Abitibi today, the third time snow has fallen this year, covering the ground and all the plants in white. Yet, a week ago it was 15 degrees, above zero the grass was green and some of my annuals were still flowering! This pre-winter, following the calendar of the Anicinabek on whose unceded land I live, is a season full of ups and downs. It prepares us for the real winter, it is a chance to find the winter boots, check if the kids need new winter clothes, put away the garden. It is also a time of adaptation for the vegetation as leaves fall, annuals and aerial organs are killed, and individual plants prepare to go into dormancy for the long winter.

We divide time into seasons, the number depending on your cultural baggage and your biome, but in truth plants are changing every day. Their change and development over the course of a year is not a series of steep slopes separated by plateaus, but rather a diverse collection of curves whose slopes are continually changing. We represent this in science with the use of Julian Days in our models describing various botanical processes, growth, photosynthetic rates, spore development. In this, our science approaches traditional knowledge rather than popular culture where each static season is represented by a single symbol (e.g. snowflake, flower, fruit, red leaf). Traditional knowledge frequently emphasizes the way ecosystems and the land are continually changing, life is a cycle in continual movement.

That each day is different from the last and will differ from the next is a fact that can be hard to remember as we are restricted in our movements and many professional and academic activities take place online, where there are no daily changes in temperature or day-length to remind us of

The Canadian Botanical Association Bulletin

The CBA Bulletin is issued three times a year (March, September and December) and is freely available on the CBA website. Hardcopy subscriptions are available for a fee.

Information for Contributors

All members are welcome to submit texts in the form of papers, reviews, comments, essays, requests, or anything related to botany or botanists. For detailed directives on text submission please contact the Editor (see below). For general information about the CBA, go to the website: www.cba-abc.ca

Executive Editor

Dr. Erin Zimmerman

cba.abc.bulletin@gmail.com

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Next issue

Texts for the next issue, 54(1), must be received by February 15th, 2021

Bulletin de l'Association Botanique du Canada

Le Bulletin de l'ABC paraît trois fois par année, normalement en mars, septembre et décembre. Il est envoyé à tous les membres de I'ABC.

Soumission de textes

Tous les membres de I'Association sont invités à envoyer des textes de toute nature concernant la botanique et les botanistes (articles, revues de publication, commentaires,requêtes, essais, etc.). Tous les supports de texte sont acceptés. Pour des renseignements détaillés sur la soumission de textes, veuillez consulter le rédacteur (voir ci-dessous). Infos générales sur I'ABC à l'url suivant: www.cba-abc.ca

Rédactrice

Dr. Erin Zimmerman

cba.abc.bulletin@gmail.com

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Prochain numéro

La date de tombée des textes du prochain numéro, le no 54(1), est le 15 février 2021

the ever changing nature of life. I wish you all the time and freedom to get outside and experience the ups and downs of pre-winter, to adapt for the coming winter, which will be like all those before in many ways and completely novel at the same time.

Sincerely,

Nicole Fenton

The view from my window on November 4th, 11th, and 15th, 2020.

New Member Publications

Barabé, D., Trivedi, K., & Lacroix, C. (2020) Developmental anatomy of flowers and resiniferous canals of *Philodendron ornatum* (Araceae). Aroideana 43(1&2): 299-314.

Caners, R.T. (2020) Bryophytes at the western limits of Canada's Great Lakes forest: floristic patterns and conservation implications. Northeastern Naturalist 27 (monograph 17): 1–37. https://doi.org/10.1656/045.027.m1701

Léveillé-Bourret, É., Chen, B.H., Garon-Labrecque, M.È., Ford, B.A., & Starr, J.R. (2020) RAD sequencing resolves the phylogeny, taxonomy and biogeography of Trichophoreae despite a recent rapid radiation (Cyperaceae). Molecular Phylogenetics and Evolution 145:106727. https://doi.org/10.1016/j.ympev.2019.106727

A request from Frederique Guinel for ABC/CBA archival material

I am currently collecting ABC/CBA-related items for the Library and Archives Canada (LAC). I am working on two specific matters and I would appreciate your help.

First, I am collating a document on the General Symposium which was organized for the CBA Annual Conference which was held in Montreal in 2014. At this specific conference we celebrated the 50th anniversary of the CBA. The symposium was entitled "Botany in Canada – Past, Present and Future". In this document, one will be able to find most of the talks given during this very special symposium because, following the meeting, many of the speakers agreed to have their talks placed in the archives. To accompany these presentations, I would like to add photographs taken throughout the meeting.

Second, I would like to make a photographic collection of the different bowls received by the Mary E. Elliott Award recipients. The bowls have been carved over the years by Dr. David Sweet, who retired recently from the UBC Faculty of Dentistry. When I had mentioned these bowls to the person responsible for the CBA archives at LAC, he thought that a photographic album of these bowls would be a great addition to the CBA records. So if you are a recipient and have received a bowl, please take a few photographs of it.

If you have any photographs that you think would be meaningful to supplement either of these two collections, please send them to me at **fguinel@wlu.ca**. Thank you for your help.

New Collections Curator, Bryophytes, Lichens, & Fungi at UBC

We are excited to announce that Dr. Karen Golinski is the new Collections Curator of Bryophytes, Fungi & Lichens at UBC. She takes over from Olivia Lee, UBCs first Manager of the Bryophyte Collection, who retired in September 2019.

Karen will focus on curating the bryophyte specimens in UBC's world-class collection and updating the database in support of her commitment to biodiversity research, conservation, and teaching. UBC's bryophyte collection is one of the largest and most comprehensive collections of western North American diversity, and is a tribute to the legacy of Dr. Wilf Schofield and his students. The collection was recently augmented by three important and large donations of specimens. Thanks to the efforts of Curator Emeritus Dr. Judith Harpel, UBC now houses the collections of Dr. Judith & Geoffrey Godfrey, Dr. Diana Horton, and Dr. David Jamieson.

The UBC herbarium welcomes loan requests from other institutions. Information about the bryophyte collection, including the searchable database and Karen's contact information, can be found at https://beatymuseum.ubc.ca/research-2/collections/herbarium/herbarium-bryophytes/

~ Jeannette Whitton, Director, University of British Columbia Herbarium (UBC), Vancouver, British Columbia

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The Mary Elliott Service Award, 2020

The Mary Elliott Service Award was given this year to Dr. Timothy Dickinson. The custom-made plaque was created by Dr. David Sweet, a retired dentist from UBC. The plaque is 265mm (10-1/2") in diameter and is made from Bigleaf Maple wood. It is finished with walnut oil and beeswax.

Botany Recent Issues

September 2020

Special issue: Special issue from the IUFRO World Congress, Curitiba, Brazil 2019 Symposium on Mistletoes

Complex interactions of mistletoe, ecosystems, and people
Luiza Teixeira-Costa, David C. Shaw, Simon Francis Shamoun
Botany, 2020, 98:(9), v - vi, 10.1139/cjb-2020-0081

Mistletoes in a changing world: a premonition of a non-analog future?
Francisco E. Fontúrbel
Botany, 2020, 98:(9), 479 - 488, 10.1139/cjb-2019-0195

Towards best-practice management of mistletoes in horticulture
David M. Watson, Melinda Cook, Rodrigo F. Fadini
Botany, 2020, 98:(9), 489 - 498, 10.1139/cjb-2019-0205

The European mistletoe (Viscum album L.): distribution, host range, biotic interactions, and management worldwide with special emphasis on Ukraine
Yuliya Krasylenko, Yevhen Sosnovsky, Natalia Atamas, Grigory Popov, Volodymyr Leonenko, Kateřina Janošíková, Nadiya Sytschak, Karol Rydlo, Dmytro Sytnyk
Botany, 2020, 98:(9), 499 - 516, 10.1139/cjb-2020-0037

Expansion of the invasive European mistletoe in California, USA
David C. Shaw, Christopher A. Lee
Botany, 2020, 98:(9), 517 - 524, 10.1139/cjb-2019-0215

Hiding in plain sight: experimental evidence for birds as selective agents for host mimicry in mistletoes
M.E. Cook, A. Leigh, D.M. Watson
Botany, 2020, 98:(9), 525 - 531, 10.1139/cjb-2019-0209

Subdividing the spectrum: quantifying host specialization in mistletoes
Kirsty V. Milner, Andrea Leigh, William Gladstone, David M. Watson
Botany, 2020, 98:(9), 533 - 543, 10.1139/cjb-2019-0207

October 2020

Contrasting effects of freezing-stress memory on biomass production among herbaceous plant species
Ricky S. Kong, Hugh A.L. Henry
Botany, 2020, 98:(10), 545 - 553, 10.1139/cjb-2020-0024

Isoetes ×blondeaui hyb. nov. (Isoetaceae), a new hybrid quillwort from eastern Quebec, Canada
D.F. Brunton, P.C. Sokoloff
Botany, 2020, 98:(10), 555 - 562, 10.1139/cjb-2020-0065

Germination time influences post-germination life-history traits and progeny seed germination patterns in the desert annual Erodium laciniatum (Geraniaceae)
Nasr H. Gomaa
Botany, 2020, 98:(10), 563 - 573, 10.1139/cjb-2020-0001

Reactive oxygen species are required for spore-wall formation in Physcomitrella patens
Fazle Rabbi, Karen S. Renzaglia, Neil W. Ashton, Dae-Yeon Suh
Botany, 2020, 98:(10), 589 - 602, 10.1139/cjb-2020-0014

Impact of biased sex ratio on the genetic diversity, structure, and differentiation of Populus nigra (European black poplar)
Asiye Çiftçi, Burak Yelmen, Funda Ö. Değirmenci, Zeki Kaya
Botany, 2020, 98:(10), 603 - 613, 10.1139/cjb-2020-0046

Seed germination requirements of Hypericum scruglii, an endangered medicinal plant species of Sardinia (Italy)
Marco Porceddu, Martina Sanna, Sara Serra, Maria Manconi, Gianluigi Bacchetta
Botany, 2020, 98:(10), 615 - 621, 10.1139/cjb-2020-0039

November

Studies in Basidiodendron eyrei and similar-looking taxa (Auriculariales, Basidiomycota)
Viacheslav Spirin, Vera Malysheva, Renato Lucio Mendes-Alvarenga, Heikki Kotiranta, and Karl- Henrik Larsson
Botany, 2020, 98 (11) ,623-638 10.1139/cjb-2020-0045

Effects of ABA and NaCl on physiological responses in selected bryophyte species
Marija Ćosić, Milorad M. Vujičić, Marko S. Sabovljević, and Aneta D. Sabovljević
Botany, 2020, 98 (11), 639- 650 10.1139/cjb-2020-0041

Genetic differences and variation in polysaccharide antioxidant activity found in germplasm resources for Job's tears (Coix lacryma-jobi L.)
Lingyan Xuan, Xiujie Xi, Zixian Xu, Huijun Xie, Yunguo Zhu, Zhou Cheng, and Shan Li
Botany, 2020, 98 (11) ,651-660 10.1139/cjb-2019-0182

Characterizing genetically diverse blue grama [Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths] seed sources
G.M.A. Friesen, S.R. Smith, D.J. Cattani, and A.T. Phan
Botany, 2020, 98 (11) ,661-671 10.1139/cjb-2020-0029

Physiological and biochemical insights for salt stress tolerance in the habitat-indifferent halophyte Salsola drummondii during the vegetative stage
Attiat Elnaggar, Kareem A. Mosa, Ali El-Keblawy, Amel Tammam, and Mohamed El-Naggar
Botany, 2020, 98 (11) ,673-689 10.1139/cjb-2019-0160

December

Ontogenesis, histochemistry, and seasonal and luminous environmental characterization of secretory cavities in leaves of Myrcia splendens (Myrtaceae)
Isabela Santiago Carneiro da Costa, Eliseu Marlônio Pereira de Lucena, Oriel Herrera Bonilla, Aleksandar Radosavljevic, and Ítalo Antônio Cotta Coutinho
Botany 2020, 98 (12), 691-701 10.1139/cjb-2020-0060

Flower morphogenesis and gametophyte fertility attest to the rare condition of gynomonoecy in Parietaria debilis (Urticaceae)
Giseli Donizete Pedersoli and Simone Pádua Teixeira
Botany 2020, 98 (12) ,703-715 10.1139/cjb-2020-0082

Spatial pattern of intraspecific trait variability in Sphagnum fuscum
Tobi A. Oke and M.R. Turetsky
Botany 2020, 98 (12) ,717-723 10.1139/cjb- 2020-0077

Valve morphogenesis in selected centric diatoms
Irena Kaczmarska, James M. Ehrman, Nickolai A. Davidovich, Olga I. Davidovich, and Yulia A. Podunay
Botany 2020, 98 (12) ,725-733 10.1139/cjb-2020-0088

Influence of pipelines and environmental factors on the endangered plant, Halimolobos virgata (Nutt.) O.E. Schultz over a 10 year period
M. Anne Naeth, David Alexander Locky, Sarah Rachel Wilkinson, Candace Leanne Bryks, Caitlin Heather Low, and Meghan Robyn Nannt
Botany 2020, 98 (12) ,735-746 10.1139/cjb-2020-0026

Find these issues and more at:
https://www.nrcresearchpress.com/journal/cjb

Botany Special Issue ~ Édition spéciale de la revue *Botany*

There will be a special issue of the journal *Botany* associated with the ABC-CBA 2020 conference! All participants are welcome to submit a paper. The deadline for submission of articles is December 31st, 2020, with the intention of publishing the special issue on May 1st, 2021.

Il y a aura une édition spéciale du journal *Botany* associée à la rencontre ABC-CBA 2020! Tous les participants sont invités à soumettre un article. La date limite pour la soumission des articles est le 31 décembre 2020, la mise en ligne de l'édition spéciale est prévue pour le 1er mai 2021.

Click to submit:

https://mc06.manuscriptcentral.com/botany-pubs

or contact Christian Lacroix: lacroix@upei.ca

Cliquez pour soumettre un article:

https://mc06.manuscriptcentral.com/botany-pubs

ou contactez Christian Lacroix: lacroix@upei.ca

Botany
An International Journal for Plant Biology

Special issue timeline/ Échéancier pour cette édition spéciale

Submissions open	Ouverture des soumissions	August/août 1, 2020
Submission deadline	Date limite des soumissions	December/décembre 31, 2020
Deadline to finish peer review*	Date limite pour l'évaluation par les pairs*	February/février 1, 2021
Deadline to export papers to CSP	Date limite pour transmettre à CSP	March/mars 1, 2021
Proposed issue date	Date proposée de publication	May/mai 1, 2021

* Note that some peer reviews under COVID-19 are taking a little longer than expected. Please be flexible.

* Notez que des délais peuvent survenir lors de l'évaluation par les pairs en raison des différentes contraintes liées à la COVID-19. Merci de votre flexibilité.

Canadian Botanical Association/ Association Botanique du Canada

2021 Call for Award Nominations and Applications

Each year the Canadian Botanical Association gives awards to botanists studying in Canada and Canadian botanists studying abroad. Many of the awards are available to non-Association members. Applications and nominations are now open for the following:

STUDENT AWARDS

For research related travel to Canada's North

Laurie Consaul Northern Research Scholarship — Value $1000

Deadline: February 28th 2021

For published papers

Porsild-Consaul Award for best paper in plant systematics or phytogeography — Value $1000

Stan Rowe Award for best paper in plant ecology — Value $500

Taylor Steeves Award for the best paper in plant development or structure — Value $500

Luella Weresub Award for the best paper in mycology or lichenology — Value $1000

Deadline: March 31st 2021

For best presentations at the Annual CBA/ABC meeting

Lionel Cinq-Mars Award is awarded for the best oral presentation — Value $500

Iain and Sylvia Taylor Award is awarded for the best poster — Value $500

For travel to attend the Annual CBA/ABC meeting

Macoun Award for graduate students presenting talks or posters. Several awards are available — Value $200-$600

Winterhalder Award for undergraduate students presenting talks or posters. Several awards are available — Value $200-$600

Deadline: Abstract submission deadline for the 2021 conference (TBD)

CBA/ABC MAJOR AWARDS

The Mary Elliott Service Award is given to an individual for meritorious service to CBA.

The Magister Award is given for excellence in plant science teaching.

The Lawson Medal is the most prestigious award of the CBA. It recognizes excellence in the contribution of an individual to Canadian botany.

Nomination deadline: February 26th 2021

For more information: https://www.cba-abc.ca/awards/

Tales from the Field

When in Rome…

By Julian Starr

Have you ever been to Sparta? Sparta, Wisconsin? Are you already disappointed with my tale? Read on!

When you are in the field, you sometimes find yourself in the oddest of places, often populated by the oddest of people, and one such day was when Simon Joly and I landed in Sparta, Wisconsin. We had just left the joint Botany BSA/CBA annual meeting in Madison where Simon had won the Lionel Cinq Mars Award, and we had spent the day heading north collecting roses along the way. When it began to get rather late, we started to think of a place to sleep, and the only seemingly town-ish thing on the map was Sparta (no GPS then). Well, Sparta is not the kind of town that has much folk or food, and it oddly has a High School whose mascot is a Roman Centurion, but one thing that Sparta does have is one whopping big Legion. The kind that has a Huey on one side and tank on the other. For those unfamiliar with field work in backwoods USA, I highly recommend a stop at the local Legion. Small towns might lack a restaurant or even a bar, but their Legion is guaranteed to have both and it's cheap. So after finding a rather run down motel (beds with no back support), we tootled down to the local legion for some bread and beer before a long night's session of pressing plants. Sure enough, the food was simple, but good, and the beer was plentiful, but bad (something like Budweiser or Miller). After dinner, we got up and headed into the bar for a little R&R before hitting the presses.

Well, only one word can describe what we witnessed - it was "Rocking"! There must have been at least 100 people dancing, singing and laughing at the tops of their lungs. And they were of every sort, from highschoolers to grandmothers, and everything in between. Wary of the scene, Simon and I pull up a chair in a far corner lest the action turn ugly. It was not long before someone came to our table, but instead of asking us about drinks, he asked who we were – this is Sparta after all, and we were obviously not Romans. Anyway, we gave our names, explained that we were from Canada, Montréal even, and that we were collecting roses. He seemed satisfied with this, turned, and a few minutes later, he appeared behind the bar, with a microphone in his hand. He did that thing where you turn on the mike and pat it in your hand to quiet down the crowd, and said "Hello-ooooo everybody-eeeeeee! I have some important news to tell you!" He then turned toward us, pointed and said, "All the way from Montree-aaaal, Canada, our friends and allies, Simon and Julian!" And the crowd went wild! Hoping, jumping, waving, and shouting, it was simply over the top. And he continued, "To celebrate this extraordinary occasion, the Commander of Legion 100 is going to give two! that's right, I said two! free drinks to Simon and Julian!" And again, the crowd went nuts, we were the absolute toast of the town, and everybody took the chance to tell us. Who could have known that one soldier's grandmother was from Montréal and that she used to stop him crying as a baby by rubbing Crown Royal on his gums (a rather cute tale of Canadiana, but not recommended these days)? Another had once been on an American military base in Newfoundland – apparently he adored the local music. And of course, everybody wanted to buy us drinks. We were having a wonderful time, but we couldn't risk getting boozed up when a full night's pressing was yet to come, so when they were distracted, we slipped out the door and into the night. Besides the memories, I also slipped away with one of the two free drink chits the Commander gave us. I still keep it in my office with all my other mementos from the field (Fig. 1), although I have never asked Simon what he did with his.

Fig. 1. The heads and tails of the Commander's free drink chits!

When in Rome…or Sparta…

Plants, pixels, and perception: botany in video games

By Paul Sokoloff, Canadian Museum of Nature

It wasn't really fieldwork, but it was the next best thing. I was looking at a book of proceedings from a long-ago conference. The page was open to a passage where a botanical expert was presenting the myriad beneficial properties of a plant which, at least to me, looked like wild lettuce. While this text was old and this enthusiastic botanist had passed on long ago, one of his old trainees had asked if I could sort out his research backlog, and collect new samples from across this species range for an ongoing project. No problem at all I thought, just like collecting samples for population genetics. I just had to avoid the deep elves, climb past the towering glowing mushrooms, and figure out the steam-powered puzzle cube.

Wait, did I forget to tell you this was a video game?

Despite 200 years of radioactive fallout, the crustose and foliose lichens that cover cliff faces in Fallout 4 seem healthy and add realistic color to the wasteland. ©Bethesda Softworks

Last March, when many of us started working from home and hunkering down in the early days of the COVID-19 pandemic, nostalgic pastimes were an important part of getting though that strange tail end of winter. Sourdough starters proliferated, YouTube baking tutorials flourished, and gamers the world over dusted off old consoles, or simply picked up their saved games from the day before. I decided to delve back into Skyrim, a role-playing game (RPG) from Bethesda Softworks named after its setting, the northernmost province in the fantasy world of Tamriel. If I couldn't go botanizing in Canada's North, then hiking across a virtual tundra seemed like a good way to pass the time. This game is an old favourite of mine, and a few years back I even wrote a blog on the parallels between the flora of this virtual world and our own, where tundra cotton stands on for *Eriophorum* and mountain flowers are clearly different *Castilleja* morphotypes (Sokoloff, 2015).

Bioluminescent mushrooms are a fixture across the wasteland in Fallout 4, just as they are in our own northeastern North America. © Bethesda Softworks

Through the spring and summer, as we continued to stay home, Skyrim was played through and I began to explore a slate of games new and old. In many of these games, plants are often featured as helpful items you can collect in the game world – something to increase your health or to raise your stats. However, in recent playthroughs (and because I really can't switch off the botany part of my brain), I started to notice that the biota in the background is often, well, right. The plants and lichens in the environment are detailed, and often in the right place to faithfully depict the game's setting.

As I scrambled over cliff-faces just outside of post-apocalyptic Boston in Fallout 4 (also from Bethesda), I noticed the bright orange and green flecks of *Xanthoria* and *Xanthoparmelia*. While the designers might not have bothered with details like exactly what lichens might grow on a rock face 200 years after a nuclear war, the fact that they did indicates a keen perception of the natural world which has translated into realism within the game.

In an age where we worry about the lack of botany courses our universities offer, and our colleagues grapple with plant awareness disparity – the increasing knowledge gap on plant diversity relative to other organisms

(Parsley, 2020), it's heartening to see that many video games include faithful representations of plants. After all, just like with plant awareness disparity, gamers might not notice the complete detail in the digital flora but would certainly notice if it was conspicuously absent.

Though the plants in Control come from another plane of existence, the epiphytic lichens there seem to occupy the same niche as real ones. © 505 Games and Remedy Entertainment

Perhaps due to their exploration-heavy nature, RPGs contain some of the best background plants in any video games I've played. In Metro Exodus, from 4A Games, I spent far too much time admiring the alders (*Alnus* sp.) as they swayed in the breeze in post-apocalyptic Vladivostok. In Control, where you battle Eldritch horrors and the plants come from another dimension, the epiphytic lichens that grow over your office plants look just like what you would see on any other tree, providing an element of the familiar as players navigate the game's creepy levels.

The landscape of another post-nuclear apocalypse video game, Metro Exodus, seem much greener, and includes many detailed real-world plants, like these alders (*Alnus* sp.). © 4A Games

This attention to detail isn't limited to plants in their natural environment on Earth either. In Tacoma, a story game from Fullbright where you have the chance to explore an abandoned space station, you might stumble across the botany module. There the station's resident space botanist (where do I find that job?!) tends to the plants that help keep the crew alive. This space is bursting with greenery, and the three dominant species, *Hedera helix* (English Ivy), *Dracaena trifasciata* (Variegated Sanseviera), and *Chamaedorea seifrizii* (Bamboo Palm) are all species documented to improve indoor air quality according to a NASA-sponsored study (Wolverton et al. 1989). Here again, design choices rooted in current botanical science add realism to the experience.

Of course, games haven't always gotten plants right. In Perfect Dark, by Rare, players eventually come to a level where they must save the President of the United States of America from his evil clone, created as a part of an extraterrestrial plot. Please, try to keep up here. Playing this as a kid, I was more concerned about my high score, but as an adult botanist I was excited to note that this level takes place about 32 km north of Ulukhaktok, Northwest Territories. I had actually been there – for a field expedition in 2010 – so was naturally excited to return digitally. When I came across a large stand of conifers, about 400 km above the treeline, I decided they clearly must be poorly rendered willow shrubs (*Salix alaxensis*), which do grow to tree-like proportions in that area (Saarela et al. 2020).

While some games might not focus on plants as a game mechanic or background, botany might serve to inspire other parts of their story. In Sagebrush, an indie gem from Redact Games, the player takes on the role of a woman re-visiting the abandoned compound of a doomsday cult - her former cult - in rural New Mexico. While the plants are too pixelated to identify – this whole game is purposely low-res as a nod to early exploration games, the name itself evokes the image of *Artemisia*, fragrant in the desert sun and brushing your ankles as you explore this darkening world.

The plants in Tacoma's botany module are not only accurately rendered, but are species previously identified by NASA as being powerhouses of air purification. ©Fullbright

Though most current video games get the botany right, this level of Perfect Dark set on Victoria Island, Northwest Territories, shows large trees in an area high about the Arctic Circle. ©Rare

The Outer Wilds, from Mobius Digital and Annapurna Interactive, is set in the far-reaches in the galaxy. Here, you take on the role of an intrepid space explorer as they explore a solar system that explodes every 22 minutes – don't worry, you're a time traveler too. While there are large trees on your very small home world, and a neighbouring planet consists solely of a large bramble hedge, the biggest easter egg for the botanically inclined comes from the history recorded in the ruins of the Nomai, a long-extinct species that constructed wonders across this solar system. With names like Avens, Solanum, and Idaea, these beings were clearly dreamed up while the designer had Botanical Latin on the brain.

It's clear that faithfully depicting plants in video games is here to stay – at least for those games set on Earth and/or anchored in our own reality. With the release of a new generation of gaming consoles earlier this fall, upgraded processing and rendering power can only mean we are in for a new slate of high-resolution virtual blooms, thanks to designers and their keen eye for accuracy and environmental realism.

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World Floristic Regions for Teaching Botany and Plant Ecology

by Paul Keddy

World floristic regions are an important basic concept for teaching botany and ecology. This single map provides essential background for teaching topics including plant evolution, continental drift, planning for protected area systems, threats posed by invasive species, and choosing species to be used in habitat restoration.

In my experience, world floristic regions are frequently overlooked in basic ecology and botany books and lectures, perhaps because of the lack of a good coloured map. So, I had such a map prepared for the latest edition of my text book on plant ecology. Here, to assist with your teaching, I share this map, and its key, along with a short excerpt from Chapter 2 (pages 81-82, *Plant Ecology: Origins, Processes, Consequences*, Cambridge University Press). You can also download the map and the key compiled as a jpeg file (here), ready to insert in your PowerPoint lecture and share with your classes via video-conference screen share.

One important lesson from this map: a majority of the world's plant diversity lies below the equator, in the fragments of the old continent of Gondwana. And another lesson: one small area in South Africa (Region 28 on the map, light green) is more or less the botanical equivalent of all of northern North America, Europe and northern Asia! Hence, our North American students can easily underestimate the sheer magnitude and complexity of plant diversity in the world as a whole.

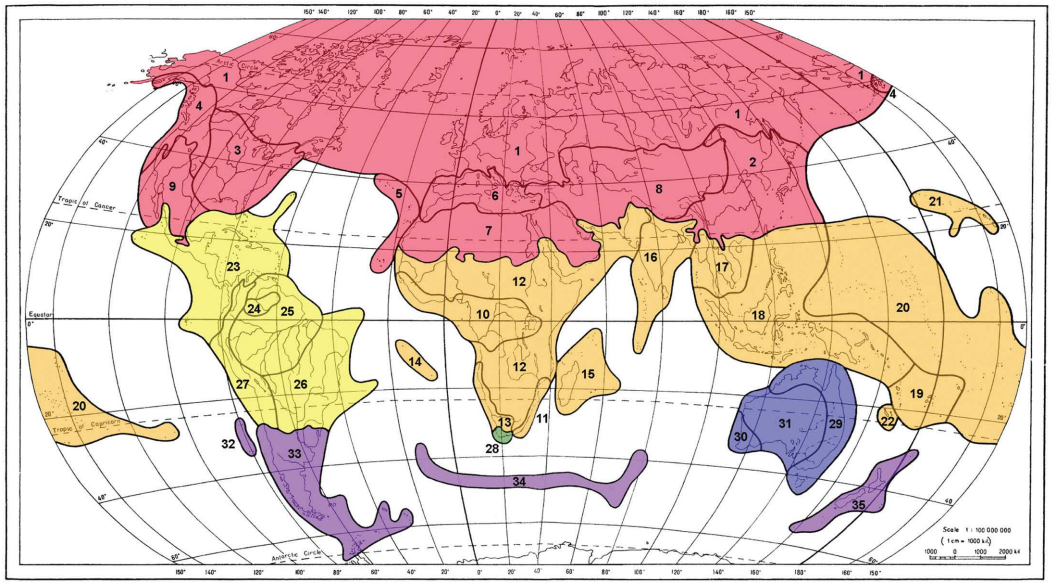


Table 2.5 The 35 floristic regions of the world mapped in Figure 2.12. (Following Takhtajan 1986)	
I. Holarctic Kingdom	D. Polynesian Subkingdom
A. Boreal Subkingdom	20. Polynesian
1. Circumboreal	21. Hawaiian
2. Eastern Asiatic	E. Neocaledonian Subkingdom
3. North American Atlantic	22. Neocaledonian
4. Rocky Mountain	**III. Neotropical Kingdom**
B. Tethyan Subkingdom	23. Caribbean
5. Macaronesian	24. Guayana Highlands
6. Mediterranean	25. Amazonian
7. Saharo-Arabian	26. Brazilian
8. Irano-Turanian	27. Andean
C. Madrean Subkingdom	**IV. Cape Kingdom**
9. Madrean	28. Cape
II. Paleotropical Kingdom	**V. Australian Kingdom**
A. African Subkingdom	29. Northeast Australian
10. Guineo-Congolian	30. Southwest Australian
11. Uzambara-Zululand	31. Central Australian (Eremaean)
12. Sudano-Zambezian	**VI. Antarctic Kingdom**
13. Karroo-Namib	32. Fernándezian
14. St. Helena and Ascension	33. Chile-Patagonian
B. Madagascan Subkingdom	34. South Subantarctic Islands
15. Madagascan	35. Neozeylandic
C. Indo-Malesian Subkingdom	
16. Indian	
17. Indochinese	
18. Malesian	
19. Fijian	

FIGURE 2.12 The 35 floristic regions of the world fall into six kingdoms. (From Takhtajan 1986) See Table 2.5 for region names. (Note that an earlier version, Takhtajan 1969, recognized 37 regions.)

Now the excerpt:

2.3.6 World floristic regions are based on phylogeny and geography

Most plants are restricted to rather small geographic ranges. If you compile the data on their ranges, you can map

which parts of the world have similar plant species, genera or families. Figure 2.12 shows the floristic regions of the world as mapped by the Russian botanist, Takhtajan (1969, 1986). Each region of the figure is mapped based on floristic similarities. To illustrate Takhtajan's regional classification, consider two examples, one from North America and the other from Africa. The North American Atlantic Region (3) is described as follows:

> Endemic families Hydrastidaceae and Leitneriaceae, no fewer than a hundred endemic genera (including *Sanguinaria, Sarracenia, Dirca, Neviusia, Hudsonia, Dionaea, Yeatesia, Pleea, Uvularia*) and numerous endemic species.
>
> (Takhtajan 1969, p. 244)

Similarly, the Karroo-Namib Region (13) is described as having:

> Very many endemic species; *Mesembryanthemum* and allied genera, *Tetragonia, Pelargonium, Rhigozum, Pentzia, Pteronia* and other shrubby Asteraceae are especially characteristic; in the northern parts of the Namib *Welwitschia* and *Acanthosicyos horridus* are endemic.
>
> (Takhtajan 1969, p. 248)

…. Takhtajan's entire classification of regions is presented in Table 2.5. This also gives you a key for the map in Figure 2.12.

References:

Takhtajan, A. 1969. *Flowering Plants: Origin and Dispersal*. Edinburgh: Oliver and Boyd. Translated and revised from a Russian second edition published in Moscow in 1961.

Takhtajan, A. 1986. *Floristic Regions of the World.* Berkeley: University of California Press. Translated by T. J. Crovello.

Bioblitz au parc national d'Opémican

Un texte de Julie Arseneault

Crédit photo : Julie Arseneault, Mariano Feldman et Enrique Hernandez

Le 15 août dernier, nous avons eu le plaisir de participer à un bioblitz au parc national d'Opémican. Cette activité était initialement prévue comme une des sortie terrain faisant suite à l'édition 2020 de la conférence annuelle de l'ABC qui devait avoir lieu à l'Université du Québec en Abitibi-Témiscamingue. Comme cette conférence s'est tenu entièrement en ligne, c'est un groupe restreint d'une vingtaine de botanistes et naturalistes, amateurs ou professionnels, provenant de plusieurs régions du Québec et de l'Ontario, qui se sont réunis sur l'invitation des agents de conservation du parc pour y explorer différents habitats.

Les participants ont pu déguster leur repas à l'ombre des grands pins sur la berge sableuse du lac Témiscamingue

Les paysages grandioses

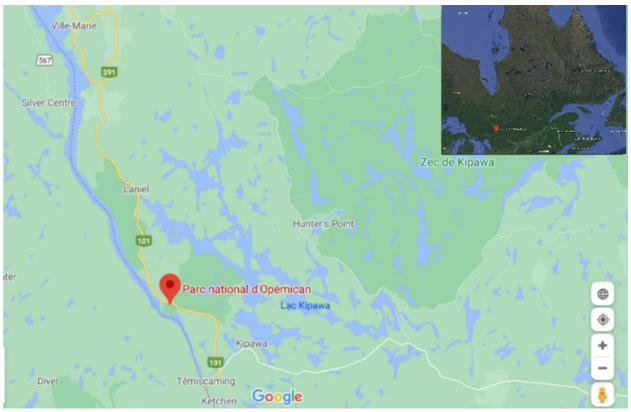
Dernier né de la Société des établissements de plein air du Québec (Sépaq), ce magnifique lieu chargé d'histoire témoigne d'une période phare dans le développement de la région d'Abitibi-Témiscamingue. Des vestiges de l'époque de la traite des fourrures avec les nations Anicinabek (Algonquins) qui ont occupé le territoire depuis des millénaires sont d'ailleurs encore visibles sur les lieux de la pointe Opémican et les environs.

Le petit dico

- **Bioblitz** : étude réalisée sur une portion précise de territoire par un groupe de scientifiques et/ou de bénévoles pendant un court laps de temps. L'objectif est d'identifier et de répertorier toutes les espèces d'organismes vivants présents dans une zone donnée.
- **Algonquin** : dérive du malécite *elakómkwik* et signifie « Ce sont nos alliées / notre parenté »
- **Opémican** : mot algonquin qui signifie «le long du chemin suivi par les amérindiens»
- **Témiscamingue** : provient de l'algonquin *timiskaming* signifiant « au lac profond »

En plus de nombreux lacs, ruisseaux et milieux humides, c'est particulièrement le relief accidenté et peu élevé qui constitue un trait remarquable du paysage. De nombreuses collines aux sommets aplatis côtoient d'abruptes parois rocheuses qui plongent dans le lac Témiscamingue. Ce lac, situé à l'ouest du parc, est un élargissement de la rivière des Outaouais. Il s'allonge sur une distance de 110 km et est relativement étroit, parfois moins d'une centaine de mètres séparent le Québec de l'Ontario! Du coté est, le lac Kipawa, un véritable joyau ponctué de centaines d'îles et de baies profondes, couvre plus de 300 km2. Il est reconnu comme l'un des dix plus beaux lacs du Québec pour la qualité de son eau et de sa pêche. Entre les deux, plusieurs secteurs sont à découvrir. La Grande Chute de la rivière Kipawa constitue un des attraits indéniables du parc. Mise en vedette sur le nouveau billet de 10$, elle tombe de plus de 15 mètres et dévale puissamment jusqu'au lac créant ainsi un paysage époustouflant.

Couvrant une superficie d'environ 250 km2, le parc est divisé en trois secteurs distincts : le secteur de la Rivière-Kipawa, le secteur du Lac-Marsac et le secteur de la Pointe-Opémican où se sont concentrées les observations réalisées lors de cette édition du bioblitz.



Localisation géographique du parc national d'Opémican

La rencontre des écosystèmes

Situé dans la zone de transition entre la forêt feuillue et la forêt boréale mixte, le parc national d'Opémican vise à protéger un échantillon de la région naturelle des Laurentides méridionales. À cheval entre les deux domaines bioclimatiques, la diversité des paysages y est étonnante. Le parc renferme des habitats variés et riches abritant plusieurs espèces floristiques et fauniques, mais ce sont surtout les silhouettes des grands pins s'élevant à plus de 40 mètres qui retiennent l'attention. Symbole de la jonction entre les domaines feuillu et boréal, les abondantes pinèdes blanches et rouges côtoient des érablières matures, des prucheraies, ainsi que de jeunes peuplements de bouleaux et de peupliers.

Tout est à faire à Opémican! Des activités de caractérisation permettent de bonifier la connaissance du territoire afin de déterminer où sont les espèces sensibles et les habitats fragiles. Bien que toutes les observations n'aient pas encore été compilées, les participants ont déjà fait mention de plusieurs espèces intéressantes parmi lesquelles une cinquantaine de plantes vasculaires, herbacées ou ligneuses et plus de 80 espèces de bryophytes. Mentionnons, au niveau des plantes vasculaires, ces quelques espèces peu communes ou à leur limite de répartition : *Ostrya virginiana* (Miller) K. Koch, *Rubus setosus* Bigelow, *Carex crinita* Lamarck, *Sparganium americanum* Nuttall, *Medeola virginiana* Linnaeus, *Collomia linearis* Nuttall, *Botrypus virginianus* (Linnaeus) Michaux, *Dryopteris intermedia* (Muhlenberg ex Willdenow) A. Gray, *Fallopia convolvulus* (Linnaeus) Á. Löve et *Zizia aurea* (Linnaeus) W.D.J. Koch.


La Médéole de virginie, une espèce à la limite nord de son aire de répartition.

Parmi les bryophytes détectées par l'œil aguerri des participants, les espèces suivantes présentent un intérêt particulier par leur rareté ou la nordicité de leur répartition : *Anastrophyllum michauxii* (F. Weber) H. Buchm, *Anomodon rugelii* (Müll. Hal.) Keissl., *Atrichum crispulum* Schimp. ex Besch., *Schljakovia kunzeana* (Huebener) Konstant. & Vilnet, *Brachythecium starkei* (Brid.) Schimp., *Cephaloziella divaricata* (Sm.) Schiffn., *Dichelyma capillaceum* (With.) Myrin, *Grimmia muehlenbeckii* Schimp., *Isopterygiopsis muelleriana* (Schimp.) Z. Iwats., *Lophozia silvicola* H. Buch, *Pohlia bulbifera* (Warnst.) Warnst., *Polytrichum densifolium* Wilson ex Mitt., *Pseudobryum*

Calopteryx maculata

Lestes rectangularis

cinclidioides (Huebener) T.J. Kop., *Pseudoleskeella nervosa* (Brid.) Nyholm, *Scapania paludicola* Loeske & Müll. Frib. var. paludicola, sans oublier *Fossombronia foveolata* Lindb.

Bien que composé principalement de botanistes, le groupe comprenait aussi des amateurs de la faune et leurs observations sont tout aussi cruciale pour la compréhension de la répartition de toutes les espèces du parc. Au niveau des insectes observés, mentionnons *Sympetrum obtrusum* (HAGEN 1867), *Lestes forcipatus* Rambur, 1842, des représentants des genres *Melanoplus* sp., *Sympetrum* sp. et *Scudderia* sp. dont l'identité reste à être confirmé.

Des espèces à la limite nord de leur aire de répartition ont aussi été observées : *Lestes rectangularis* Say, 1840 et *Calopteryx maculata* (Palisot de Beauvois, 1807), une espèce qui se rencontre principalement près des rivières. Il s'agissait de la première mention de cette espèce pour notre entomologiste officiel!

Les données sont ajoutées sur le site de INaturalist. Les participants sont encouragés à y consigner leurs observations. Une partie des spécimens est conservée à l'herbier du Canada à Gatineau ainsi qu'à l'herbier de l'UQAT à Rouyn-Noranda.

Il est certain que l'Université du Québec en Abitibi-Témiscamingue offrira à nouveau cette activité en 2022 et une plus grande variété d'habitat pourra être inventorié.

The Agnes Marion Ayre Herbarium of Memorial University: brief history, current status and future

By Nicolas Peñafiel[1] and Julissa Roncal[1]

[1]Department of Biology, Memorial University of Newfoundland, St. John's A1B 3X9

Brief history and general characteristics of the collections

One couldn't think of a better name to baptise Newfoundland and Labrador's largest plant collection than the name of Agnes Marion Ayre (1890-1940), a self-taught botanist of great distinction, daughter of a family of merchants, and pioneer in the documentation of Newfoundland's native plants. Another botanist, Ernest Rouleau, who also made a paramount contribution to the knowledge of the flora of Newfoundland was a co-founder of the Agnes Marion Ayre Herbarium (NFLD), established between the late 1940s and early 1950s under the sponsorship of the Government of Newfoundland and Labrador. Today, NFLD hosts the original specimens prepared by both Ayre (2,440) and Rouleau (unknown number), and a total of around 100,000 specimens of vascular plants and bryophytes, mostly native to the province.

The tracheophyte collection consists of around 40,000 specimens representing over 3,300 species and more than 1,000 genera within 176 families of angiosperms, 26 of pteridophytes and six of gymnosperms. Additionally, Agnes Marion Ayre's original artwork, consisting of 1,876 watercolours and drawings depicting the local flora, resides at the Center for Newfoundland Studies at Memorial University of Newfoundland (MUN). (http://collections.mun.ca/cdm/landingpage/collection/cns_ayre). Drs. Orvil Olsen and Peter Scott were professors and curators of NFLD until 1975 and 2008, respectively.

The largest of the collections held at NFLD is that of the bryophytes, with around 60,000 samples of mosses, liverworts and hornworts, mainly from the province, but also from other Holarctic regions of the world. Its founder, Dr. Guy Brassard, started this collection in the early 1970s with specimens that he and his students collected, and established an exchange program with about 30 other bryophyte herbaria worldwide, which grew our collection quickly.

In addition to the tracheophyte and bryophyte collections, MUN has a phycological collection. Dr. G. Robin South established it in 1967, modelled on his prior experience with the UBC Phycological Herbarium established by Dr. Robert Scagel. Dr. South was assisted by Dr. Robert Hooper, who was responsible for the acquisition of most of the 35,000 marine algae specimens and who served as curator from 1984 until the late 1980s, when all activities were put on standby along with those of the bryophyte collection.

Current status

When the new curator of the herbarium (Dr. Roncal) arrived in 2013, we sought to revitalize it by promoting the engagement of students and researchers, and by working towards an easy availability of its data content. The first task, however, was to "save" the collection and the archive from a condemned building at MUN's main campus. This 2016 move was certainly a milestone in the herbarium's history, although the collection had been moved several times before. Dozens of boxes were transported to its current facility in Mt. Scio Road, just across MUN Botanical Garden. Decades of hand-written archives and hundreds of student-collected specimens added to the inventory of the herbarium. Biology graduate teaching assistants packed, unpacked, and organized specimens, cabinets, and the office space in the new location.

After moving the herbarium, our foremost goal was to bring the collection into the digital era. Digitizing the collection would bring benefit to students, researchers, and the general public in the province, nationally and internationally. After NFLD joined the Consortium of Northeastern Herbaria (CNH), digitized specimens became available through the Symbiota Software Project (www.symbiota.org). The adoption of this information management system has been crucial to start our digitization project and we highly recommend it especially for institutions with limited professional, technical and financial resources. Additionally, the data hosted at the CNH have been shared with the Canadensys network (https://community.canadensys.net/), thus broadening the reach of our collection. As of today, ca. **8,500** vascular plant and bryophyte specimens have been digitized and are available here: https://portal.neherbaria.org/portal/.

Guy Brassard

Along with this permanent digitization effort, organizational activities are ongoing. These include tracking and creating a digital database of past and current specimen loans. Fortunately, the record of loans during past administrations is available to trace back missing specimens. Dr. Guy Brassard's commitment to the bryophyte collection led him to visit NFLD in 2018 to help organize it in its new location (see photo). Lately, with the help of three Biology graduate students, we have drafted a plan to update the systematic arrangement of vascular plant families following a linear phylogenetic classification, as proposed in Christenhusz et al. (2011a and b), and the Angiosperm Phylogeny Group IV (2016).

As part of its commitment to support and foster research, NFLD has maintained collaboration with national institutions in terms of specimen loans, exchanges and gifts. For instance, ca. 600 specimens have been returned by the Louis-Marie Herbarium of Laval University used for the ongoing project "Flore Nordique du Quebec et du Labrador" (Payette et al. 2018). Most recently, Dr. Terry Hedderson, currently at the University of Cape Town in South Africa, has returned over 1,000 bryophyte specimens collected in Ellesmere Island with grants from Dr. Guy Brassard while working at MUN.

MUCEP students 2018

Engaging the academic community at MUN and beyond

The herbarium is a great teaching resource for any university. Both undergraduate and graduate students at MUN have been regularly recruited to join our crew. Many undergraduate students have been hired on a semester basis through Memorial's Undergraduate Career Experience Program (MUCEP). The selected MUCEP students have assisted mainly with the collection's digitization effort. This task provides students a first-hand experience in database and botanical collection management, as well as acquaints them with botanical nomenclature, taxonomy, geography, ecology, and information systems (see photo). Graduate students at MUN have also participated through Teaching Assistantships, gaining undergraduate supervision and curatorial skills. The Introductory Botany course at MUN takes undergraduate students to the herbarium, where they learn how to press and mount botanical specimens, the systematic organization of specimens, and the importance of maintaining biological museum collections. For most of these students, who are not just Biology majors, this is their first visit to an herbarium.

Since 2016, we have received scholars and enthusiasts from the province, from elsewhere in Canada, and abroad. The range of projects that drove them to NFLD included the study of plant pathogens, the history of women in botanical collections, invasive plants, ethnobotany of Labradorean plants, and conservation genetics, among others. Notable was the visit of the Botanical Art Society of Newfoundland and Labrador, whose purpose was to get acquainted with the herbarium as a potential resource for artwork. These visits exemplify the scope of services that an herbarium can provide, and that is well beyond academic botanical research.

Looking into the future

Our herbarium faces many of the same challenges that numerous collections in Canada and abroad face. The lack of any full- or part-time permanent staff translates into a very slow digitization pace, and limited growth of the collection. This also prevents the implementation of citizen science initiatives. Nevertheless, we look forward to continuing our ambitious project of a complete digitization when funds become available. We plan to develop a geo-referencing protocol to add location coordinates to those specimens that do not include this information on their labels. For now, obtaining and uploading high-quality photographs of each specimen might seem like a far-away dream. Thus, we want to hear about funding agencies or sources that could be available for these goals, and we are always open to suggestions on how to speed up our digitization. Because of our awareness of the scientific and historical value held within NFLD, we are committed to upholding Ayre's and Rouleau's vision of promoting Newfoundland and Labrador's flora.

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Christenhusz M.J.M, Reveal J.L., Farjon A., Gardner M.F., Mill R.R., Chase M.W. 2011a. A new classification and linear sequence of extant gymnosperms. *Phytotaxa* 19: 55–70.

Christenhusz M.J.M., Zhang X.C., Schneider H. 2011b. A linear sequence of extant families and genera of lycophytes and ferns. *Phytotaxa* 19: 7–54.

Payette S., Garneau M., Damboise K. 2018. Flore Nordique du Quebec et du Labrador. Vol 3. Laval University Press, Quebec.

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Expanding and Reorganizing at the National Herbarium of Canada

Cassandra Robillard – Botany Project Technician,
with Jennifer Doubt – Botany Curator, Canadian Museum of Nature

Your friends at the National Herbarium of Canada have been busy adding some much-needed breathing room to our 138-year-old collection of over 1 million dried botanical specimens – yes, even during the pandemic. Here, I hope to introduce our multi-year expansion and reorganization project, outline some of the benefits it will bring users of the National Herbarium, and discuss some of the lessons we've learned so far.

Background

The Canadian Museum of Nature's Natural Heritage Campus, the building that houses the National Herbarium of Canada, opened in 1997. The national collection of vascular plants, bryophytes, lichens, and algae was set up to accommodate 20 years of slow growth, with cabinets arranged in three long, compactorized columns of at least 26 rows each. This space would hold not only the herbarium's processed and catalogued specimens, but also its unprocessed specimens and loans from other institutions.

Figure 1. An over-full cabinet of grass specimens in need of decompression.

Twenty-three years and many field seasons, donations and loans later, in a different administrative climate, with new Botany staff, the National Herbarium had far outgrown the volume of the existing cabinets within the herbarium space. As of 2013, an additional 30 cabinets had been added and the entire macroalgal collection moved to a separate part of the building, but the space created by these measures was quickly filled with incoming specimens. While plans to expand the whole campus for another 50 years of collection activity, collection-based engagement, and research are under way, these plans are not likely to be implemented for at least 10 years. In those interim years, the herbarium – by this point consisting of 655 cabinets spread across two rooms – would need to increase its capacity within the existing building.

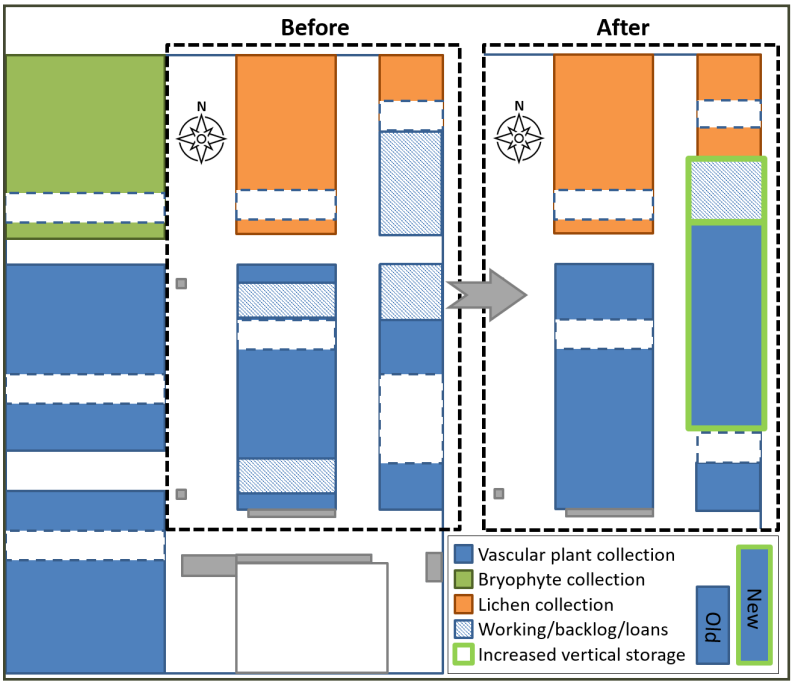

Figure 2. Map of the main herbarium, showing the central and east columns of cabinets before and after expansion activities are completed in that space. Floor space to access the stacks is indicated in white. Legend includes a side-by-side height comparison of old and new cabinets.

In 2018-19, herbarium curator Jennifer Doubt and a team of Research & Collections managers devised a plan to increase capacity for the Botany collection by filling in, expanding upward, and expanding out from the herbarium collection spaces. Filling in within the collection would involve the installation of three more rolling carriages of cabinets in the last parts of the

collection that could accommodate them. Expanding upward would involve adding taller herbarium cabinets with 32 shelves, yielding one-third more vertical space to stack specimens than standard 24-shelf models. These would not only be placed on the new rolling carriages, but would also replace most of the cabinets within the easternmost column of the herbarium. Expanding outward would involve taking advantage of unused space within the neighbouring Osteology collection room to store Botany's working and backlog material while keeping the accessioned collection together in the original space, along with loans. Working and backlog material would be stored in the older cabinets displaced from the herbarium.

Creating space to expand the herbarium's collections would introduce another rare and important opportunity: to update the 113-year-old filing system within the vascular plant collection, to one where the arrangement and order of families and genera reflect modern understanding of flowering plant evolutionary relationships. As vascular plant specimens were being redistributed across the newly created storage space, they would be reorganized to follow the linear filing system devised by the Angiosperm Phylogeny Group (APG IV 2016).

In 2019, the museum funded this expansion and reorganization project. Cabinets were purchased, movers were hired, and a project technician – me – joined the team in January, to help implement the plan. As of this November, we are well on our way through Expansion step 6 in (see Table 1), and have completed up to Reorganization steps 7 and 8. Steps 9 through 12 are expected to take multiple years, with at least 3 years budgeted for step 12 alone.

Table 1. List of major steps in the National Herbarium's expansion and APG IV reorganization.

Step	Expansion
1	Pack and move first half of older cabinets - while full - into Osteology space
2	Install new carriages and first half of new extra-tall cabinets in main herbarium
3	Move content from second half of old cabinets into swing space; move emptied cabinets into Osteology space
4	Move shorter cabinets out of algal herbarium in preparation for new cabinet installation
5	Install second half of new cabinets in both herbaria; move content out of swing space
6	Move remaining working material, backlog, and loans into their new storage spaces
	APG IV Reorganization
7	Create database linking old taxonomic concepts to new ones by genus
8	Inventory specimen volume of each taxonomic unit (genus/family) to be moved
9	Map newly expanded collection space according to APG IV linear system and individual taxon space requirements
10	Move specimens into new positions following APG IV linear system
11	Update taxonomic concepts in collections database to follow APG IV
12	Perform detailed taxonomic and geographic updates on specimens and specimen folders

Benefits to Users

We're excited to share the benefits of an expanded and reorganized vascular plant collection with herbarium users!

The increase in space means fewer overstuffed shelves, making access easier and minimizing the risk of damage to specimens. It also means relieving pinch-points in the collection where a complete lack of space in certain cabinets has recently prevented filing of specimens. Having these specimens in their proper places increases their availability and reduces risk of loss.

Our backlog and material awaiting acquisition have been moved to a dedicated collection environment and organized for more intuitive access, where it remains well-organized and documented until it can be processed.

A filing system that reflects modern understanding of evolutionary relationships will allow modern botanists

to apply their contemporary taxonomic concepts in searching for material that is relevant to their questions.

Re-organization also provides the long-anticipated occasion to systematically identify and clean up discrepancies and eccentricities that have cropped up in the collection. For example, some specimens of a given species concept have been, over the years, inadvertently filed in multiple separate places under different names. Some sections feature unique filing conventions reflecting the preferences of former researchers of those particular groups.

In addition to known issues that will be addressed, a project of this scale and detail also tends to expose unknown issues that can then be resolved. As an example, over the course of inventorying space in the vascular plant collection, I found and re-filed 30 specimen folders that were out of place in less frequently used sections of the collection. In another case, while packing the backlog specimens for moving, we discovered a batch of conifer cone samples in plastic bags that had become brittle and shattered when touched. Following an impromptu, overdue re-housing project, they are safe again. With systematic surveys and preventative work taking a back seat to brisk collection development and service in recent years, this opportunity to review our collection enables more informed management decisions, for better preservation of this treasured collection resource.

Figure 3. We knew we would need lots of cotton lacing to bundle specimens for moving in cabinets. But we didn't realize until we did the calculations, that we would need over 3 km of lacing! Here I am holding just a portion of that supply.

As we progress through each phase of this project, we are making notes of the methods used, the challenges faced, and lessons learned. Knowing how important it has been to consult with other collection managers in this process (nothing like this had been attempted within the experience of current staff), we are, in turn, sharing our experience with other natural history collections.

Challenges and Lessons Learned…So Far

From the very start of this project, the new challenges we've faced have taught us new lessons. Take the sheer size of the project: I'm a visual person, and rely heavily on my ability to picture space in order to solve problems. But this project involves hundreds of cabinets, thousands of shelves of material, and hundreds of thousands of specimens, undergoing multiple moves with multiple steps required. It's difficult to complete work in one cabinet, and make a quick on-the-fly prediction of how long that same work will take when applied to over 100 cabinets. Time trials, mock-ups, careful calculations, and repeated verification have all been key to the successful management of both time and material supplies throughout this project. In preparation for step one, taping the outlines of the rows of Botany cabinets on the floor of the Osteology room revealed an error in the project drawings that affected what we understood both about the capacity of the space, and the functionality of the aisles. Finding the error and revising the floor plans and moving plans before any cabinets had been packed saved us time, moving expenses, materials, and a load of in-the-minute stress! These trial and verification steps often can feel like a luxury when a project is on a tight timeline but in our experience, they have saved us time in the long run.

Figure 4. Movers using a tilting dolly to fit the new cabinets through low doorways.

Nonetheless, the height of the new cabinets, which are much taller than any other cabinets previously in the

herbarium, still made for some unpredicted challenges when going from planning to implementation. We knew that they would need to be on an angle in order to be brought through some collection spaces, but did not foresee some other complications it would introduce, including the time-consuming dismantling of a "removable" panel above the herbarium door, and the temporary displacement of an entire bank of vial storage cabinets, just to allow the angled cabinets enough area to turn as they went in the door of the algal herbarium. Equipment for moving these cabinets was not as readily available as we expected, either.

Speaking of challenges of scale: the herbarium has 17 carts that can accommodate a total of 190 herbarium shelves. Our working tables can fit approximately 120 shelves of material without over-stacking. Although the vast majority of the first half of the cabinets moved into Osteology were moved while full, even the small minority of exceptions stretched this capacity. Despite borrowing large carts from other departments, there were times when every square foot of available surface space was in use. We even unlocked an unused display case so that we could store boxes inside …and on top.

Figure 5. Trays of lichens too heavy to be moved inside their cabinets, awaiting cabinet replacement.

The volume of temporarily-displaced algal specimens also exceeded the capacity of our carts with the added challenge that the algal herbarium lacked free surface space. In order to move algal cabinets while empty, we performed an intricate cart choreography: as many carts as we had were filled in advance, keeping careful notes of the origin of each cart's contents. Once the source cabinets were moved, they were re-filled from each cart, to release it immediately back into rotation. This dance of carts - as well as other similar steps where packing or storage resources were limited - was understandably time-sensitive, requiring tight coordination, artful stepping, and frequent communication among collection staff and movers.

As you might well be thinking, this year has also come with its own unique challenges to all projects. Our Botany team all suspected when we went home on Friday, March 13th that it wouldn't be long before the reality of COVID-19 in Canada would begin to affect our work. But I don't think any of us truly believed that we would be waking up Monday morning to an email advising all CMN staff that they were to stay home. It was the first day of the first week of the first month of COVID-19 lockdown. And that morning we had our first truck full of new cabinets waiting at the loading dock.

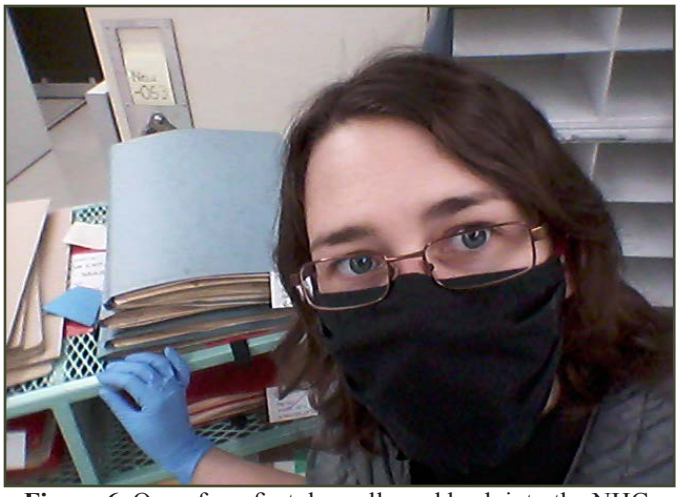

Figure 6. One of my first days allowed back into the NHC, moving specimens into swing space while wearing a mask and gloves.

We were able to go in to complete the work, with appropriate safety measures. Since then, the collections facility has reopened gradually, allowing collections staff to complete tasks on-site as needed while continuing to work from home whenever possible. The pandemic has made work in some phases more difficult than in others. For example, creating a workflow that allowed for distancing while unloading, inspecting, and cleaning newly arrived cabinets was a challenge when each delivery involved enough cabinets to line our entire collections corridor side-by-side. On the other hand, the silver lining of having very limited presence in the herbarium at this time is that some larger, more disruptive steps can take place with less interruption to herbarium users.

The scale of this project can feel overwhelming when considered all at once, but every new milestone we reach gives us the motivation we need for the next step. We look forward to offering collection users a great herbarium experience well into the future. If you or your herbarium have advice to offer or any questions about the project, we would love to chat. Send an email to crobillard@nature.ca to get in touch with me.

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Acknowledgments

Many thanks to the Canadian Museum of Nature for supporting this project. We greatly appreciate the expert advice provided by Mare Nazaire (RSA-POM), Luc Brouillet (MT), Tiana Rehman (BRIT), Susan Lutz (US), and Kirsty McFadyen (LEA), from their own moving and reorganization projects. Special thanks go to the Conservation, Facilities, and Zoology staff at the NHC, for sharing their time, energy, and floor space! Finally, thanks to Paul Sokoloff for the lacing portrait and for comments on figures.

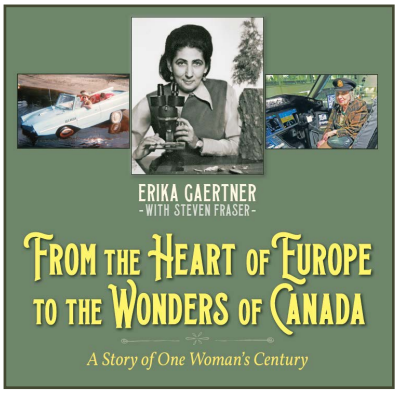
An update on Erika Gaertner's autobiography, *From the Heart of Europe to the Wonders of Canada: A Story of One Woman's Century*: the book is now available both digitally and in print at the following locations...

Digital Options (Amazon link provides access to the opening chapters):

- https://www.amazon.com/Heart-Europe-Wonders-Canada-Century-ebook/dp/B08HVZX2VL
- https://www.kobo.com/ca/en/ebook/from-the-heart-of-europe-to-the-wonders-of-canada-a-story-of-one-woman-s-century

Print Option (Burnstown Publishing House):

- https://burnstownpublishing.com/product/from-the-heart-of-europe-to-the-wonders-of-canada-a-story-of-one-womans-century/



Using citizen-science to discover bryophyte-cyanobacteria associations

By Mélanie Jean

The covid-19 pandemic has forced many of us to rethink the way we conduct research and field work given the sanitary measures in place and travel restrictions. Citizen-science projects are an interesting avenue for continuing to collect data from various areas while respecting regional public health measures. During the spring of 2020, we initiated an online data collection project in collaboration with citizen scientists from the Société Québécoise de Bryologie (SQB). While discussing with them, they told me that they often notice cyanobacteria on the leaves and stems of bryophytes during their identifications under the microscope. These observations are precious because limited information exists about the cyanobacteria associated with bryophytes. Nitrogen (N)-fixing cyanobacteria associated with bryophytes are an important source of plant-available N in many ecosystems. However, ecological research on this topic has often been limited to the most common bryophyte species given the lack of taxonomic expertise in bryophyte identification and the lack of resources. Amateur and professional bryologists are passionate and spend numerous hours observing bryophytes under the microscope to identify a wide range of species from a broad range of habitats, most of which have rarely or never been assessed with regard to their capacity to host N-fixing bacteria. Bryologists can therefore collect invaluable information in a way that would otherwise be unmanageable for single observers. We are hoping that this data collection effort will serve as a steppingstone to enable more targeted molecular and biogeochemical studies of bryophytes' microbiota and associated N-fixation.

Figure 1: Cyanobacteria in the hyaline cells of *Sphagnum divinum*. Picture by J. Doubt.

N -fixation in the bryosphere

Symbiotic associations between plants or fungi and nitrogen (N)-fixing bacteria play key roles in ecosystems found in all terrestrial biomes. Globally, the biological fixation of atmospheric N is the primary natural source of plant-available N in ecosystems.[1] N is often the nutrient-limiting plant growth in northern ecosystems such as boreal forests or tundra, both of which are of global importance as carbon (C) sinks[2]. Some of the most well-known associations include those of nodulated plants, such as alders (*Alnus* spp.) or legumes, which are used in agriculture to improve soil fertility or in restoration projects. Bacterial families such as the Frankiaceae, Rhizobiaceae, Burkholderiaceae, and Nostocaceae (cyanobacteria) contain some of the most well-known N-fixing bacteria. Endophytic or epiphytic microbes living in association with plants and fungi (cyanolichens with cyanobacteria as a photosynthetic partner) can also be found outside of differentiate root nodules, for example on the leaves, stems, and roots of coniferous trees, perennial grasses, or bryophytes. Bryophytes can significantly contribute to N inputs in boreal ecosystems[3], but still very little is known about cyanobacteria-bryophyte associations. These lesser-known associations can be key N sources of both host plants and their ecosystems.

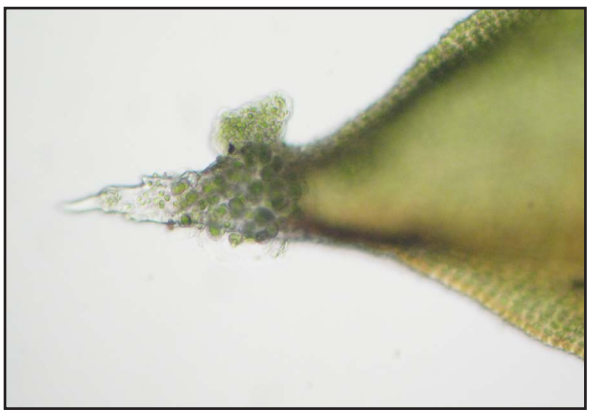


Figure 2: Cyanobacteria colonizing the tip of the hyaline point of a leaf of *Hedwigia ciliata*. Picture by Stéphane Leclerc.

The bryosphere represents the complex network of associations between the microorganisms and invertebrates living on the leaves, stems, and decaying parts of bryophytes[4]. Epiphytic or endophytic associations with N-fixing organisms have been reported in all three classes of bryophytes: Anthocerotae or hornworts (genera *Anthoceros, Phaeoceros, Notothylas*, and *Dendroceros*),

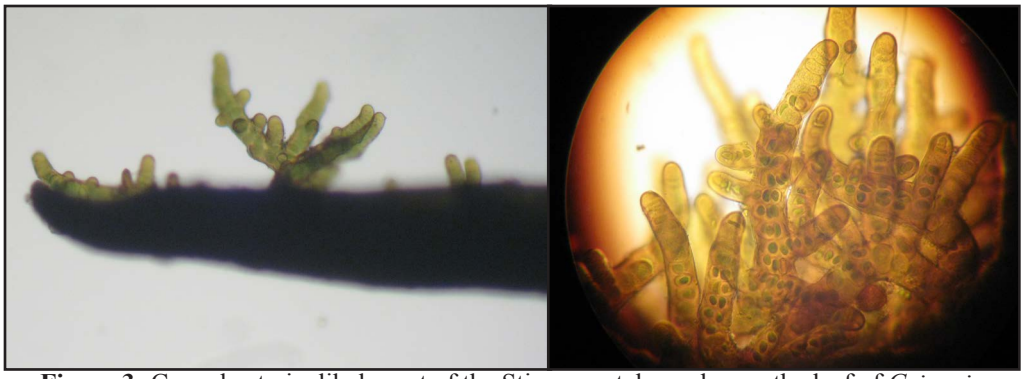


Figure 3: Cyanobacteria, likely part of the Stigonematales order, on the leaf of *Grimmia unicolor*. Picture by Stéphane Leclerc.

the Hepaticae or liverworts (genera *Marchantia, Porella, Blasia, Cavicularia*), and the Musci or mosses (various true mosses and *Sphagnum*). The importance of N-fixation by these bryophyte-associated bacteria is increasingly recognized in boreal[3,5], subarctic[6,7], Arctic ecosystems, and temperate ecosystems[8–10], as those N inputs are possibly critical for forest productivity in N-limited systems. Due to the prevalence of extensive moss carpets in boreal and subarctic forests, the majority of studies on bryophyte-associated N-fixation has been concentrated in Scandinavia and Alaska and on common moss species such as *Pleurozium schreberi, Hylocomium splendens,* or *Sphagnum* spp.[16,17].

Cyanobacteria, also known as blue-green algae, are microscopic and present characteristics of both bacteria (absence of organelles in the cells) and algae (photosynthesis). Their ability to photosynthesize and the fact that they are often found in the same places as algae that earned them the name blue-green algae when they are actually bacteria. A distinguishing characteristic of cyanobacteria is that their chlorophyll is widespread in their cells rather than being concentrated in chloroplasts, as it is for true algae. Cyanobacteria can be found as individual cells, in groups, or as filaments formed from many cells. In some filamentous cyanobacteria, heterocysts are found, which are cells that specialize in nitrogen fixation. These cells can be recognized by their larger size, rounded shape, and the fact that they are lighter than other cells. Many cyanobacteria are relatively large and can be easily observed with a light microscope and can either be endophytic, for example, in the hyaline cells of *Sphagnum* species (Figure 1), or epiphytic, i.e., living at the surface of the leaves and stems (Figures 2-5). Cyanobacteria from the genera *Nostoc, Stigonema*, and *Calothrix*, among others, have been identified for the commonly studied feather mosses[13–15]. Cyanobacteria are very sensitive to environmental conditions (temperature, humidity, pH, nitrogen availability), and a growing number of studies suggest that the host species of bryophytes exerts a strong control on the composition of their bacterial community.

Figure 4: Filamentous cyanobacteria on the leaf of *Amblystegium serpens*. Picture by Marie D'Aoust

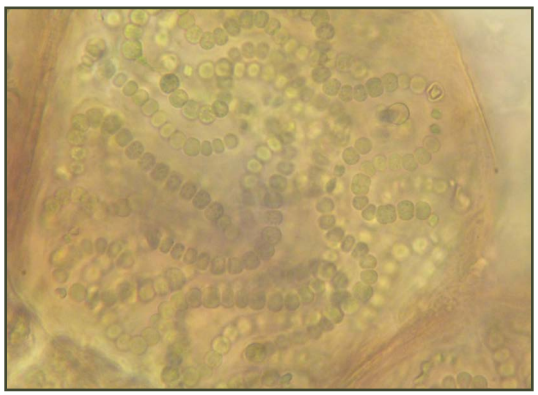


Figure 5: Filamentous cyanobacteria (Nostocales cf.) on the leaf of *Tortella inclinata*. Picture by Stéphane Leclerc.

How you can contribute

In an ongoing project where we are working on synthesizing available information on bryophyte associations with N-fixing bacteria in the scientific literature, we noticed how much information is lacking for the vast majority of species. Bryophyte species for which we have little to no information can be locally abundant and may still carry out important N-fixing functions in their habitat. With this knowledge gap in mind, we decided to tap into the existing work accomplished by amateur and professional bryologists in Canada who are already examining bryophytes under the microscope for identification purposes. If you see something that looks like a cyanobacteria while identifying a bryophyte, please record your observation.

We created a Google Form with a few questions to fill in and there is the possibility of attaching a photo of your observation (Box 1), as well as supporting documentation. Following data submission, pictures of cyanobacteria will be visually classified into broad categories (cyanobacteria taxonomy is a whole world in itself). This will give us new insights into species of bryophytes that have the potential to harbour nitrogen-fixing cyanobacteria by broadening the spectrum of species and ecosystems studied. It can also highlight possible patterns of co-occurrence of cyanobacteria on specific bryophyte taxa. Ultimately, we hope that our findings will prioritize targeted, more detailed molecular and biogeochemical studies of the bryosphere and its associated N-fixation.

Box 1: Online form

- Your contact information, so that I can reach you if I have any questions about your observation (facultative).
- Date of collection of the bryophyte sample in the field.
- Date on which the observation of the bacteria was made on the sample.
- What species of bryophyte was the bacterium observed on?
- Where was the bryophyte collected?
- Brief description of the type of ecosystem in which the bryophyte was harvested?
- Where on your bryophyte sample did you notice the bacterium?
- Did you notice heterocyst cells on the cyanobacteria (cells that are larger than others and translucent rather than green)?
- If you have taken a photo(s) of your observation of the bacteria, can you attach it to this form?
- Other potentially useful information.

If you have any questions, please do not hesitate to contact me at melanie.jean@uqat.ca. Moreover, if you have experience in cyanobacteria identification, please reach out as we are looking for an expert to help us out!

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From the CBA Bulletin archives

January 1975, Volume 8, Number 1

WE ARE TEN YEARS OLD!

This year we are 10 years old! A history of these brief but activity filled years appears in this edition of the Bulletin. In these 10 years the CBA/ABC has become a focal point of contact and communication for botanists across Canada. This has been achieved principally through the annual meetings which are held each year in different parts of the country, and through the Bulletin which is the newsletter of the Association. Besides being a means of contact and communication within the botanical fraternity of Canada the CBA has become a means of interaction between botanists and workers in related disciplines. This is particularly well demonstrated by the 1975 annual meetings which will be held in Saskatoon in conjunction with the Entomological Society of Canada and the Canadian Phytopathological Society. This should provide a stimulating opportunity for interchange of ideas and it is hoped that as many of our members as possible will join us at Saskatoon. The planning for these meetings is well advanced thanks to the energetic activity of our organizing committee and details of the programme are included in this issue of the Bulletin. So, please come to Saskatoon and make our Tenth Anniversary Meetings an outstanding success!

TOP CANADIAN ORNAMENTAL PLANTS. 27. Primroses

ERNEST SMALL[1, 2]

Primroses are among the most gorgeous of flowering plants, exhibiting an astonishing range of floral colours and shapes. They are easy to grow, with numerous very hardy cultivars ideal for Canadian conditions. Their small size makes primroses particularly suited to limited spaces, both indoors and outside. They are also excellent houseplants, widely grown as short-term disposables, but they can be maintained indefinitely indoors if provided with appropriate care.

Names

Scientific name: The genus Primula is based on the Latin primus, meaning first, reflecting the early spring flowering.

English names: Primrose, primula. The "evening primroses" are species of *Oenothera*. "Water primroses" are *Ludwigia* species. "Cape primroses" are *Streptocarpus* species. As noted later, some groups of primroses are known by their own names (such as the polyanthus and the auriculas) and there are some classes of primroses (such as drumsticks and candelabras).

French name: Primevère.

Figure 1: A display of colourful flowering primrose cultivars. © Yewchan (CC BY SA 2.0).

Symbolism

Cowslip (*P. veris*) is well known in the U.K., and is the "county flower" of Northamptonshire, Surrey and Worcestershire. The primrose (likely *P. vulgaris*, the English primrose) was the favourite flower of Benjamin Disraeli (1804–1881), Tory (Conservative) prime minister of England. This led to the founding in 1883 of the Primrose League, an organisation for spreading Conservative principles in Great Britain, which was influential until its disbandment in 2004. "Primrose Day" (April 19) in the U.K. marks the anniversary of Disraeli's death. The much-repeated phrase "Primrose path," referring (often pejoratively) to a hedonistic route through life, was coined by Shakespeare, in Hamlet (in the very early 17th century).

Wild *Primula* species

Primulas are mostly herbs, usually perennial but sometimes short-lived or rarely annual. They are native to the temperate northern hemisphere, extending southward to tropical Asian mountains and temperate southern South America. The Himalayas and western China are major centres of distribution, where hundreds of species occur in a wide variety of habitats, including damp alpine meadows, forests, valleys, mountain sides, and stream sides. In Canada, there are about 12 indigenous species of *Primula* as traditionally defined, and an additional eight species transferred from *Dodecatheon* to *Primula*.

Most primroses are small stemless herbs, less than 30 cm tall and wide. The leaves are stalked (petiolate), oval or roundish, and in a basal rosette. The foliage in the rosette is sometimes deciduous, but is typically evergreen or persistent, although often deteriorated in cold, snowy environments. A stout peduncle arises from the rosette, bearing a solitary flower, or more usually a spherical cluster of flowers. The corolla tube opens into five spreading petals, which may be red, pink, purple, blue, white, or yellow. The five stamens are attached to the wall of the corolla tube. The pistil arises from a superior ovary, and has a single slender style topped by a broad stigma. The flowers are typically 2–5 cm in diameter, and often have an eye in the centre that is a different colour than the petals. In the Primulaceae, only species of *Cyclamen* and a few *Primula* species (in-

1 Science and Technology Branch, Agriculture and Agri-Food Canada, Saunders Bldg., Central Experimental Farm, Ottawa ON, K1A 0C6

cluding those formerly in *Dodecatheon*) share the characteristic of the corolla reflexing backwards, making it appear as if the flower has been turned inside-out. The fruit capsule, if produced, has numerous small seeds. Many of the alpine species are small plants which are ideal for rock gardens and containers.

Heterostyly is the presence in a species of floral classes ("morphs") differing in relative position of stamens and styles. There are two classes of heterostyly: distyly with two floral morphs and tristyly in which there are three morphs. Primula is known for distyly, producing two types of flowers in approximately a 50:50 ratio: long-styled flowers with anthers attached midway along the floral tube ("L-morph,", or "pin'), and short-styled flowers with anthers attached at the top of the floral tube ("S-morph,", or "thrum'). Crossing between but not within the two floral types produces viable seeds. Heterostyly has evolved in more than two dozen plant families. Heterostylous species frequently are programmed to reject pollen not just from the same plant but also from the same floral morph. About 90% of *Primula* species are distylous, whereas the remaining 10% produce self-compatible flowers of just one type. Charles Darwin, experimenting with primroses, was the first to explain that heterostyly is a mechanism promoting outbreeding. In 1876 he wrote: "I do not think anything in my scientific life has given me so much satisfaction as making out the meaning of the structure of heterostyled flowers." Darwin was responsible for the terms pin and thrum. He named pin flowers for the resemblance of the prominent style and stigma in the mouth of the flower to a dress-makers pin, and thrum flowers for the resemblance of the anthers at the mouth of the flower to a "thrum" – an old weaving term for a tuft of thread.

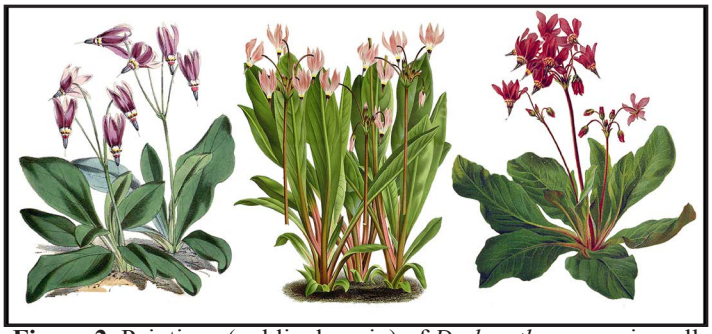

Figure 2. Paintings (public domain) of *Dodecatheon* species, all in Canada. The genus has been transferred to *Primula*. Left: *Dodecatheon frigidum* (*Primula frigida*). Source: Curtis, W. 1870. Curtis's botanical magazine vol. 96, t. 5871. Centre: *Dodecatheon jeffreyi* (*Primula jeffreyi*). Source: Van Houtte, L.B. 1865. Flore des serres et des jardin de l'Europe, vol. 16, t. 1662. Right: *Dodecatheon meadia* (*Primula meadia*). Source: The Garden. 1876, vol. 10, t. 41 p. 360.

Domesticated Primula species

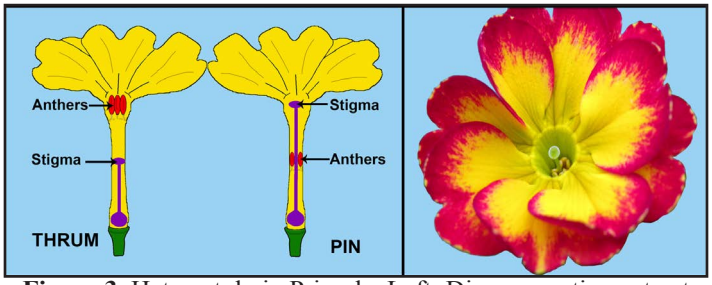

Figure 3. Heterostyly in Primula. Left: Diagrammatic contrast of Pin (long-styled) and Thrum (short-styled) flowers of *P. veris*. The calyx is not shown. Prepared by B. Brookes. Right: Pin flower. © Nicolas Gent (CC BY ND 2.0).

Primroses have been cultivated for centuries. As with other major ornamental plants, most cultivars grown today are hybrids, often with parentage tracing to several wild species. Although most varieties have Asian par-

Figure 4. Chinese primrose (*Primula sinensis*), which was much more popular in the past than today. Public domain illustrations. Top: Cover (public domain) of a 19th century catalogue. Bottom: Painting from Lindley, J. 1821–1826, Collectanea botanica or, figures and botanical illustrations of rare and curious exotic plants. Richard and Arthur Taylor, London.

entage, several European species were also domesticated over the last several hundred years, such as English primrose (*P. vulgaris*), also known as acaulis primrose), oxlip (*P. elatior*), cowslip (*P. veris*), and fairy primrose or baby primrose (*P. malacoides*). English primrose is one of the main parents in the polyantha hybrids, discussed next, and the name English primrose is often employed as a generic name for many of the polyantha hybrids. Houseplant primroses are often the English primrose.

"Polyanthus" primroses (horticulturally termed *P. ×polyantha*) are hybrid cultivars of *P. veris* and *P. vulgaris*. The word polyanthus is based on the Greek polyanthos meaning many-flowered. A large variety of colourful varieties are available, and these frequently dominate offerings at garden centres. Indeed, most primroses cultivated outdoors are these hybrids. The group has especially diverse flowers, some bi-coloured, some striped, and some doubled. The polyanthas are perennial, although often short-lived (grown as annuals or biennials), and are often established from seed or from young plants. The polyanthus primroses and its parental species are often grown as pot plants. In Japan, *P. ×polyantha* was crossed with *P. juliae* to produce unique dwarf cultivars called Julian Hybrids.

The orchid primrose (*P. vialii*) (also known as Chinese pagoda primrose and poker primrose) is a particularly attractive short-lived garden perennial, growing to

Figure 5. "Polyanthus" primroses (*Primula ×polyantha*). Left: © Foshie (CC BY 2.0). Right: © Garry Knight (CC BY 2.0).

30–45 cm in height. At first sight it does not look like a typical primrose. It produces spikes of tiny pinkish-purple flowers, but the uppermost flowers, which are unopened, are reddish. The species is relatively frost tender, but can be grown as an annual in Canada.

Several other species are particularly well known, as exemplifed by the following. "Candelabra" primroses (such as such as *P. japonica, P. bulleyana*, and *P. florindae*) carry their flowers in whorls spaced on a main peduncle. Many of the cultivars have doubled flowers. Drumstick primrose (*P. denticulata*) is a widely planted garden species, with globular flower heads on 30 cm long peduncles (looking like drumsticks).

Figure 6. Orchid primrose (*Primula vialii*) © Harlow Carr (CC BY ND 2.0).

Some of the species develop a white mealy white powder ("farina") on their surfaces. This is most pronounced in some of the natives of high-altitude habitats where there is high irradiation. The farina appears to be protective, like sunblock lotion. The character has been particularly selected for its ornamental value in auricula primroses (*P. auricula*), which are often grown protected in glass houses to maximize the white bloom for competitive flower shows. Auricula primroses have small clusters of flat topped flowers, and grows 15–20 cm in height. Numerous floral variations have been selected. Aside from the powdery coating, the plants are also notable for their distinctive thick leaves. Unusual for primroses, they are adapted to alkaline soil.

Figure 7. Paintings (public domain) of some popular primrose species. Left: Drumstick primrose (*P. denticulata*). Source: Curtis, W. 1842. Curtis's botanical magazine, vol. 68, t. 3959. Centre: Auricula primrose (*P. auricula*), showing various strains, by Pierre Joseph Redoute (1827). Notice the farina (whitish covering) on foliage. Right: *Primula japonica*, a "candelabra" type. Source: Revue horticole, sér. 4, vol. 42 (1870).

The very attractive poison primrose (also known as German primrose; *P. obconica*) has leaves that can cause skin irritation, and indeed this was a problem in the past, especially for florists. In modern times the cultivar 'Touch Me' is often marketed, since it lacks primine, the principal sensitizer causing itching.

Figure 8. Poison primula (*Primula obconica*). Left: Chromolith, ca. 1897. © Welcome collection (CC BY 4.0). Right: © Yewchan (CC BY SA 2.0).

Economic importance

Primroses represent one of the major, standard flowering commercial ornamentals, grown in numerous greenhouses for sale as houseplants, and bedding and container plants. Many commercial interests internationally are involved in breeding and selling of primroses.

Care of indoor plants

Figure 9. Primroses being grown in a commercial greenhouse. © Vicky Brock (CC BY SA 2.0).

Figure 10. Container plants, the main way that primroses are grown in Canada (public domain images). Left: English primrose (*Primula vulgaris*). Source: Revue horticole, Librairie agricole de la maison rustique, Paris (1898). Right: source: Piklist.com.

The majority of potted houseplant primroses are purchased in supermarkets (hence the nickname "grocery store primroses"), often as gift plants. They are extremely attractive, relatively cheap, and compact, and so appeal strongly to impulse buyers. Unfortunately many are disappointed by difficulties in maintaining the plants long term. Primroses need moderate light and cool temperatures to thrive, and do not respond well to relatively dark, overheated homes, especially in winter. They also require consistent moist but not soaked soil. To prolong good growth, the following procedures are recommended. Decorative wrapping or foil on the outside of the pot should be removed, as it tends to retard free drainage. The plants should be located in a cool (10 to 20°C) location, and the soil maintained neither too dry nor too wet. If a very bright location is unavailable, the plants may be placed under a fluorescent light, about 30 cm above the plants, for at least 12 hours a day. Fertilizer is usually not necessary for several months. Note that gift primrose houseplants (frequently *P. vulgaris*) are often forced to bloom for out-of-season sales, and when subsequently planted outdoors they may lack the energy reserves needed to survive. Except in the warmest areas of Canada (particularly the Pacific coast), the exercise of attempting to salvage houseplants for transplanting outdoors is likely to be unsuccessful.

Care of outdoors plants

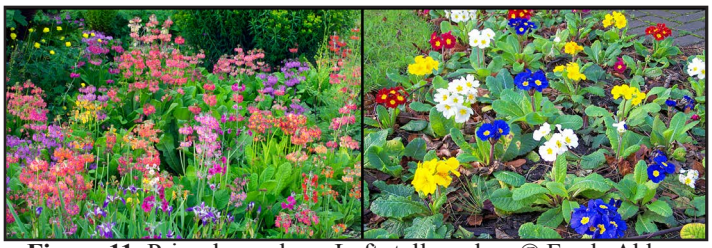

Figure 11. Primula gardens. Left: tall garden. © Forde Abbey and Gardens (CC BY ND 2.0). Right: Low garden. © Soham Banerjee (CC BY 2.0).

A considerable proportion of gardeners consider primroses to be "disposable annuals," grown primarily as dainty container plants, especially as houseplants or as patio or windowbox plants. Nevertheless, there are numerous cultivars that are viewed as superlative garden plants.

PROPAGATION

Quite cool conditions (10°C or lower) are often re-

quired to germinate the tiny seeds (often carried out in a refrigerator) and establish seedlings. Many cultivars will self-sow outdoors. After flowering in the garden, primrose can easily be lifted and divided, which may be the only way of maintaining the genetic purity of some hybrids. Primroses usually transplant well. The crowns should be position at soil level, and at least 15 cm apart.

PURCHASING

The principal cultivated species and classes are sold in mass marketing outlets. Purchasing potted primrose when they are in flower guarantees the plant will reproduce the desired kinds of flowers (seeds sometimes are of hybrid origin and the resulting plants segregate for flower colour). The uncommon species are often available from rock garden societies and specialist on-line nurseries. The American Primrose Society (see Key Websites guide, below) sells seeds to Canadians (membership is required).

SOIL & MOISTURE CONDITIONS

Most cultivated primroses of Asian and/or woodland origin prefer slightly acidic (pH ca 6.5), strongly organic soils, and some of these do best in constantly moist soils. Species of upper alpine origin tend to thrive in well-draining gritty soils resembling their high-mountain scree habitats.

LOCATION

Outdoors, primrose usually prefer partial shade, and are often planted in masses near deciduous trees, or in locations with north-facing exposure to the sun. However, planting under trees could be disadvantageous, as the tree roots may outcompete the primulas for moisture and soil nutrients. In cold, northern climates, the plants may need more exposure to the sun, although open locations may subject the plants to winter desiccation.

TEMPERATURE

Most primulas are intolerant of summer heat and drought, and indeed in such climates the plants are often grown as annuals. By contrast, numerous primrose cultivars are extremely hardy and overwinter well in Canada. Indeed, many require winter chilling to survive and produce flowers. Nevertheless, winter mulching is often recommended to minimize freezing damage.

TIPS

The doubled flower cultivars are especially attractive but tend to be relatively fragile. To maintain vigour, it has been recommended that the spent flowers be deadheaded (removed) and the plants divided every 2 or 3 years.

Curiosities of science and technology

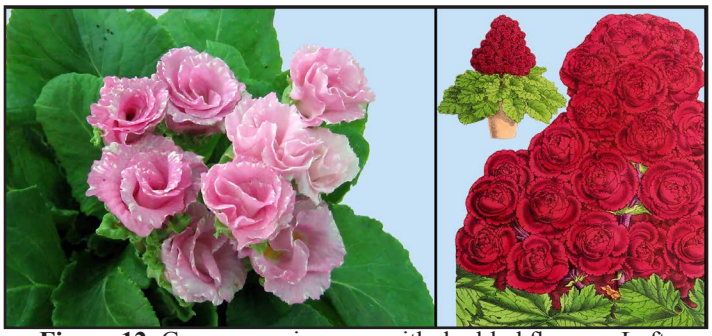

Figure 12. Gorgeous primroses with doubled flowers. Left: *Primula vulgaris* 'Scarlet Parade'. © HQ (CC BY SA 2.0). Right: *Primula sinensis*. Source (public domain): The floral magazine 1874, new serv. v. 3. London, L. Reeve & Co.

Figure 13. Left: Hose-in-hose fashion in Elizabethan times. Painting (National Portrait Gallery, London) of Henry Wriothesley, 3rd Earl of Southampton (1573–1624), one of William Shakespeare's patrons. Photo (public domain) by Ann Longmore-Etheridge. Right: Hose-in-hose mutation in Primula. © Jacki-dee ((CC BY NC ND 2.0).

- One of the oddest primula forms is called "hose-in-hose." In Elizabethan times in England (i.e. during the reign of Queen Elizabeth I, 1558–1603), it was fashionable for gentlemen to wear two pairs of "hose", the upper hose often in the form of puffy knee-length trousers which were met by the lower hose (essentially a long stocking) on the lower leg. Hose-in-hose primu-

las seem to develop a flower from inside another flower, hence the name hose-in-hose. In fact, a mutation, often observed in wild *Primula*, causes the calyx of one flower to develop into another flower. Curiously, the floral mutation is linked to the S locus which determines whether the flowers are pin or thrum.

- Reflecting the tradition of accentuating the attractiveness of women with beautiful objects, females are often shown decorated with flowers, including primroses, in allegoric paintings (i.e. art with figures reflecting a story or message).

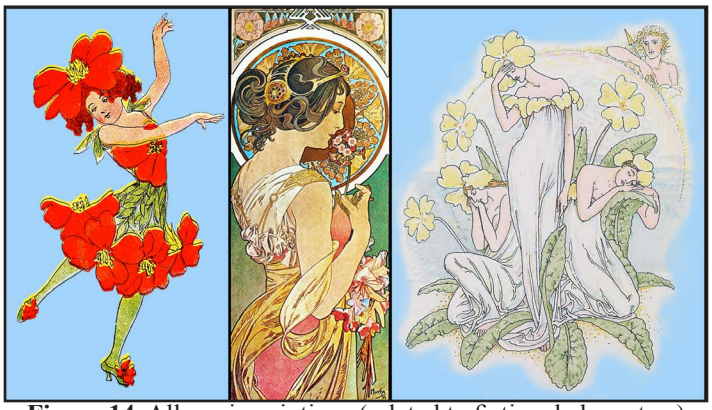

Figure 14. Allegoric paintings (related to fictional characters) showing women decorated with primroses (public domain figures). Left: Source: Gordon, A.E. 1912. Flower children; the little cousins of the field and garden. Centre: Painting, La Primevere/ Polyanthus, by Alphonse Mucha, 1899. Right: Source: Cassell & Co., Ltd., London. 1909. Flowers from Shakespeare's garden.

- Many ships are named for flowers, and the unfortunate demise of one of these is notable. In 1981, a Hong Kong-registered cargo ship, MV Primrose, ran aground on a coral reef off North Sentinel Island in the Bay of Bengal, considered to be "the last island on Earth solely inhibited by noncontacted native people." The island is out of bounds under Indian law because of the hostility of the natives. For a week, the crew was threatened by members of the Sentinelese tribe on the beach, wielding spears, shooting arrows, and attempting to board the freighter from canoes. Finally, the Indian navy rescued the crew. Less fortunate was a Christian missionary attempting to convert the natives. In 2018, he was shot to death with arrows, tipped with metal that the islanders had obtained from the Primrose wreck.

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Key websites

American Primrose Society – https://americanprimrosesociety.org/ (the principal primrose organization; most online resources require membership; provides a list of commercial seed sources and also sells seed through its seed exchange)

Canadian seed catalogue Index (Seeds of Diversity Canada) – https://seeds.ca + search for "Canadian seed catalogue index" (an extensive list of Canadian companies supplying garden seeds; however, primrose is not well represented)

National auricula and primula society – http://www.auriculaandprimula.org.uk/ (a British society, presents limited information)

Primula world: A visual reference for the genus primula – https://primulaworld.blogspot.com/ (a very extensive source of photos)

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