The Canadian Botanical Association Bulletin

Bulletin de l'Association Botanique du Canada

Vol. 49 Number 3 December/décembre 2016



Crested Wheatgrass Spike, ©M. Lavin, CC-BY-SA-2.0. See article on page 93

Highlights in this issue:

2017 Call for Awards page 80

Top Ornamental Plants: Begonia page 86

Invasive Species: Crested Wheatgrass page 93

In this issue:

President's Message 75

Announcements 77

Call for Applications to the CBA-ABC Special Project Fund 79

Call for Nominations and Applications for 2017 CBA/ABC Awards 80

2017 CBA Conference Field Trips 81

Past Meeting Locations of the CBA/ABC 83

Teaching Section News 84

Plant Development Section News 85

Top Canadian Ornamental Plants. 15. Begonia 86

Major Invasive Alien Plants of Natural Habitats in Canada. 15. Crested Wheatgrass 93

New Book: Cannabis, a Complete Guide 100

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 web site: www.cba-abc.ca

EDITOR

Dr. Tyler Smith
K.W. Neatby Building, 960 Carling Avenue
Ottawa ON, K1A 0C6
cba.abc.bulletin@gmail.com

Published in Peterborough, December 12th 2016
ISSN 0008-3046 (paper)
ISSN 1718-8164 (electronic)

NEXT ISSUE

Texts for the next issue, 50(1) , must be received by March 1, 2017

Unless otherwise stated, all content is released under the Creative Commons Attribution Share-Alike 4.0 license. Copyright remains with the authors.

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 l'ABC.

SOUMISSION DE TEXTES

Tous les membres de l'Association sont invités à envoyer des textes de toute natureconcernant 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 l'ABC à l'url suivant: www.cba-abc.ca

RÉDACTEUR

Dr. Tyler Smith
K.W. Neatby Building, 960 Carling Avenue
Ottawa ON, K1A 0C6
cba.abc.bulletin@gmail.com

Publié à Peterborough, le 12 decembre 2016
ISSN 0008-3046 (papier)
ISSN 1718-8164 (électronic)

PROCHAIN NUMÉRO

La date de tombée des textes du prochain numéro, le no 50(1) , est le 1 mars 2017

President's Message

Hopefully this issue of the Bulletin finds you well and looking forward to a more relaxing period over the Christmas holidays ahead. As the year has advanced into December already, it has provided an opportunity to reflect on the year that was, and to look ahead to 2017.

Since publication of the September 2016 issue of the Bulletin, the months of August and September were quite busy for a group (the *ad hoc* Science Policy Committee) of dedicated members who volunteered to formulate a position paper for CBA-ABC in response to the call from Canada's Fundamental Science Review. This document was submitted to the Review panel before the end of September, and has been posted to the CBA-ABC website (www.cba-abc.ca) for the past few months. There was a lot of back-and-forth discussion throughout the late summer and early autumn that led to completion of this document, and I gratefully thank these members who rose to this challenge, on our behalf: Prof. Phil Burton, Prof. Cindy Ross-Friedman, Ms. Laura Super, Prof. Emeritus Iain Taylor, and Prof. Liette Vasseur. We look forward to potential discussions with the Review panel's members and the outcomes of this review process.

In many ways, autumn 2016 was different for me owing to a 6-month sabbatical. Thus, the period of July onward provided a chance to concentrate on a new research project, and the writing of a book chapter and some papers. But, looking back, one of the highlights without doubt was an intensive 2-day workshop spent at the Royal Botanical Gardens (RBG), Burlington, Ontario, devoted to the Identification of Asters and Goldenrods [expertly and enthusiastically led by Dr. James Pringle and Nadia Cavallin (new CBA-ABC Director, East)]. My interests were fueled by these taxa serving as excellent late-summer sources of floral nectar for bees and other insect pollinators across Canada, and we used "Cultivated and Native Asters of Ontario (Compositae: Astereae)" (2002) by J.C. Semple, S.B. Heard, and L. Brouillet (Luc having been awarded the CBA-ABC's Lawson Medal in May), as our taxonomic resource. I can definitely concur with Asa Gray's quotation about the identification of this difficult group that appears on the handbook's inside cover: "If you hear of my breaking down utterly, and being sent to an asylum, you may lay it to *Aster*, which is a slow and fatal poison." (Enough said!).

Having grown up just outside of Hamilton, I had visited the RBG many times as a youngster, thanks to my parents. My family held a membership and frequented the grounds, with my mother serving as an instructor of flower arranging, among other activities. Indeed, during my undergrad years, I was even employed one summer as a gardener at the Arboretum and as an interpreter, on weekends, at Rock Chapel, nearby. But that September workshop had marked my first return to the RBG in well over a decade, regrettably.

In this photo taken at the Gardens by my dad in 1962, my older brother Pete is showing me something noteworthy. It seemed a fitting image for this president's message because sadly my father passed away in mid-November, following a 3-month illness. Thus, this photo has served to reinforce



Pete Davis introducing brother Art to the world of botany, 1962

in me that although we're never too old to expand our botanical knowledge base, through the various public gardens, city parks, and other green spaces around us, we continually need to connect those extremely important habitats with our younger generations, be they our own children, grandchildren, or members of the general public. As mentioned above, besides their exceptional educational value, these places even provide an important source of student employment, particularly during the summer months.

It takes a fair amount of courage to put oneself in the line of fire of good botanical questions from students and the public, for which I find continual humility while often fumbling for even basic answers. There seem to be so many queries for which I simply do not have a clue. But I find it helps to remember that there are over 250,000 angiosperm species alone, and so there's always going to be more to learn. We all have an important role to play in passing our knowledge about and enthusiasm for plants, to others. And these efforts typically can be performed without any great hardship or hefty financial burden. Maybe it can serve as a New Year's resolution for each of us to deliver one more presentation or guided tour for children or youth during 2017, to fulfill that educational need.

One such opportunity around the corner will be the annual "Fascination of Plants Day" which occurs on May 18, 2017 (or, if that day proves unsuitable for activities, anytime from May 3-31, 2017). Following the lead of some of our colleagues at the University of British Columbia who participated in 2016, we should all try to promote the wonders of plants on our Canadian university and college campuses, for example. I anticipate it will be a lot of fun, and let's be sure to take some photos that can be posted later at our CBA-ABC website.

Something new for the CBA-ABC in 2017 is the inaugural announcement (please see page 79) about the Special Project Fund, an initiative arising during the presidency of John Markham. Also, see page 80 for the annual call for nominations for the CBA-ABC's Major Awards (Lawson, Elliott, Magister) and the announcement and variable deadlines for spring 2017's many CBA-ABC Student Awards. Let's aim

to submit many applications for the Fund and these various awards.

Moreover, following on from the Annual Meeting of CBA-ABC at the University of Victoria last May, please remember to mark your calendar now for the 2017 meeting from July 4-8 at Wilfrid Laurier University. As chairperson of the local organizing committee, Vice-President Frédérique Guinel has been working diligently with her team on our behalf, to prepare a stimulating and educational conference next summer in Waterloo, Ontario.

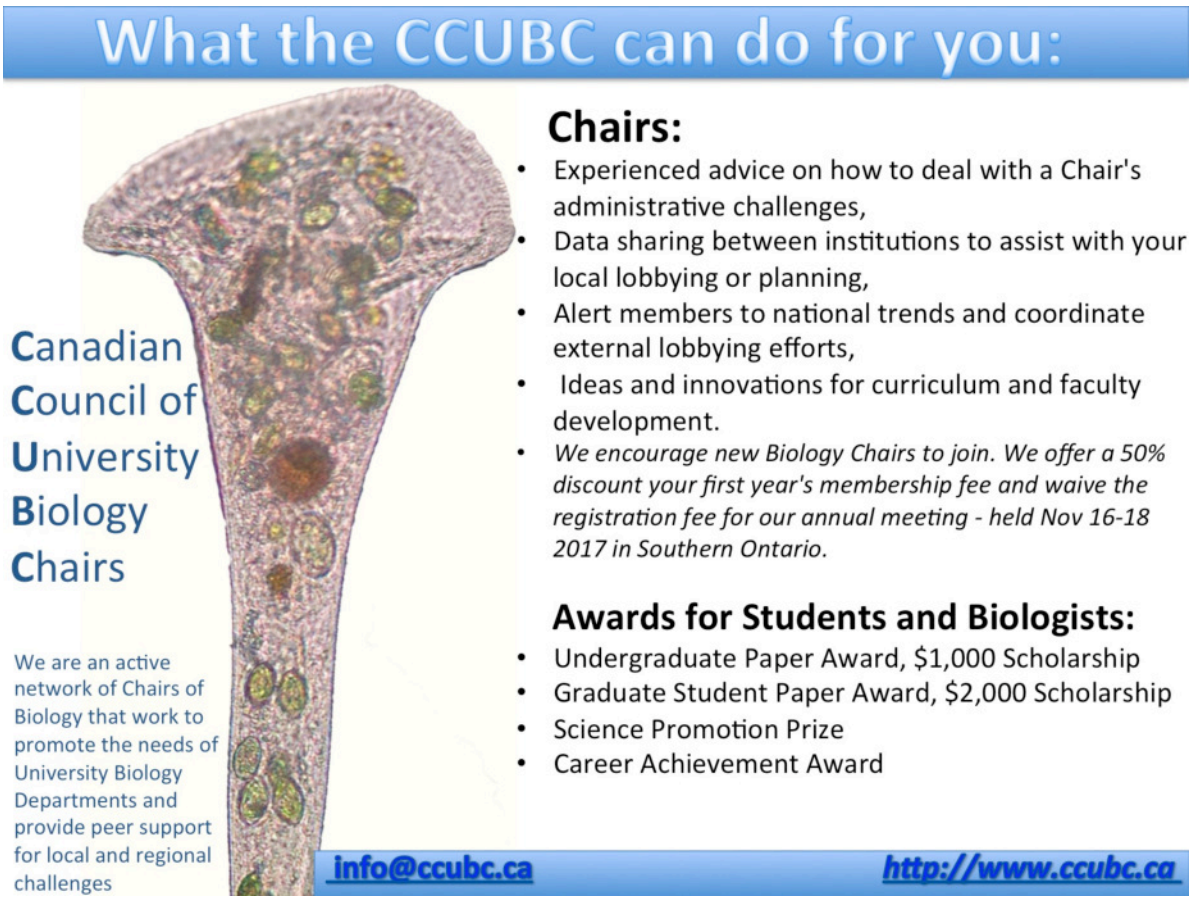
Also in that same vein of looking ahead, we are presently without a confirmed venue for the 2018 Annual Meeting. Accordingly, if you and your associates are considering that possibility to host during summer 2018, please contact a member of the CBA-ABC Executive soon so that we could bring that possibility to our discussions at the January 2017 teleconference. To help guide proposals for the association's meeting places into the future, Frédérique has compiled a comprehensive list of past venues for CBA-ABC annual meetings (please see page 83).

Sorry, this got a little lengthy and it's time to throw in the trowel … Wishing you the very best for a Happy New Year in 2017!

Respectfully,



Art Davis, University of Saskatchewan



ANNOUNCEMENTS

Job Opportunities

Part-time Plant Research Technician

The **San Antonio Botanical Garden**, a member of the Center for Plant Conservation network for over 30 years, is currently seeking a part time Plant Research Technician. If you are interested in this position, please apply following the instructions below. Please feel free to pass the information on to anyone you think may be interested.

JOB RESPONSIBILITIES

Specific job responsibilities include, but not limited to:

- Botanical Garden liaison with the Center for Plant Conservation (CPC).
- Update the detailed documentation of history of SABG with CPC from 1980 to present.
- Provide current status of CPC program and all plants in plant research
- Properly label all research plants on the SABG property.
- Seed storage per CPC guidelines
- Supervise volunteers working in the plant research program.
- Organization of Plant Research Files
- Propagation and growing of designated plant research material.
- Maintenance of plant research greenhouses
- Coordination of seed collection of designated plant material.

Other:

- Some travel necessary using private vehicle to Lady Bird Research Center in Austin (expenses reimbursable)
- Use of private vehicle for possible seed collection trips (expenses reimbursable)

QUALIFICATIONS

Preferred: Degree in botany or a related field of study that has equipped the applicant with the necessary knowledge, skills and abilities to perform the duties and responsibilities of the position. Equivalent work experience may be acceptable. Applicants should have previous research experience.

This part-time position, open until filled.

For more information, please contact Bob Brackman at (210) 207-3260 or john.brackman@sanantonio.gov.

To apply, please send a letter of interest, resume, and professional references to:

Bob Brackman
San Antonio Botanical Garden
555 Funston, San Antonio, TX 78209

Research Botanist

Applications will be accepted until January 15, 2017.

Position starting date flexible, but as early as February 1, 2017.

Marie Selby Botanical Gardens invites applications for a full-time position of Research Botanist. The primary function of the job will be to conduct an integrated research program on a vascular plant family rich in epiphytic species in the New World tropics. The researcher will utilize modern and traditional methods such as comparative morphology, molecular systematics, floristics, and informatics, with the ultimate goal of understanding, and conserving plants and their natural habitats. Geographical areas of particular interest are the Caribbean, Central America, and the Andes.

A Ph.D. in plant systematics or closely related field is required for this position, and postdoctoral experience is preferred. A history of raising funds from foundations, government agencies, or other grantors is desirable. The successful candidate will maintain an active research program as measured by scientific peer-reviewed journal publications, grant-funded proposals in support of research, development and curation of the Gardens' living and preserved collections, contributions to the Gardens' outreach activities, and dissemination of research at professional meetings. They must also serve in an editorial capacity for the Gardens' scientific publication, Selbyana, assist in the organization of symposia and other meetings, and participate in intern- and university-level student education. Good public speaking ability is desirable. The successful candidate will interact with Selby Gardens' administration, staff, donors, volunteers, and members to assist in raising funds and promoting the work of botanical science.

To apply, please collate the following into a single PDF file and send to careers@selby.org.

- 1-page cover letter
- Curriculum vita
- Names and addresses of three references

Marie Selby Botanical Gardens is a drug free workplace and an equal opportunity employer.

ANNOUNCEMENTS

Eagle Hill Botany Field Courses

The Eagle Hill Institute (formerly the Humboldt Field Research Institute), located on the eastern coast of Maine, is offering a full slate of field courses in 2017. These one-week field courses are aimed at keen amateurs, students, and consulting professionals. The instructors include nationally and internationally recognized experts. University students can receive course credit. The 2017 schedule includes:

LICHENS

- Crustose Lichens of the Acadian Forest
- Undergraduate Field Studies: Introduction to Bryophytes and Lichens
- Lichens and Lichen Ecology
- Lichens, Biofilms, and Stone
- Independent Studies: Interesting and Challenging Saxicolous Lichens of North America

COMMUNITY ECOLOGY

- Undergraduate Field Studies: Marine Intertidal Community Ecology
- Bogs and Fens: Maine Peatlands
- Wetlands Identification and Delineation
- Tidal Marsh Restoration: A Traveling Course from Rhode Island to Maine

BRYOPHYTES

- Mosses: Structure, Ecology, and Identification
- Liverworts and Liverwort Ecology

MYCOLOGY

- Boletes and Other Fungi of New England
- Mushroom Identification for New Mycophiles: Foraging for Edible and Medicinal Mushrooms

VASCULAR PLANTS

- Exploring Medicinal Plants of Maine (and Beyond)
- Sedges and Rushes: Identification and Ecology
- Survey of Grasses: Their Structure, Identification, and Ecology
- Submersed and Floating Aquatic Plants
- Field Botany and Plant Ecology of the Eastern Maine Coast
- Identification, Biology, and Natural History of Ferns and Lycophytes

For course details and schedule, see the Eagle Hill website: www.eaglehill.us/programs/nhs/nhs-calendar.shtml.

Participants Needed For Research in Museum Educator Professional Learning

We are looking for volunteers to take part in a study of the professional development patterns of Canadian museum educators.

As a participant in this study, you would be asked to fill in an online survey questionnaire. Survey participants may also choose to be contacted for a telephone interview.

Your participation is entirely voluntary and survey completion would take up approximately 10 minutes of your time. Telephone interviews will also take up approximately 15 minutes of your time, and will be held between November 15 and December 31, 2016. By participating in this study you will help us to better understand the factors that impact Canadian museum educators in their pursuit of lifelong learning.

In appreciation for your time, survey participants will be entered to win a $50 Visa gift card. Participants selected for interview will be entered to win an additional $50 Visa gift card.

To learn more about this study, or to participate in this study, please click the link below:

rsurvey.athabascau.ca/limesurvey/index.php?sid=71479&lang=en

PRINCIPAL INVESTIGATOR

Chett Bradley

chettb@yahoo.com

SUPERVISION

Dr. Debra Hoven

1 866-441- 5517

debrah@athabascau.ca

This study has been reviewed by the Athabasca University Research Ethics Board.

Botanical Artists of Canada Exhibition

We are pleased to let you know that the annual juried exhibition of the Botanical Artists of Canada will be held at Wilfrid Laurier University in conjunction with the CBA Annual conference. The theme is "A Celebration of Canada's 150th Anniversary' through its Native and Indigenous plants". The Botanical Artists of Canada will be presenting a Juried Botanical Exhibition of Paintings and Drawings depicting native and indigenous plants of Canada. The exhibition will celebrate the existence, beauty, uniqueness and diversity of Canada's native and indigenous plants (including fungi) and inform the public of how our native plants sustain our lives, our habitat and the natural world.

Exhibition dates: July 5 to 26, 2017

Venue: Robert Langen Art Gallery, Wilfrid Laurier University, Waterloo campus

Interested CBA members are invited to submit to the exhibition in accordance with the BAC Call for Entry which will be posted by the 31st of December, 2016 on the BAC website www.botanicalartistsofcanada.org and on our Facebook Page www.facebook.com/BotanicalArtistsOfCanada

Call for Applications to the CBA-ABC Special Project Fund

Art Davis, President, CBA-ABC

The following outline of the Special Project Fund is based on several sources, including i) discussions during the CBA-ABC Board's teleconference in January 2016, ii) the minutes (January 21, 2016) prepared from that discussion, and iii) the motion (M. Jones/F. Guinel), and unanimous recommendation by delegates, for implementation of a Special Project Fund at the CBA-ABC's Annual General Meeting held at the University of Victoria, BC, on May 18, 2016.

Significant, initial ideas about the Fund were advanced by John Markham during his CBA-ABC presidency, and I thank John (Past-President) and Julian Starr (President-Elect) for their comments and guidance of the Fund description and terms of reference, including suggested application date and funding level, thereby allowing its inaugural call for applications.

*Accordingly, applications are now invited (**deadline for receipt is February 1, 2017** to art.davis@usask.ca) for consideration of funding from the CBA-ABC Special Project Fund. Please note that this year's Fund will provide a maximum of $1,000. The CBA-ABC Awards Committee's decision will be announced to applicants by March 1, 2017.*

CBA-ABC Special Project Fund

Explanation of the fund: The CBA-ABC is financially sound and has a mandate to promote botany in Canada. The purpose of the Special Project Fund is to support botanists, promote botanical research and education, and to raise the profile of the CBA-ABC.

Potential uses of the Special Project Fund include:

- Travel support for research early in a graduate student's program.
- Support of publically accessible botanical resources, including collections.
- Botany education projects.
- Seed money to support collaborative research initiatives among labs.

Funding level and applicant eligibility: Each year up to half of the CBA-ABC's profits from its annual meeting will be available for the Special Project Fund. The funding level for the award will normally be recommended at the Incoming Board meeting, but ideally will be a minimum of $1,000 per year and ultimately decided by the CBA-ABC Executive. Applicants must be CBA-ABC members in good standing. Applicants are eligible for funding in subsequent years, but priority will be given to new applicants.

Adjudication: The CBA-ABC Awards Committee will make award decision(s) from the applications received by the annual deadline (e.g., February 1st) posted with the annual call for applications, in the CBA-ABC Bulletin. Awards will be judged based on the following criteria:

- Support of CBA-ABC student members in need.
- Provision of funding to CBA-ABC members for projects that lack other funding sources.
- Raising the profile of the CBA-ABC.
- Providing outreach to the general public.

Application procedure

An application shall include:

- Name and position of the applicant.
- A brief (one page) description of the project.
- A budget, including a description of other funding sources.
- A description of how the project relates to the award criteria listed above.
- A plan for disseminating the results of the project.

Article for CBA-ABC Bulletin: Within 12 months of receipt of funds from the Special Project Fund, award recipient(s) shall submit a formal one-page report about their project and its outcomes, for publication in the CBA-ABC Bulletin.

Call for Nominations and Applications for 2017 CBA/ABC Awards

Each year the Canadian Botanical Association / L'Association Botanique du Canada provides awards to botanists studying in Canada, and/or to Canadian botanists studying abroad. Many of the awards are available to non-Association members. Applications and nominations are now open for the following:

CBA-ABC Major Awards

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

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

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

For more information about these major CBA-ABC awards, please see www.cba-abc.ca

Nomination deadline: February 28, 2017.

CBA-ABC Student Awards

PUBLISHED PAPERS

These awards are given to students for a paper they have published in the last year:

Porsild-Consaul Award, $1000: awarded for the best paper in phytogeography or systematics.

Stan Rowe Award, $500: awarded for the best paper in plant ecology (see below for additional details).

Taylor Steeves Award, $500: awarded for the best paper in plant development or structure (see page 85 for additional details).

Luella Weresub Award, $1000: awarded for the best paper in mycology or lichenology.

Application deadline: April 15, 2017.

FOR PRESENTATIONS AT THE ANNUAL CBA-ABC MEETING

Lionel Cinq-Mars Award, $500: awarded for the best oral presentation.

Iain and Sylvia Taylor Award, $500: awarded for the best poster presentation.

Application deadline: May 1, 2017.

FOR TRAVEL TO PARTICIPATE AT THE ANNUAL CBA-ABC MEETING

These awards provide modest funds to assist travel costs by graduate (**Macoun Travel Bursary**) or undergraduate (**Winterhalder Travel Award**) students presenting talks or posters at the annual CBA/ABC meeting.

Value: $150-500

Application deadline: May 1, 2017.

FOR RESEARCH TRAVEL RELATED TO CANADA'S NORTH

Laurie Consaul Northern Research Scholarship, $1000

Application deadline: February 28, 2017.

For further information and the application procedures for these CBA-ABC student awards, please see www.cba-abc.ca.

Stan Rowe Award Plant Ecology Award

This award was established to celebrate the life and work of Stan Rowe, eminent Canadian Plant Ecologist. Student award winners receive a one year membership in the Canadian Botanical Association, along with a $500 prize.

CRITERIA OF THE AWARD:

- Subject related to plant ecology – Canada
- Important field component
- Based on work done within a graduate degree
- Published within 2 years of graduation
- The paper must have been published during the year preceding the annual meeting of the CBA/ABC
- Students do not have to be CBA members to be eligible.
- No candidate may submit a paper for more than one CBA award.

To apply submit to Nicole Fenton (Nicole.fenton@uqat.ca) or André Arsenault (andre.arsenault2@canada.ca):

- CV including current address and email;
- Letter of presentation highlighting your role in the study and paper, with supporting letters from the other authors;
- Letter of support from your supervisor indicating that the work was undertaken as part of a graduate program;
- A copy of the paper or proof of the paper plus a letter from the editor of the journal stating that the paper is in press within the eligible publication date.

The Judging Committee reserves the right to make no award if submissions are not considered of sufficiently high quality, or to share the award between two applicants if their papers appear to be of equal merit. The winner will be notified, and the award will be presented during the Annual Meeting of the CBA, the winner is encouraged to attend.

2017 CBA Conference Field Trips
Inglis Falls and Bruce Peninsula National Park

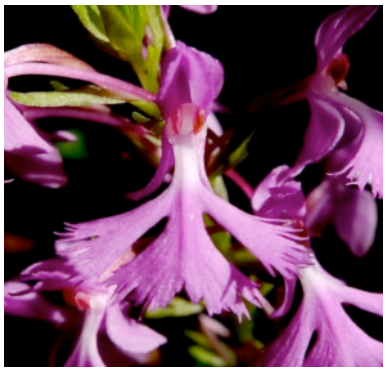



This will be a full-(and long!) day trip for the botanist who is willing to put up with a long drive to see many habitats and plant species. Inglis Falls is located south of Owen Sound, at the base of Bruce Peninsula, and besides the attraction provided by the cascade formed by Sydenham River, it has a unique limestone karst geology, with glacial potholes and crevices that provide a habitat for a high diversity of ferns, including *Asplenium scolopendrium* var. *americanum* and *A. rhizophyllum*. Bruce Peninsula National Park is found at the tip of the peninsula and it is one of the floristic gems of Ontario and Canada in general. This is because in a relatively small area, Bruce has an unusually rich diversity of habitats: mixed forests, alvars, rocky cliffs, sand dunes, fens, and bogs. Most of the day will be spent botanizing at "Singing Sands", on the shore of Huron Lake. There will be plants to satisfy all the botanical desires: from gorgeous orchids, strange carnivorous and parasitic plants, to technical sedges and grasses. The field trip will end with a visit to beautiful "Little Cove", on the shore of Georgian Bay. For a visual sampling of the flora please go to Phytoimages (http://www.phytoimages.siu.edu/); type "Bruce Peninsula" in "Key words or locality", hit "search", and then browse the images by family.


Lonicera dioica


Utricularia cornuta


Lilium philadelphicum


Platanthera psycodes


Cypripedium reginae

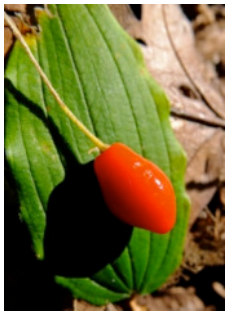

Pogonia ophioglossoides

2017 CBA CONFERENCE FIELD TRIPS
American Ginseng experimental plots and Backus Woods

This day-long trip will be composed of two parts. We will first visit the experimental plots of American ginseng (*Panax quinquefolius*) from St-Williams, Norfolk Co., where researchers from OMAFRA attempt to find cultivation solutions for a number of soil diseases that attack ginseng roots. Then, we will continue to Backus Woods, located at ca. 20 km north of Port Rowan and Long Point Provincial Park. Backus Woods include some spectacular remnants of old-growth Carolinian forest, which have been recently granted a World Biosphere Reserve status. Carolinian trees and shrubs will be seen, including towering specimens of tulip tree (*Liriodendron tulipifera*), sassafras (*Sassafras albidum*), eastern flowering dogwood (*Cornus florida*), and black gum (*Nyssa sylvatica*). Backus Woods still contains vegetative specimens of sweet chestnut (*Castanea dentata*), nearly wiped out in North America by the chestnut blight (*Cryphonectria parasitica),* as well as the endangered butternut (*Juglans cinerea*). Among the many herbaceous plants worth mentioning are: the beechfern (*Phegopteris hexagonoptera),* yellow mandarin (*Prosartes lanuginosa*), and horse balm (*Collinsonia canadensis*). Interspersed among the forest stands are a few well-conserved tallgrass prairie areas dominated by *Schizachyrium scoparium*, *Monarda fistulosa* and *Pycnanthemum virginianum*.



Panax quinquefolius



Prosartes lanuginosa



Pycnanthemum virginianum

Grand River Rafting Trip, Paris, Ontario

This is a 3-4 hour guided rafting tour on a slow moving section with easy rapids of the Grand River. The trip is a scenic 13 km that starts at the Paris Dam, Paris, and ends at the Brant Conservation Area, Brantford. It features a panoramic view of the Grand River Valley and includes various activities, such as visiting a gypsum mine from 1830, drinking from springs, seeing a nesting area for Blue Herons, hiking to a lookout where we learn about edible plants and First Nation's history, and having lunch overlooking the valley. Participants will also have a chance to observe the aquatic vegetation on the Grand River. This tour is ideal for first time paddlers and non-swimmers; however, there are numerous swim spots as well as a 400-meter body surf spot along the river for those who are more adventurous.

PAST MEETING LOCATIONS OF THE CBA/ABC

1965: Carleton University Ontario

1966*: University of British-Columbia (with CSPP & CPS) British Columbia

1967: University of Ottawa Ontario

1968: Lakehead University Ontario

1969*: University of Washington, Seattle (with IBC)

1970*: Laval University (with CSPP) Québec

1971*: University of Alberta, Edmonton (with AIBS) Alberta

1972*: Dalhousie University, Halifax (with CSPP) Nova Scotia

1973: University of Western Ontario, London Ontario

1974*: University of Arizona, Tempe (with BSA)

1975*: University of Saskatchewan, Saskatoon (with ESC & CPS) Saskatchewan

1976: Bishop's University, Lennoxville Québec

1977*: University of Manitoba, Winnipeg (with GSC & CTIA) Manitoba

1978: Memorial University Newfoundland

1979: Carleton University Ontario

1980*: University of British-Columbia (with BSA) British Columbia

1981: University of Guelph Ontario

1982*: University of Regina (with CSPP) Saskatchewan

1983*: University of North Dakota (with AIBS)

1984: University of New Brunswick, Fredericton New Brunswick

1985*: University of Western Ontario, London (with BCC) Ontario

1986: Laurentian University, Sudbury Ontario

1987: Université de Montréal Québec

1988*: University of Victoria (with CSPP) British Columbia

1989*: Toronto (joint with AIBS) Ontario

1990: University of Windsor Ontario

1991: Edmonton Alberta

1992: Truro Nova Scotia

1993*: Ames, Iowa (joint with AIBS)

1994: University of Calgary Alberta

1995: University of Guelph Ontario

1996: University of Prince-Edward Island PEI

1997*: Université de Montréal (with BSA) Québec

1998: University of Saskatchewan, Saskatoon Saskatchewan

1999*: St. Louis, Missouri (with XVI IBC)

2000*: University of Western Ontario (with CSPP) Ontario

2001: Okanagan University College, Kelowna British Columbia

2002*: Madison, Wisconsin (with BSA)

2003*: St. Francis Xavier University (with Plant Canada) Nova Scotia

2004: University of Manitoba, Winnipeg Manitoba

2005: Plant Canada 2005, Edmonton Alberta

2006: Concordia University, Montréal Québec

2007: Plant Canada 2007, Saskatoon Saskatchewan

2008*: Vancouver (with BSA, ASPT, AFS) British Columbia

2009: Acadia University, Wolfville Nova Scotia

2010*: University of Ottawa (with SPNHC) Ontario

2011: Plant Canada 2011, Halifax Nova Scotia

2012*: Columbus, Ohio (with BSA)

2013: Thompson Rivers, Kamloops British Columbia

2014: Montreal Botanical Garden Québec

2015*: Plant Canada 2015, Edmonton (with BSA and others) Alberta

2016: University of Victoria British Columbia

2017: Laurier University Ontario

2018: ?

Co-hosts

AFS: American Fern Society

AIBS: American Institute of Biological Sciences

ASPT: American Society of Plant Taxonomists

BCC: Biological Council of Canada

BSA: Botanical Society of America

CPS: Canadian Phytopathological Society

CSPP: Canadian Society of Plant Physiologists

CTIA: Canadian Tree Improvement Association?

ESC: Entomological Society of Canada

GSC: Geological Survey of Canada

IBC: International Botanical Congress

SPNHC: Society for the Preservation of Natural History Collections

Meetings By Province

Canadian Province	Years as Host
British Columbia	7
Alberta	5
Saskatchewan	4
Manitoba	2
Ontario	14
Québec	6
New Brunswick	1
Newfoundland	1
Nova Scotia	5
Prince Edward Island	1
U.S.A. (joint meeting)	7

TEACHING SECTION NEWS

Botanical Teaching Workshop

Please join the Teaching Section's Botanical Teaching Workshop at this year's annual meeting of the Canadian Botanical Association/L'Association Botanique du Canada (CBA/ABC) at Wilfrid Laurier University, Waterloo, ON, (July 4 – 8, 2017). We invite participants and presenters! Come try or share new or tried and tested lab, field, classroom or even outdoor activities and have fun exploring and experiencing new ways to engage students in the world of botany. We invite new and experienced instructors and extend a special invitation to graduate and undergraduate students! All presenters and participants will leave the Botanical Teaching Workshop with valuable feedback and new ideas to continue to transform the teaching of botany. Contributions in English and French are welcome. Les conférenciers et conférencières sont également invités à offrir les contributions en français.

DATE

The BTW Session will be held on: Thursday, July 6th, 2017, 5:00 – 6:30 PM.

SESSION FORMAT AND GUIDELINES

The Botanical Teaching Workshop will consist of approximately 15 teaching demonstrations that will be simultaneously presented over 1.5 hours. Each teaching demonstrations should be around 5 – 10 minutes in length and will be presented repeatedly as people move around the various lab benches.

These demonstrations are an opportunity to share effective approaches to teaching botany. They are not strictly limited to presentations about teaching in a laboratory setting. They may be presented as a demonstration, computer laboratory, classroom or field activity.

Presenters should supply their own materials, including handouts, and are responsible for all conference and travel costs. The conference host can provide general lab equipment (i.e. glassware and microscopes) on request. If you have questions regarding equipment or supplies, contact the Teaching Section co-chairs.

Please fill out the BTW submission form at right and send directly to the Teaching Section co-chairs:

Christine Petersen cpetersen@tru.ca
Rafael Otfinowski r.otfinowski@uwinnipeg.ca

BOTANICAL TEACHING WORKSHOP SUBMISSION

Name

Institution

Years of teaching experience (<1, 1-5, 5-10, >10)

Teaching Activity Title

Brief Abstract (140 words)

Equipment list needed (Microscopes can be provided)

Plant Development Section News

Thirteen members from the universities of British Columbia, Dalhousie, Lethbridge, Montréal, Prince Edward Island, Saskatchewan, Waterloo, and Wilfrid Laurier attended the lunchtime meeting of the section at the CBA/ABC annual meeting in Victoria, BC, May 15-18, just after an excellent section-sponsored symposium on Vascular Development and Function, organized by Co-Chair (now Chair) Simon Chuong (University of Waterloo). The 2016 symposium featured three researchers presenting their latest research updates on vascular development. Dr. Enrico Scarpella (University of Alberta) and Dr. Elizabeth Schultz (University of Lethbridge) focused on the molecular controls of leaf vein pattern formation. Dr. Brian Byung-Kook Ham (University of California, Davis) described the role of the vascular system in mediating the long-distance translocation of proteins and RNAs. Unfortunately, there were no submissions for the Taylor Steeves Award for the best student paper in plant development, structure or morphology, so no prize was awarded at the annual meeting in Victoria. Several previous competitions have required actively contacting members or non-members who conduct research in plant development to solicit applications, and this was not done in 2015-2016.

Taylor Steeves Award Plant Development Award

Students conducting research in plant development, structure or morphology are encouraged to submit applications for this award. The award honours Taylor A. Steeves (1926-2011), whose many research and teaching accomplishments and contributions to the CBA were remembered in the December 2011 Bulletin (Vol. 44, No. 3). For further information or to submit applications or nominations, please contact Simon Chuong (University of Waterloo, email below).

Complete applications should be received by April 1st 2017. A complete application consists of:

- a copy of the published research (undertaken while the candidate was a student)
- the candidate's curriculum vitae
- a statement indicating that the candidate is enrolled in a degree program, or has completed the relevant degree program
- separate statements from the candidate, supervisor and any co-authors indicating the contributions made by each to the final publication.

It should be noted that terms of this award require eligible students have graduated from or are currently enrolled in a Canadian University. The judging committee considers originality, scientific significance, presentation and use of language. The judging committee consists of the Chair of the Plant Development section and two others. Any members interested in serving as judges should contact:

Simon Chuong, schuong@uwaterloo.ca
Department of Biology, University of Waterloo

Moira Galway, mgalway@stfx.ca
Department of Biology, St. Francis Xavier University

Top Canadian Ornamental Plants. 15. Begonia

Ernest Small[1,2]



Figure 1: Mixed tuberous begonias in a planter. ©KENPEI (CC BY SA 3.0).

Begonia lovers are sometimes affectionately termed "begoniacs," an indication that the flowers are attractive to the point of addiction. Along with petunias, impatiens, marigolds, and geraniums, begonias rank among the top five bedding plants grown for floral display, not only in Canada but in the entire Northern Hemisphere. Begonias also are considered to be among the most popular houseplants. The 15,000 or so begonia hybrid cultivars are astonishingly diverse, because hybridization is easy, and there are over 1,500 wild species providing breeding material. The floral cultivars are dazzlingly beautiful, the same is true of the foliage cultivars, and the colourful displays last for months. Moreover, most varieties are adapted to shade, where only a minority of ornamentals thrive.

Names

Scientific names: The genus name *Begonia* commemorates Michel Bégon (1638–1710), a French administrator [intendant of San Domingo (western part of the island of Haiti) and governor of French Canada], and an amateur botanist known for collecting "curious, useful and pleasant plants."

English names: Begonia.

French names: Bégonia, bégonie.

Wild *Begonia* species

Taxonomy & distribution

The Begoniaceae family is made up mostly of the genus *Begonia*, but it also includes the genus *Hillebrandia*, which has only one species, *H. sandwicensis*, named for the Sandwich Islands (now known as the Hawaiian Islands). Older literature, however, recognizes several other genera in the family.

Begonia is considered to be the fifth or sixth largest genus of flowering plants, with estimates ranging from 1,500 to 2,000 species. The primary center of diversity of this pantropical genus is the Neotropics (Mexico to Argentina), where about 700 species occur. A second center of diversity is in southcentral and southeastern Asia, with about 650 species. About 160 species are native to the southern, southeastern, and western parts of Africa. The Asian and American species are thought to have arisen from the African species. *Begonia* species are frequent in tropical and subtropical regions, usually in shady locations in forested areas, from sea level to 3,000 m (32,800 feet). Most occur in moist, humid microhabitats, although some are adapted to quite dry situations.

Morphology

Most begonias are perennials, but some are annuals, and in temperate regions the perennials are normally grown as annuals. Most are small or medium-sized, ranging from under 5 cm to over 2 m. Most are herbaceous with succulent juicy stems, but some develop soft-wooded stems. A few are vine-like (described as "climbing," "trailing" or "hanging"), sometimes over 5 m in length. Some are epiphytes that live entirely on trees, the roots never reaching the ground. Most

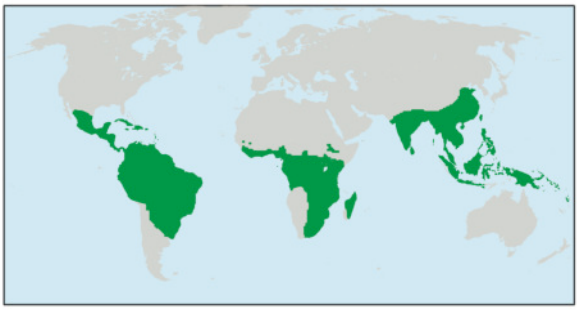


Figure 2: Geographical distribution of *Begonia* species.

[1]Science and Technology Branch, Agriculture and Agri-Food Canada, Saunders Bldg., Central Experimental Farm, Ottawa ON, K1A 0C6
[2]©Government of Canada. Verbatim redistribution for personal, non-commercial use is permitted.



Figure 3: Wing-like leaves often formed by begonias. Also note asymmetrical leaf bases. **Left:** Begonia 'Angel Wing' (*B. aconitifolia* × *B. coccinea*). ©Yercaudelango (CC BY SA 4.0). **Right:** Begonia 'Dragon Wing Red' (*B.* × *hybrida*). ©Kenpei (CC BY SA 2.1 JP).

are rooted in the ground, and the underground part is usually a thick rhizome or, less often, a tuber, from which fibrous roots arise. Although virtually all begonias have fibrous roots, so-called "fibrous-rooted begonias" refers to plants lacking well-developed rhizomes or tubers. The base of the leaves is characteristically asymmetrical, and leaves may be less than 2 cm to over 50 cm in length. *Begonia thiemei* of Mexico and Honduras has petioles as long as 1 m. Wild begonias produce unisexual male and female flowers that are predominantly white, but may be pink, red, orange, or occasionally yellow. Most plants bear both male and female flowers, but some species produce plants with male flowers, others with female flowers. Usually male but not female flowers produce nectar, the female flowers deceitfully attracting pollinators by virtue of their resemblance to the male flowers. Pollination has not been extensively studied in wild plants, and the extent to which pollinators and wind are significant pollen vectors is unclear. Domesticated species are self-pollinating. The fruit is usually a dry capsule, but is occasionally fleshy and berry-like. There may be hundreds of tiny dust-like seeds in the capsules. Seeds are distributed by animals, wind, gravity and rain drops (by the "splash cup syndrome").

Domesticated *Begonia* species

Begonia appears to have been first cultivated at the Royal Botanic Gardens at Kew in 1777. By the mid-19th century, species from the West Indies, Mexico and South America were being grown in Europe, and hybrids were being created. Hybridization has continued to this day, although the parentage of most cultivars has been poorly documented. The international horticultural trade does not utilize the scientific taxonomies of *Begonia* that have been proposed, but instead employs an artificial classification popularized by the American Begonia Society (which incorporated the Canadian Begonia Society). The following simplified presentation summarizes the most important of these arbitrary cultivar groups. Uncommonly cultivated form-classes, not discussed, include shrub-like, thick-stemmed, cane-forming, and trailing or climbing begonias. As is the case for many ornamental species, the artificial horticultural classes of cultivars that are recognized are sometimes difficult to recognize because inter-group cultivars have been generated.

The different groups of begonia have different cultural requirements, but since most species come from tropical and semi-tropical regions, they can only be grown outdoors year-round in subtropical and tropical climates. In temperate climates such as Canada, begonias are grown outdoors as annuals, or indoors as house plants. Most begonias need warm temperatures, semi-shade, and a well-drained soil that is maintained semi-moist (this applies both to bedding plants and indoor potted plants). Recommended soils are rich in organic matter, and supplemental inorganic fertilization should not be excessive. Although begonias are adapted to shade, moderate light is usually necessary to prevent legginess.

A. Wax Begonias (*Begonia* × *semperflorens-cultorum*)

Wax begonias are the best known kind of begonias. The common name is due to the foliage often having a waxy look. These plants are widely grown by home gardeners, and are often exhibited as mass displays in public gardens and parks. They are so popular as bedding plants that wax begonias are sometimes called "bedding begonias." Wax begonias dominate so-called "fibrous-rooted begonias," and popular articles on begonias sometimes employ the phrase "fibrous-rooted begonias" to refer specifically to wax begonias. In Europe, wax begonias are called "Semperflorens gracilis" (a pseudo-scientific name, cultivar group name, or cultivar name). In the U.S., annual sales of wax begonias are estimated to be worth about $60,000,000. This kind of begonia is believed to have arisen from the crossing in 1878 of two Brazilian species, *B. cucullata* var. *cucullata* (*B. semperflorens*) and *B. schmidtiana*.



Figure 4: Top: Wax begonia beds. ©Zefram (CC BY SA 3.0). **Bottom:** Wax begonia flowers. ©Rosina Peixoto (CC BY SA 4.0).



Figure 5: *Begonia veitchii*, one of the ancestors of modern hybrid tuberous begonias. Source: La Belgique Horticole, journal des jardins et des vergers 29: plate 3-4 (published in 1879).

Wax begonias have somewhat succulent stems, and are bushy and compact, usually less than 30 cm in height. The leaves are glossy, rather rounded or spoon-shaped, sometimes bronzed or brownish ("mahogany"), with some recent cultivars producing variegated leaves and even new leaves that are white. The plants bloom continuously (the epithet *semperflorens* mentioned above means "ever-flowering"), producing numerous small flowers that are red, pink or white depending on the cultivar. Cultivars with semi-double or doubled flowers are available. The plants are perennials in their native habitats, but are widely grown as annuals. Wax begonias are often commercially propagated from seeds (especially single-flowered forms), but begonia seeds are very small, often with about 35,000 seeds per gram (or 1,000,000 seeds per ounce). The seeds are sometimes pelleted to facilitate handling. The tiny seedlings produced are initially quite fragile, and growth is slow, so home gardeners usually buy trays of young plants in plugs. In temperate regions, wax begonias grow well in both full sun (especially bronze-leaf cultivars) and partial shade (but deep shade should be avoided).

B. Tuberous Begonias

Next to wax begonias, tuberous begonias are the most popular kind.



Figure 6: A collection of hybrid tuberous begonias (*Begonia* × *tuberhybrida*). ©James (CC BY SA 2.0).

B1. Hybrid Tuberous Begonias (*B.* × *tuberhybrida*)

This very popular group of hybrids was first developed in the middle and latter 1800s from tuberous-rooted *Begonia* species of the South American Andes (notably *B. boliviensis*, *B. clarkei*, *B. davisii*, *B. pearcei*, and *B. veitchii*). Most cultivars are grown for their blooms. The flowers are generally large (occasionally the size of dinner plates) and colourful, sometimes produced singly (in which case they are large) or in clusters (of smaller blooms), sometimes with frilled tepal margins, in solid or variegated colours. Many cultivars produce doubled male flowers (with stamens transformed to petals), and some specialists remove the less attractive female (single, i.e. non-doubled) flowers. Doubled flowers often resemble roses and carnations. Some cultivars have trailing growth habits, others are bushy or compact. Tuberous begonias are employed as bedding plants, potted plants and hanging baskets. They become dormant during the short days of fall and winter (reflecting their Andean history), and the tubers can be dug up before frost and stored overwinter in a dry cool area, in vermiculite, peat, sawdust or paper. Tubers sprout towards the end of winter, at which time they should be potted indoors and watered, and replanted outdoors when the weather is suitable. Some cultivars are grown from seeds, but more often commercial growers propagate the plants by stem cuttings. Gardeners can purchase dormant tubers (specialist mail-order firms will have the best selections) or young potted plants. Tuberous begonias usually grow best in partial shade, but a few recent cultivars also do well in full sun.

B2. Hiemalis Begonias (*B.* × *hiemalis*, *B.* × *elatior*)

This hybrid species complex arose from crosses of *B. socotrana* (named for Socotra, an island south of the Arabian Peninsula) and hybrid tuberous begonias from Peru and Bolivia. Cultivars are often encountered under the names Rieger begonia and Elatior begonia, and are also referred to as autumn- and winter-flowering begonias. There is a very wide range of cultivars of this group, which are among the most important begonias grown as commercial potted flowering plants. In Europe, the international begonia trade is dominated by this class of begonia. Although the flowers are smaller than most hybrid tuberous begonias, they are produced profusely, usually doubled, and available in many colours. After flowering the stems tend to die back, and because the plants are difficult to recuperate, they are usually discarded. Cultivars are vegetatively propagated commercially by leaf or stem cuttings, as well as by tissue culture.

B3. Lorraine or Christmas Begonias (*B.* × *cheimantha*)

This group originated from crosses between *B. socotrana* and *B. dregei* in 1880. The first cultivar, Gloire de Loraine, is responsible for the common name, Lorraine begonia. Cultivars are commonly called Scandinavian-, Norwegian- and Christmas- begonias (they do flower in early winter).

Like the much more popular hiemalis begonias noted previously, after these plants flower they are difficult to rejuvenate. Also like the hiemalis begonias, they are vegetatively propagated.



Figure 7: Hiemalis begonias (*Begonia* × *hiemalis*). **Left:** A pot of mixed cultivars. ©Tequila (CC BY SA 3.0). **Right:** Begonia 'Karen'. (©Serres Fortier (CC BY 2.0).

C. Rex Begonias

While they do produce flowers, these popular begonias are mainly grown for their often variegated or multi-coloured leaves, which are available in various sizes and shapes. The foliage comes in shades of green, purple red, brown, silver, and pink, often with metallic highlights. The "rex begonia" (*B. rex*) was introduced to Europe from the Himalayas in 1856. It was crossed with Asian species (*B. annulata*, *B. decora*, *B. diadema*, *B. robusta*, *B. tenuifolia*) to produce various hybrid cultivars, under the name *B.* × *rex-cultorum*. Subsequently, additional species from Mexico have been used to produce hybrids. In addition to rex begonia cultivars, some other species are also employed as foliage ornamentals, notably *B. masoniana* (Iron Cross begonia). Rex begonias are usually grown as houseplants, and tend to suffer from overwatering, too much heat, and too little atmospheric humidity. Moistening the leaves should be avoided, and so should use of saucers under the pots, which tend to accumulate water that soaks the soil (putting pots on a layer of stones in which water is placed to increase atmospheric humidity is recommended). Sometimes the plants become semi-dormant in winter, losing many or most of their leaves, in which case watering should be reduced until new growth resumes. The plants do well in moderate heat, and temperatures lower than 21°C (70°F) may induce dormancy.

Edibility and toxicity

In the areas that begonias grow as native plants (Africa, Asia and South America) the plants (especially the leaves) have been employed as a potherb and as a flavourant herb. In Yunnan Province of southern China, the foliage of *B. fimbristipula* is an important herbal tea. Some species contain calcium oxalate crystals in the leaves, which need to be deactivated by first boiling them. Oxalic acid in the plants produces a tart pleasant taste, but as with spinach and rhubarb, large quantities can be toxic, especially for sensitive individuals. Despite its name, *B. deliciosa* from Borneo, which is cultivated as an ornamental, has bitter foliage (some have claimed the flowers are sweet). Dog and cat websites often list ornamental begonias as (mildly) toxic. In Gabon, chimpanzees and gorillas commonly consume *B. mannii*.

Medicinal uses

Both foliage and underground parts of begonias have been rather widely employed in folk medicine, especially in herbal teas in areas where the plants are indigenous. Examples include *B. mooreana* herbal tea to treat stomach ailments in New Guinea, and herbal tea using *B. humilis* and B. *rotundifolia* to treat colds and fevers in South America. Roots and tubers have been employed as emetics and purgatives, suggesting that their edible use is unwise.



Figure 8: Lorraine begonia (*Begonia* × *cheimantha* 'Gloire de Lorraine'). Source: L'Illustration Horticole 43: plate 58 (Belgian journal published in 1896 by C.H. Lemaire).



Figure 9: Rex begonia (*Begonia rex*). Source: L'Illustration Horticole 26: plate 335 (Belgian journal published in 1871 by C.H. Lemaire).

Curiosities of Science and Technology

- Belgium is the world's largest producer of tuberous begonias, annually exporting over 60 million tubers. To promote the industry, a breathtaking "flower carpet" made up of cut tuberous begonia flowering stems has been assembled every 2 years since 1971 in Brussels, the capital. Craftsmen arrange the carpet by hand, inserting flowering stems directly into the cobblestones of the public square. The carpet is typically based on medieval carpet designs. The display lasts 3 or 4 days, the flowers kept fresh by sprinklers concealed within the pattern of the carpet.

- Kimjongilia, a tuberous begonia cultivar, was named in honour of North Korea's past president, the "Dear Leader" Kim Jong-il. The plant has been claimed to bloom annually on his birthday (Feb. 16). When he died in 2011, his publically displayed corpse was adorned with Kimjongilia flowers. The cultivar is highlighted in a North Korean song:

  > The red flowers that are blossoming over our land
  > Are like hearts: full of love for the leader
  > Our hearts follow the young buds of Kimjongilia
  > Oh! The flower of our loyalty!



Figure 10: Rex begonia hybrids (*Begonia* × *rex-cultorum*). **Left:** ©GCornelis (CC BY SA 3.0). **Right:** ©Nemrace (CC BY SA 3.0).

- How popular is your name? Estimations of the popularity of names in the United States can be found at www.mynamestats.com. "Begonia" is ranked as the 31,899th most popular given name with an estimated population of only 135.

- Blue iridescent leaf colouration occurs in some plants growing in very shady conditions, and this is the case for some *Begonia* species. Jacobs et al. (2016) demonstrated that the bluish sheen in *B. pavonina* is due to reflectance of the blue wavelengths in modified upper (adaxial) epidermal chloroplasts ("iridoplasts"). Chloroplasts contain thylakoids, membrane-bound compartments in which the light reactions of photosynthesis occur. In iridoplasts, the thylakoids are stacked in a much more regular arrangement that in normal chloroplasts, giving them lens-like light-concentrating properties. These special chloroplasts are adaptive in two ways. First, they are very efficient at capturing the predominantly green wavelengths available in deep shade (sunlight reaching the floor of forests occupied by *Begonia* species can be reduced by one millionth to one ten-millionth). Second, they concentrate the more abundant green and red wavelengths of light on the leaves' energy absorbing apparatus, producing a 5% to 10% increase in energy capture.

Key publications

Basurto-Peña, F., Castro-Lara, D., and Martínez-Alfaro, M.A. 2003. Edible begonias from the north of Puebla, Mexico. Econ. Bot. 57: 48–53.

Bowes, B.G., and Curtis, E.W. 1991. Conservation of the British National Begonia Collection by micropropagation. New Phytol. 119: 169–181.

Brilmayer, B. 1960. All about begonias. Doubleday, Garden City, NY. 223 pp.

Catterall, E. 1991. Begonias: The complete guide. Crowood Press, Ramsbury, Marlborough, Wiltshire, U.K. 199 pp.

Clement, W.L., Tebbitt, M.C., Forrest, L.L., Blair, J.E., Brouillet, L., Eriksson, T., and Swensen, S.M. 2004. Phylogenetic position and biogeography of *Hillebrandia sandwicensis* (Begoniaceae): a rare Hawaiian relict. Am. J. Bot. 91: 905–917.

De Wilde, J.J.F.E. 2011. Begoniaceae. *In* Families and genera of vascular plants (Vol 10, flowering plants), Eeudicots, *edited by* K. Kubitzki. Springer, Berlin, Germany. pp. 56–71.

Dewitte, A., Twyford, A.D., Thomas, D.C., Kidner, C.A., and Van Huylenbroeck, J. 2011. The origin of diversity in *Begonia*: Genome dynamism, population processes and phylogenetic patterns. *In* Genome dynamism, population processes and phylogenetic patterns, the dynamical processes of biodiversity – case studies of evolution and spatial distribution, *edited by* O. Grillo. Intech, Rijeka, Croatia. pp. 27–52.

Doorenbos, J., Sosef, M., and de Wilde, J. 1998. The sections of Begonia (Studies in Begoniaceae VI). Backhuys, Leiden, The Netherlands. 266 pp.

Forrest, L.L., and Hollingsworth, P.M. 2003. A recircumscription of *Begonia* based on nuclear ribosomal sequences. Plant Syst. Evol. 241: 193–211.



Figure 11: "Flower carpet" made up of cut tuberous begonias, assembled in Grand-Place, Brussels, Belgium, a UNESCO world heritage site with spectacular baroque, Gothic, neo-Gothic and neo-classical architecture. The carpet is 75 m long by 24 m wide, with around 300 cut flowers per m^2. Up to 1,00,000 flowers are required, and are assembled by more than 100 volunteers. Public domain photo from Pixabay.

Forrest, L.L., Hughes, M., and Hollingsworth, P.M. 2005. A phylogeny from *Begonia* using nuclear ribosomal sequence data and morphological characters. Syst. Bot. 30: 671–682.

Goodall-Copestake, W., Harris, D.J., and Hollingsworth, P.M. 2009. The origin of a mega- diverse genus: dating *Begonia* (Begoniaceae) using alternative datasets, calibrations and relaxed clock methods. Bot. J. Linn. Soc. 159: 363–380.

Goodall-Copestake, W., Pérez-Espona, S., Harris, D.J., and Hollingsworth, P.M. 2010. The early evolution of the mega-diverse genus *Begonia* (Begoniaceae) inferred from organelle DNA phylogenies. Biol. J. Linn. Soc. 101: 243–250.

Haegeman, J. 1979. Tuberous begonias. Origin and development. J. Cramer, Vaduz, Liechtenstein. 268 pp.

Harrison, N., Harrison, R.J., and Kidner, C.A. 2016. Comparative analysis of *Begonia* plastid genomes and their utility for species-level phylogenetics. PLoS ONE 11(4): e0153248. doi:10.1371/journal.pone.0153248.

Hughes, M., and Hollingsworth, P.M. 2008. Population genetic divergence corresponds with species level biodiversity patterns in the large genus *Begonia*. Molec. Ecol. 17: 2643–2651.

Hvoslef-Eide, A.K., and Munster, C. 2007. *Begonia*. History and breeding. *In* Flower breeding and genetics, *edited by* N.O. Anderson. Springer, Dordrecht, The Netherlands. pp. 241–275.

Hvoslef-Eide, A.K., T. Fjeld, and J.W. Einset. 1995. Breeding Christmas begonia (*Begonia* × *cheimantha* Everett) for increased keeping quality by traditional and biotechnological methods. Acta Hort. 405: 197–204.

Jacobs, M., Lopez-Garcia, M., Phrathep, O.-P., Lawson, T., Oulton, R., and Whitney, H.M. 2016. Photonic multilayer structure of *Begonia* chloroplasts enhances photosynthetic efficiency. Nature Plants 2, Article 16162, doi:10.1038/nplants.2016.162.

Karlsson, M.G., and Heins, R.D. 1992. Begonias. *In* Introduction to floriculture, second edition, *edited by* R.A. Larson. Academic Press, New York, NY. pp. 409–427.

Kramer, J. 1967. Begonias: indoors and out. E.P. Dutton, New York, NY. 128 pp.

Krempin, J.L. 1993. Know your begonias. Krempin Books, Broadbeach Waters, Queensland, Australia. 119 pp.

Langdon, K.B. 1969. The tuberous begonia. Cassell, London, U.K. 98 pp.

Misono, I. 1974. Begonias. Translated 1978 by A.M. DeCola and H. Arakawa. American Begonia Society, Los Angeles, CA. 77 pp.

Moonlight, P.W., Richardson, J.E., Tebbitt, M.C., Thomas, D.C., Hollands, R., Peng, C.-I., and Hughes, M. 2015. Continental-scale diversification patterns in a megadiverse genus: the biogeography of Neotropical *Begonia*. J. Biogeogr. 42: 1137–1149.

Neale, S., Goodall-Copestake, W., and Kidner, C.A. 2006. The evolution of diversity in *Begonia*. *In* Floriculture, ornamental and plant biotechnology, *edited by* J.A. Teixeira da Silva. Global Science books, Middlesex, U.K. pp. 606–611.

Rajbhandary, S., Hughes, M., Phutthai, T., Thomas, D.C., and Shrestha, K.K. 2011. Asian *Begonia*: out of Africa via the Himalayas? Gardens' Bulletin Singapore 63: 277–286.

Stevens, M. 2002. Begonias. Firefly Books, Buffalo, NY. 96 pp. (This is an ideal guide to begonias for the average gardener. The photos are stunningly beautiful.)

Stults, D.Z., and Axsmith, B.J. 2011. First macrofossil record of *Begonia* (Begoniaceae). Am. J. Bot. 98: 150–153.

Tebbitt, M.C. 2005. Begonias: cultivation, identification and natural history. Timber Press, Portland, OR. 272 pp. + 64 plates.

Thompson, M.L., and Thompson, E.J. 1981. Begonias: The complete reference guide. Times Books, New York, NY. 356 pp. + 32 plates.

Wyatt, G.E., and Sazima, M. 2011. Pollination and reproductive biology of thirteen species of *Begonia* in the Serra do Mar State Park, São Paulo, Brazil. J. Pollin. Ecol. 6: 95–107.

Yu, N.A., and Fershalova, T.D. 2015. The creation of protected ecosystems as the conservation-friendly way to save genus *Begonia* from extinction. J. Trop. Resour. Sustain. Sci. 3: 164–168.



Figure 12: *Begonia pavonina*. As noted in the text, the blue iridescent sheen of the foliage is related to the presence of special epidermal chloroplasts that capture light relatively efficiently in extremely shady habitats. ©Clivid (CC BY ND 2.0).

Key Websites

American Begonia Society – www.begonias.org
Brad's Begonia World – www.bradsbegoniaworld.com
Montreal Botanical Garden / Begoniaceae – espacepourlavie.ca/en/botanical-garden-collections/begoniaceae

Acknowledgements

Brenda Brookes skillfully assembled and enhanced the illustrations for publication. Creative Commons Licenses employed in this article:

- CC BY 2.0 (Attribution 2.0 Generic)
- CC BY ND 2.0 (Attribution NoDerivs 2.0 Generic)
- CC BY SA 2.1 JP (Attribution-ShareAlike 2.1 Japan)
- CC BY SA 3.0 (Attribution ShareAlike 3.0 Unported)
- CC BY SA 4.0 (Attribution ShareAlike 4.0 International)

Major Invasive Alien Plants of Natural Habitats in Canada. 15. Crested Wheatgrass

15a. Crested Wheatgrasses, agropyre à crête *Agropyron cristatum* (Linnaeus) Gaertner
15b. Siberian Wheatgrass, agropyre de Sibérie, *Agropyron fragile* (Roth) P. Candargy

Paul M. Catling[1,2], Amanda Ward[1] and Gisèle Mitrow[1]

DEPENDING on the situation Crested Wheatgrass is a valuable economic plant or a serious pest. Acceptance of both aspects seems a desirable course. It is the most commonly planted exotic grass in western North America but the extent to which it escapes from plantings in various circumstances is unclear. Management has been effective in some situations but methods are site specific and monitoring is important to ensure longer term success.

Using exotic plants like Crested Wheatgrass for revegetation is controversial to say the least. Values held by many people are challenged on both sides of the issue. On one hand, those in opposition feel that revegetation should only be with native species … Staunch proponents claim that using exotic species provides better forage for livestock and improves range stability. Still others see both benefits and drawbacks to their use.

— Utah State University

Classification and Identification

Crested Wheatgrass is a member of the grass family, Poaceae. Formerly a large genus including species now placed in *Elymus* and other genera, the name *Agropyron* is now restricted to the perennial Triticeae with keeled glumes, generally called the Crested Wheatgrasses. It is believed that three species (*A. cristatum*, *A. desertorum* and *A. fragile*) in this group may have been introduced to North America, but they are said to have "soon lost their taxonomic identity and genetic integrity because of extensive intercrossing that occurs in nursery situations". Most recently only the two species have been recognized in North America: Crested Wheatgrass has been introduced across Canada for soil stabilization and forage. Siberian Wheatgrass is a much less commonly encountered introduction.

Description of Crested Wheatgrasses

Both species are first included in a general description, followed by short specific descriptions and a key indicating differentiating characters. Plants perennial, cespitose or rhizomatose (these species are mostly cespitose bunchgrasses); culms 25-110 cm tall; inflorescences pectinate spikes; ligules membranous; blades 1.5-6 mm wide; glumes 3-6 mm long; lemmas 5-9 mm long; anthers 3, 3-5 mm long, yellow. Caryopses falling with lemmas and paleas attached.



Figure 1: Comb-like inflorescences of Crested Wheatgrass. ©M. Lavin, Montana, 18 Aug. 2009. CC-BY-SA-2.0.

Agropyron cristatum (Linnaeus) Gaertner (*A. cristatum* subsp. *desertorum* (Fischer ex Link) Á Löve, *A. cristatum* subsp. *pectinatum* (M. Bieberstein) Tzvelev, *A. desertorum* (Fischer ex Link) Schultes, *A. imbricatum* Roemer & Schultes, *A. pectiniforme* Roemer & Schultes). Spikes 1.3–10.5(15) cm long, 5–25 mm wide, narrowly to broadly lanceolate, rectangular, or ovate, sometimes tapering distally; spikelets diverging from rachis at angles of 30-90°; lemmas usually awned with awns 1-6 mm long. Some authors have recognized nine subspecies in *A. cristatum*. The species is now broadly interpreted (note the synonyms above).

Agropyron fragile (Roth) P. Candargy (*A. cristatum* subsp. *fragile* (Roth) Á Löve, *A. cristatum* var. *fragile* (Roth) Dorn, *A. fragile* subsp. *sibiricum* (Willdenow) Milderis, *A. fragile* var. *sibiricum* (Willdenow) Tzvelev, *A. mongolicum* Keng, *A. sibiricum* (Willdenow) P. Beauvois). Spikes (5)8–15 cm long, 5–13 mm wide, lanceolate; spikelets diverging from rachis at angles of less than 30°; apices of lemmas mostly unawned but more or less mucronate with mucros up to 0.5 mm. It has been suggested that this species may have lost its identity in North America through hybridization. Some authors

[1]Science and Technology Branch, Agriculture and Agri-Food Canada, Saunders Bldg., Central Experimental Farm, Ottawa ON, K1A 0C6
[2]©Government of Canada. Verbatim redistribution for personal, non-commercial use is permitted.



Figure 2: *Triticum cristatum* from Icones et descriptiones graminum austriacorum. 24, vol. 2, by Nicolai Thomae Host.

have recognized two varieties: var. *sibiricum* has smooth leaf sheaths whereas var. *fragile* has hairy leaf sheaths. A. hybrid involving *A. repens* and *A. sibiricum* has been reported and one author noted that the two are closely related.

Identification

The two taxa may be separated as follows:

1. Lemmas mostly with awns 1-6 mm long; spikelets diverging from rachis at angles of 30-90° ***Agropyron cristatum***
1. Lemmas without awns, sometimes mucronate with mucros up to 0.5 mm long; spikelets diverging from rachis at angles of less than 30° . . . . . ***Agropyron fragile***

Agropyron cristatum and *A. fragile* are connected by intermediates which are presumably of hybrid origin. In an extensive study, one author provided evidence that the Siberian Wheatgrass cultivars P-27 and Vavilov are introgressed. See also the suggestion of intercrossing above. Some specimens that we have examined have narrow spikes with ascending spikelets but with some awns on the lemmas over 1 mm long. Other specimens have broad spikes with strongly diverging spikelets but the lemmas are without awns. The character of the width and shape of the spike is related to the extent to which the spikelets spread or ascend.

One author found the ratio of spike length/width was "highly diagnostic" when separating Siberian Wheatgrass from the standard Crested Wheatgrass cultivar called Nordan. The following key utilizes this feature:

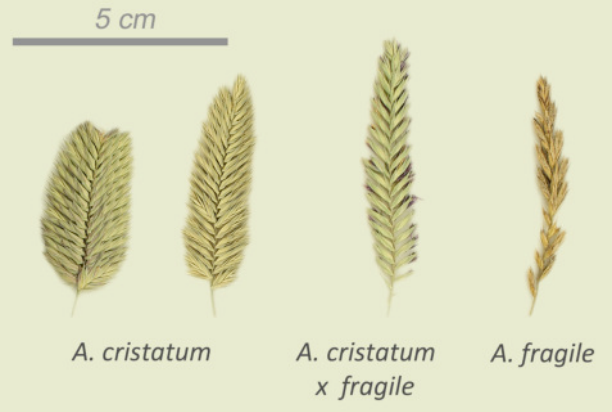


Figure 3: Spike of Crested Wheatgrass, Siberian Wheatgrass and their putative hybrid. From left to right DAO 769177, DAO 81488, DAO 900416, DAO 81806.

1. Ratio of spike length/width 3.2-8.2 . . . . . ***A. cristatum***
1. Ratio of spike length/width 7.0-41.3 . . . . . ***A. fragile***

Considering that intermediate plants can be identified, it seems appropriate to recognize them as likely hybrids. In the present case, the key characters provided above were used to assign specimens to *A. cristatum*, *A. fragile*, or *A. cristatum* ×*fragile*.

Distribution

Both Crested Wheatgrass and Siberian Wheatgrass are species of the Russian and Siberian steppes. Their widespread occurrence in North America actually began more than a century ago. Several million acres of native grasslands in the northern Great Plains of the United States and Canada were broken and seeded to wheat to satisfy world demand from 1905 to 1920. When the dry years of the middle thirties came on, many abandoned wheat lands were in need of grass cover. Crested Wheatgrass was the only grass available that would fulfill this role due to its hardiness, productiveness and longevity. At this time it was widely introduced to North America, although the earliest record of importation and distribution was in 1899.

The accompanying maps showing distributions in Canada are based on collections from: for *A. cristatum* — ACAD, ALTA, CAN, DAO, HAM, LKHD, MMMN, MT, NBM, NSPM, OAC, QFA, QK, QUE, SASK, TRT, TRTE, UAC, UBC, UWO, V, and WIN; for *A. fragile* — ALTA, DAO, MMMN, TRT, TRTE, UAC, UBC, V, and WIN; for *A. cristatum* ×*fragile* — ALTA, CAN, DAO, LKHD, MMMN, MT, OAC, QFA, SASK, TRTE, UAC, UBC, UWO, V, and WIN. The following herbaria did not have specimens of the *A. cristatum* group: NFLD, NFM, NSAC, UNB, and UPEI. *Agropyron fragile* was not represented at ALTA, MMMN, MT QFA, TRTE, and UWO. A specimen labelled as *A. fragile* from La Roche, Saskatchewan at SASK was not examined. It is likely that some of the specimens mapped are a consequence of planted seed, although this is not indicated on the label.

Ecology

Crested Wheatgrass does best on loamy soils in dry grasslands with 230-380 mm of rainfall annually, but it is tolerant of a broad range of conditions. It has a C3 photosynthetic pathway but has advantages over native C3 grasses including extreme drought tolerance.

Successful invasion of native prairie by Crested Wheatgrass may be related to high seed production. Some seeds are retained on the inflorescence during periods of peak predation by ground animals and the seeds of Crested Wheatgrass also survive longer in the seed bank.

Although domestic sheep, Bighorn Sheep and Elk use Crested Wheatgrass extensively, it is not used much by Mule Deer. Jackrabbits can have an effect on cover. Crested Wheatgrass is only "slightly damaged" or "undamaged" by fire. If it is burned, post fire recovery is rapid.

Crested Wheatgrass may inhibit or preclude re-establishment of native species on disturbed sites and may become the dominant species. A Crested Wheatgrass community in southeastern Alberta was determined to be over 40 years old, but other stands have been naturally replaced prior to reaching this age. Persistence of monocultures has been documented for up to 50 years and is generally thought to be a characteristic. A few studies have reported succession to more natural communities on more moist sites.

Crested Wheatgrass is a major host of the black grass bug (*Labops hesperius*), which can severely damage grass stands. Other insect pests of Crested Wheatgrass are leafhoppers, and mature click beetles and billbugs.

Pollination

Crested Wheatgrass is mainly wind pollinated, though some self-pollination is possible but may not lead to fertilization due to self-incompatibility.

Dispersal

The seeds are dispersed by the wind and by animals. The deer mouse (*Peromyscus maniculatus*) has been reported as a dispersal agent. The seeds attach to animal fur, especially sheep. One study reported that they remain in the wool of sheep for days and travel 16 km/day. Seeds may also be dispersed in mud on the underside of vehicles or shoes. The extent to which Crested Wheatgrass spreads from plantings in different regions is unclear, and all aspects of the ecology of the plant require further study.



Figure 4: Crested Wheatgrass spike. ©M. Lavin, CC-BY-SA-2.0.

Detrimental Aspects

Significance is suggested by the number of asterisks to 5 for highly significant.

(1) Negative effects on biodiversity generally *****

Several studies have reported negative impacts on passerine birds and small mammals, both changes in species composition and declines in total numbers. Negative impacts are more often associated with the loss of native sagebrush habitat. Some studies however, have reported beneficial effects. The level of impact on native flora and fauna probably depends on the initial biodiversity present. The loss of diversity in flora and fauna is very clear but requires more documentation and experimental research.

(2) Negative effects on biodiversity restoration ****

Using Crested Wheatgrass to restore a mine site was easily accomplished but resulted a monoculture and a much lower biodiversity than existed on the site originally. Despite convenience and ease of establishment, Crested Wheatgrass is not the best diversity restoration choice.

(3) Reduction in soil quality ***

Crested Wheatgrass appears to influence soil quality in a manner similar to that of row crops. They provide limited organic nitrogen, provide organic matter primarily in the form of carbohydrates (cellulosic crop residues), and lead to a significant decline in soil organic matter quality.

(4) Loss of Ecosystem stability ***

Crested Wheatgrass monocultures have promoted populations of native herbivores that negatively influence native prairie but normally exist at lower levels.

Beneficial Aspects

(1) Valuable forage grass *****

Planting Crested Wheatgrass in degraded rangeland can create up to five times the amount of pasture. The plant produces highly palatable and nutritious forage in both spring and fall and is important to livestock and wildlife when other food sources are unavailable. It is tolerant of drought and cold, easily established from seed, responds well to fertilizer, yields better than native grasses, and provides greater livestock weight gains. Crested Wheatgrass became widespread in the United States in the 1930s when used to seed abandoned cropland. Later native habitats were planted with Crested Wheatgrass to increase range production. Above a certain level of grazing (88% in one study) Crested Wheatgrass plants die and stand quality declines.

(2) Valuable export *****

The value of exported seed of Crested Wheatgrass exceeds 4.5 million dollars annually in Canada.

(3) Grassland fire control **

A mature stand of Crested Wheatgrass controls grassland fires, particularly in Downy Brome (Cheatgrass, *Bromus tectorum*) and sagebrush steppe habitats. It has been used to contain fires by "greenstripping" (providing a fuel-break).

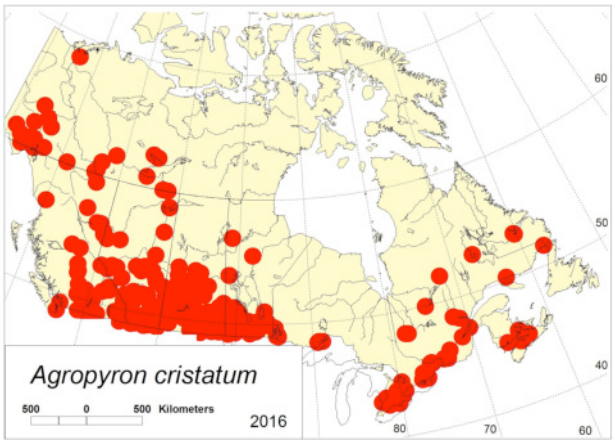


Figure 5: Distribution of Crested Wheatgrass in Canada based on specimens examined.

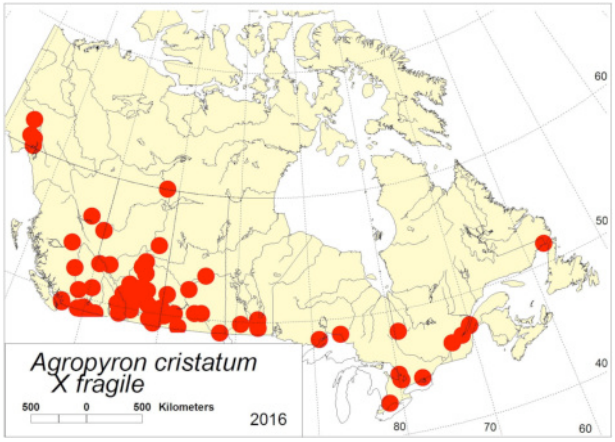


Figure 6: Distribution of putative hybrids of Crested Wheatgrass and Siberian Wheatgrass in Canada based on specimens examined.



Figure 7: Distribution of Siberian Wheatgrass in Canada based on specimens examined.

(4) Weed control **

Near Cache Creek in British Columbia, planted stands of Crested Wheatgrass inhibited the spread of introduced Diffuse Knapweed (*Centaurea diffusa*) and Downy Brome (Cheatgrass, *Bromus tectorum*) on arid study plots, but higher moisture in soils and/or higher grazing levels may reduce the effect.

(5) Turf Grass **

Low-growing rhizomatous strains of Crested Wheatgrass are used in lawns in dry areas.

(6) Erosion control **

Since it is a bunchgrass, there may still be erosion between plants because competition may prevent spaces from being filled. Nevertheless the ease of obtaining and establishing Crested Wheatgrass has made it a popular choice.

(7) The "Wheatgrass diet"

This diet includes raw vegetables, nuts, seeds and grasses. Wheatgrass is available as tablets, capsules, liquid extracts, juices and in a natural state. It has been promoted as a cure for many kinds of illnesses. While this diet may have benefits in some cases, for any illness, we recommend visiting a physician for the best remedial advice. There is some confusion in the literature as to whether the grass in Wheatgrass diets and juices is Wheatgrass (*Agropyron*) or sprouts of Wheat (the cereal grain, *Triticum aestivum* etc.). It is probably most often the latter.

Management

Legislation and regulations

Agropyron fragile and *A. cristatum* are both registered crops in Canada and are not subject to control regulations.

Crested Wheatgrass monocultures have been considered as "bridge" plant communities that would replace Downy Brome (Cheatgrass)-dominated lands for future restoration to a more diverse native plant community. Three steps are involved: (1) "capture" the site from weeds with Crested Wheatgrass; (2) reduce Crested Wheatgrass; (3) reseed with native species. Experimental applications of this procedure have not always worked well, partly because of the difficulty in reducing the Crested Wheatgrass.

Although producing pastureland or prairie after cultivation or deterioration has been a major use of Crested Wheatgrass, it is not always a necessary intermediate step for prairie restoration. In Grasslands National Park in Saskatchewan, previously cultivated fields were directly revegetated with a mix of native grasses and wildflowers. The restoration included over 280 hectares and it looked similar to native prairie in as little as four years after native seeding.

The good news is that successful management of Crested Wheatgrass has been shown not to be contingent upon environmental variation, and it has a lot to do with reducing seed production.

Given the objective of reducing Crested Wheatgrass invasion of rangeland, five precautions are listed by the Saskatchewan Watershed Authority:

- Do not seed Crested Wheatgrass in native prairie such as on pipeline or oil well disturbances.
- Do not seed Crested Wheatgrass adjacent to native grassland unless the Crested Wheatgrass will be thoroughly grazed each spring to prevent seed set.
- Do not seed Crested Wheatgrass on road allowances adjacent to native prairie.
- Do not interseed Crested Wheatgrass in native prairie.

Management not a "Cup of Tea"

Crested Wheatgrass is an extremely competitive grass species that has the ability to outcompete many of our native grass species, and as such is threatening the biodiversity of our prairie ecosystem. Management of Crested Wheatgrass must be site specific and may require the use of two or more management techniques. Management regimes must be persistent, and regularly monitored and adapted to prevent Crested Wheatgrass spread.

— Saskatchewan Watershed Authority in 2016

- If Crested Wheatgrass has produced seed, allow time for cattle to pass seed before transferring cattle from Crested Wheatgrass to native range.

Manual and Mechanical Methods

Clipping has reduced the cover of Crested Wheatgrass by 90% and doubled the cover of native species.

Grazing

Many studies have investigated management for cattle. Light to moderate grazing (to 70%) invigorates a stand but higher grazing levels reduce plant production. Experiments have suggested that heavy grazing may be useful in the management of native species.

Behaviour

Much more caution should be applied to the idea of using this plant for restoration or to improve native grasslands, especially for conservation purposes.

Burning

Spring fires reduce productivity for a few years but autumn fires may have a beneficial effect on a stand.

Biocontrol

It is not desirable to use biocontrol in the sense of introducing natural enemies from the native range to control Crested Wheatgrass because the grass has substantial economic value and traditional biocontrol cannot be contained and would therefore reduce its value. However, using the effects of competition with planted native species such as Blue Grama (*Bouteloua gracilis*) has proven very successful on a local scale.



Figure 8: June 1957 field planting of Siberian wheatgrass (*Agropyron fragile*) in foreground of the USDA Aberdeen Plant Materials Center, Aberdeen, Idaho, USA.

Chemical Methods

Herbicides can significantly reduce the cover of Crested Wheatgrass but regrowth occurs and plants persist after 4 years of herbicide application. Several years of applications may be required. Glyphosate has been recommended. Herbicide should be applied to individual clumps when they are 8-15 cm tall and definitely before they go to seed.

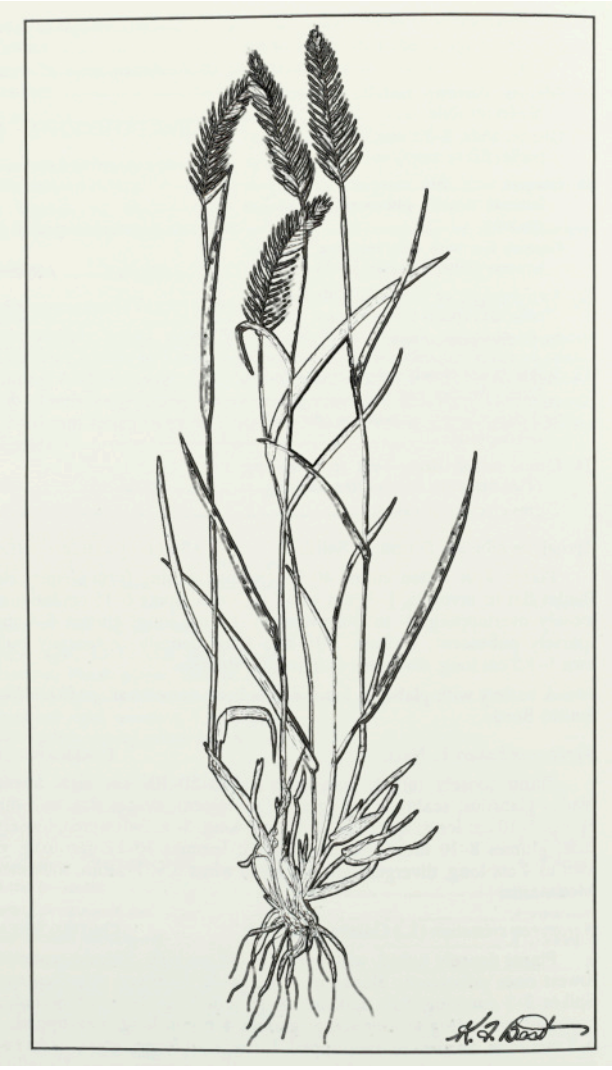


Figure 9: Drawing of Crested Wheatgrass. AAFC illustration.

Prospects

We may anticipate that a more open-minded approach to problems with Crested Wheatgrass will prevail in the future. This attitude will replace the two extreme views, one wholly opposed to its planting, the other completely in favour. It will be recognized that there are situations where it can serve as a valuable economic plant and other situations where management is necessary to protect natural resources. There is insufficient information on many aspects of the ecology of Crested Wheatgrass to permit effective site specific management so that monitoring is an important strategy. Millions of hectares have been planted over recent decades and since it will continue to be planted, increased caution in planting may be the most important way of limiting ecosystem damage.

Believe It or Not (mostly not)

- Kookie (aka Edd Byrnes), upset Connie Stevens for incessantly combing his hair. She sang "Kookie, Kookie, lend me your comb" to get the comb away from him, and of course she became famous. Edd arrived one day at the set of "77 Sunset Strip" (a famous TV show — your great aunt will remember it). Then an awful thing happened … he had lost his comb, but there in the parking lot was a plant of Crested Wheatgrass with a pectinate (comb-like) inflorescence. He was able to use this to good advantage and the subsequent use of plants based on their appearance became known as the Doctrine of Signatures.

- Crested Wheatgrass is also used and sold as a facial cream to repair sun-damaged, dry, rough skin. It removes skin problems by moisturizing and reproduces flawless, translucent skin because we deserve it.

Selected References

Asay, K.H. and D.R. Dewey. 1979. Bridging ploidy differences in Crested Wheatgrass with hexaploid ×diploid hybrids. Crop Science 19: 519–523

Asay, K.H., K.B. Jensen, C. Hsiao, and D.R. Dewey. 1992. Probable origin of standard Crested Wheatgrass, *Agropyron desertorum* (Fisch. *ex* Link) Schultes. Canadian Journal of Plant Science 72: 763–772.

Anderson, J.E. and G.M. Marlette. 1986. Probabilities of seedling recruitment and the stability of Crested Wheatgrass stands. In: Johnson, Kendall L., ed. Crested Wheatgrass: its values, problems and myths: Symposium proceedings; 1983 Oct. 3-7; Logan, UT. Logan, UT: Utah State University: 97-105.

Bakker, J.D., S.D. Wilson, J.M. Christian, and X. Li. 2003. Contingency of grassland restoration on year, site and competition from introduced grasses. Ecological Applications 13(1): 137–153.

Barkworth, M.E. 2003. 13.09 *Agropyron* Gaertn. In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 20+ vols. New York and Oxford. Vol. 24 herbarium.usu.edu/webmanual

Barkworth, M. E. 2007. 13.09 *Agropyron* Gaertn. P. 62 in Barkworth, M.E., L.K. Anderton, K.M. Capels, S. Long, and M.B. Piep, eds., Manual of Grasses of North America. Utah State University Press.



Figure 10: *Agropyron cristatum* was used as a green strip along this highway (Lincoln Blvd) and it has slowly been invaded by the sagebrush steppe. More recently, a new strip of *Agropyron cristatum* cuts through the old green strip probably in a revegetation effort following the burial of a line. ©M. Lavin, Montana, 18 June 2011. CC-BY-SA-2.0.

Barkworth, M.E. and D.R. Dewey. 1985. Genomically based genera in the perennial Triticeae of North America: identification and membership. American Journal of Botany 72(5): 767-776.

Blank, R.R. 2017. Suppression of annual *Bromus tectorum* by perennial *Agropyron cristatum*: roles of soil nitrogen availability and biological soil space . Aob Plants. 7(Sp. Iss. SI), Article No.: plv006

Blass, C., K. Ronnenberg, O. Tackenberg, I. Hensen, and K. Wesche. 2010. The relative importance of different seed dispersal modes in dry Mongolian rangelands. Journal of Arid Environments 74: 991-997.

Bleak, A., T. Plummer, and A. Perry. 1954. Grazing Crested Wheatgrass by sheep. Journal of Range Management. 7: 63-68.

Bowden, W.M. 1965. Cytotaxonomy of the species and interspecific hybrids of the genus *Agropyron* in Canada and neighboring areas. Canadian Journal of Botany 43: 1421-1448.

Chen, S.-L. and G.-H. Zhu. 2006. *Agropyron*. Pp. 439–441 *in* Z.-Y. Wu, P.H. Raven, and D.-Y. Hong (eds.). Flora of China, vol. 22 (Poaceae). Science Press, Beijing, Peoples Republic of China and Missouri Botanical Garden Press, St. Louis, Missouri, U.S.A. 653 pp. flora.huh.harvard.edu/china/mss/volume22/index.htm

Dewey, D.R. 1983. Historical and current taxonomic perspectives of *Agropyron*, *Elymus*, and related genera. Crop Science 23: 637-642.

Dewey, D.R. 1986. Taxonomy of the Crested Wheatgrasses (*Agropyron*). Pp. 31–42 *in* K.L. Johnson (ed.). Crested Wheatgrass: Its Values, Problems and Myths; Symposium Proceedings. Utah State University, Logan, Utah, U.S.A. 348 pp.

Dillman, A.C. 1946. The beginnings of Crested Wheatgrass in North America. Journal of the American Society of Agronomy 28: 237–250.

Dusek, G.L. 1975. Vegetational responses by substrate, gradient, and aspect on a twelve acre test plot in the Bull Mountains. In: Clark, W. F., ed. Proceedings of the

Fort Union Coal Field symposium; Billings, MT. Montana Academy of Sciences: 233-246.
Frid, L. and J.F. Wilmshurst. 2009. Decision analysis to evaluate control strategies for Crested Wheatgrass (*Agropyron cristatum*) in Grasslands National Park of Canada. Invasive Plant Science & Management. 2(4): 324-336.
Hansen, N.J. 2007. Evaluating management strategies and recovery of an invasive grass (*Agropyron cristatum*) using matrix population models. Biological Conservation. 140(1-2): 91-99.
Hansen, M.J. and S.D. Wilson. 2006. Is management of an invasive grass *Agropyron cristatum* contingent on environmental variation? Journal of Applied Ecology. 43(2): 269-280
Haws, B., B. Austin, and G.E. Bohart. 1986. Black grass bugs (*Labops herperius*) Uhler (Hemiptera: Miridae) and other insects in relation to Crested Wheatgrass. In: Johnson, Kendall L., ed. Crested wheatgrass: its values, problems and myths: Symposium proceedings; 1983 Oct. 3-7; Logan, UT. Logan, UT: Utah State University; 1986: 123-145.
Heidinga, L. and S.D. Wilson. 2002. The impact of an invading alien grass (*Agropyron cristatum*) on species turnover in native prairie. Biodiversity Research 8: 249–258.
Jensen, K.B., K.H. Asay, D.A. Johnson, and B.J. Li. 2000. Characterization of Siberian Wheatgrass germplasm from Kazakhstan (Poaceae: Triticeae). Journal of Range Management 53: 347-352.
Lattin, J.D., A. Christie, and M.D. Schwartz. 1994. The impact of nonindigenous Crested Wheatgrass on native Black Grass Bugs in North America: a case for ecosystem management. Natural Areas Journal 14: 136-138.
Lesica, P. and T.H. DeLuca. 1996. Long-term harmful effects of Crested Wheatgrass on Great Plains grassland ecosystems. Journal of Soil and Water Conservation 51: 408–409.
Löve, A.A. 1984. Conspectus of the Triticeae. Feddes Repertorum 95: 425-521.
Macdougall, A. S. and S.D. Wilson. 2011. The invasive grass *Agropyron cristatum* doubles belowground productivity but not soil carbon. Ecology (Washington D C). 92(3): 657-664.
Ogle, D.G. 2006. USDA-NRCS Plant Guide: Crested Wheatgrass *Agropyron cristatum* (L.) Gaertn. Washington, DC, USA: 6 pp. plants.usda.gov/plantguide/pdf/pg_agcr.pdf [Accessed November 24, 2016]
Pyke, D.A. 1990. Comparative demography of co-occurring introduced and native tussock grasses: persistence and potential expansion. *Oecologia*, 82, 537–543.
Reynolds, T.D. 1978. The response of native vertebrate populations to different land management practices on the Idaho National Engineering Laboratory Site. In: Markham, O. D., ed. Ecological studies on the Idaho National Engineering Laboratory Site: 1978 Progress Report. IDO-12087. Idaho Falls, ID: U.S. Department of Energy, Environmental Sciences Branch, Radiological and Envirnomental Sciences Lab: 171-188.
Romo, J.T., P.L. Grilz, and L. Delanoy. 1994. Selective control of Crested Wheatgrass (*Agropyron cristatum* [L.] Gaertn.and *A. desertorum* Fisch.) in the northern Great Plains. *Natural Areas Journal*, **14**, 308–309.
Roundy, B.A., G.J. Cluff, J.K. McAdoo, and R.A. Evans. 1985. Effects of jackrabbit grazing, clipping and drought on Crested Wheatgrass seedlings. Journal of Range Management 38: 551–555.
Saskatchewan Watershed Authority. 2016. Managing Crested Wheatgrass in Native Grassland. 4 pp.
Sarkar, P. 1956. Crested Wheatgrass complex. Canadian Journal of Botany 34: 328-345.
Smoliak, S., A. Johnston, and R.W. Lodge. 1981. Management of Crested Wheatgrass pastures. Publ. 1473. Department of Agriculture, Ottawa. 19 pp.
Sutter, G.C. and R.M. Brigham. 1998. Avifaunal and habitat changes resulting from conversion of native prairie to Crested Wheatgrass: patterns at songbird community and species levels. Canadian Journal of Zoology 76: 869-875.
Tsvelev, N.N. 1976. Zlaki SSSR. Nauka, Leningrad [St. Petersburg], Russia. 788 pp.
Wiens, J.A. and J.T. Rotenberry. 1985. Response of breeding passerine birds to rangeland alteration in a North American shrubsteppe locality. Journal of Applied Ecology. 22: 655-668.
Wilson, S.D. and M. Pärtel, 2003. Extirpation or coexistence? Management of a persistent introduced grass in a prairie restoration. Restoration Ecology 11: 410–416.
Zlatnik, E. 1999. *Agropyron cristatum*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). www.fs.fed.us/database/feis/plants/graminoid/agrcri/all.html

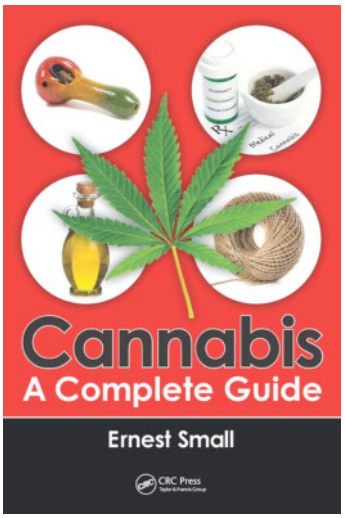
Cannabis

A Complete Guide

Ernest Small
Agriculture and Agri-Food Canada, Ottawa, Ontario



Cannabis sativa is best known as the plant source of marijuana, the world's most widely consumed illicit recreational drug. However, it is also extremely useful as a source of stem fiber, edible seed oil, and medicinal compounds, all of which are undergoing extraordinarily promising research, technological applications, and business investment. This book is a comprehensive reference reviewing, analyzing, and summarizing botanical, horticultural, genetic, ecological, chemical, medical, historical, sociological, legal and business considerations that are critical for the wise advancement and management of cannabis.



KEY FEATURES

- Serves as the most comprehensive available guide for scientists, doctors, economists, students, industries, and governments to evaluate risks and benefits of all aspects of cannabis.
- Incorporates a very high level of scholarship, including a thorough and up-to-date analysis of the literature (with more than 1,700 literature citations), almost half a century of personally published research by the author, and consultations with leading experts.
- The text is accessible, user-friendly, concise, and well-organized, making numerous complex topics comprehensible and easily digested, and therefore readable not only by specialists but also by students and the general public.
- Over 500 high-quality illustrations are included, mostly in color, complementing the text.
- Numerous topics are presented in an entertaining fashion, including a section for each chapter that features memorable, fascinating, or humorous facts.

SELECTED CONTENTS

Introduction. Prehuman and Early History of *Cannabis sativa*. The Ecology of Wild *Cannabis sativa.* Sex Expression. Photoperiodism. Shoot and Foliage Architecture. Fiber. Oilseed. Essential Oil. Minor Uses. *Cannabis* Chemistry: Cannabinoids in *Cannabis*, Humans, and Other Species. Non-Medical Drug Use. Medical Marijuana. Cannabusiness: The Legitimate Marijuana Industry. Sustainability. Germplasm Resources. Botanical Classification and Nomenclatural Issues. Literature Cited. Guide to Cultivars.

Catalog no. K28818
November 2016, 597 pp.
ISBN: 978-1-4987-6163-5
$119.95 / £76.99

SAVE 20% when you order online and enter Promo Code JMQ77

FREE standard shipping when you order online.

www.crcpress.com

CRC Press
Taylor & Francis Group

e-mail: orders@crcpress.com
1-800-634-7064 • 1-561-994-0555 • +44 (0) 1235 400 524