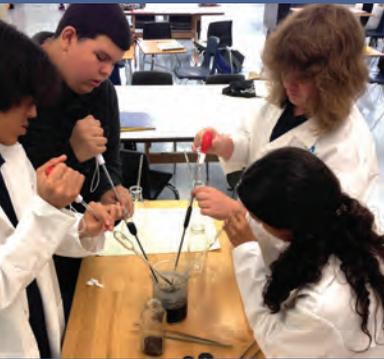




PLANT SCIENCE BULLETIN

SPRING 2016 VOLUME 62 NUMBER 1

A PUBLICATION OF THE BOTANICAL SOCIETY OF AMERICA

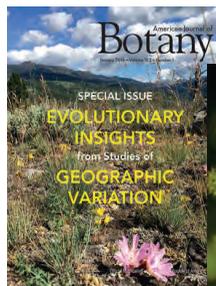


SPECIAL FEATURE: BOTANICAL SOCIETY ENGAGEMENT IN CITIZEN SCIENCE

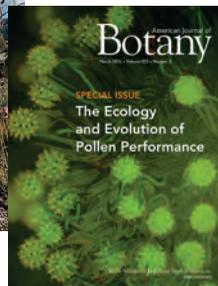
IN THIS ISSUE...



Hawai'i botanists complete assessments for IUCN Red List of Threatened Species p. 4



American Journal of Botany kicks off 2016 with two Special Issues.... p.7



Introducing BSA's Education Technology Coordinator, Dr. Jodi Creasap Gee... p. 34

From the Editor

Greetings!

It is fair to say that one of the current trends in science is the application of “Citizen Science.” Researchers are relying more and more on amateur scientists and the general public for data collection and increasingly incorporating crowd-sourced data into their analyses. However, this movement has not been without its challenges and skeptics. In this issue of *Plant Science Bulletin*, I am pleased to present a special feature on Citizen Science as it relates to botany. On page 10, Maura Flannery describes Citizen Science, discusses the response of the botanical community, and argues the importance of these kinds of projects for plant research. Following this (page 16) are brief descriptions of projects in which BSA members and botanical institutions have been involved. I want to send a special “thank you” to those of you who responded to my request for these project descriptions that exemplify the types of citizen science that we, as botanists, can undertake.

I also want to share some important news regarding *Plant Science Bulletin*. Starting with this issue, *PSB* will be published three times a year (March, July, and October). My goal is to produce content-rich and reflective issues of *PSB*. Publishing fewer times a year will allow us to better focus on each issue and to assemble more special content, such as we did for this issue. Two other factors were important in shaping our decision. First, news and announcements are now distributed virtually immediately via email, the BSA homepage, and social media. Updated news can always be found at <http://cms.botany.org/news/> and, therefore, *PSB* has become less important as a vehicle for timely announcements. Second, starting in 2017, *American Journal of Botany* will no longer be distributed in print, eliminating the need to coordinate mailings of *PSB* with those of *AJB*. I am confident that this will be a positive change for *Plant Science Bulletin* and I am looking forward to the rest of 2016.



Mackenzie

PLANT SCIENCE BULLETIN

Editorial Committee

Volume 62



**L.K. Tuominen
(2016)**

*Department of Natural Science
Metropolitan State University
St. Paul, MN 55106
Lindsey.Tuominen@metrostate.edu*



**Daniel K. Gladish
(2017)**

*Department of Biology &
The Conservatory
Miami University
Hamilton, OH 45011
gladisk@muohio.edu*



**Kathryn LeCroy
(2018)**

*Environmental Sciences
University of Virginia
Charlottesville, VA 22904
kal8d@virginia.edu*



**Melanie Link-Perez
(2019)**

*Department of Biology
Armstrong State University
Savannah, GA 31419
melanie.link-perez@armstrong.edu*



TABLE OF CONTENTS

SOCIETY NEWS

Big Policy Year for Science.....	2
New Funding Opportunity	2
“IUCN Red List Assessment Training and Bioblitz” Workshop at Botany 2016	3
AIBS Policy News Reminder	3
Hawai'i Botanists Complete IUCN Red List Assessments for 90 Endemic Species (and Counting!)	4
The <i>American Journal of Botany</i> Kicks Off 2016 with Two Special Issues.....	7
New bush tomato species is the link between botany and an Oscar-nominated Hollywood movie.....	8

ARTICLES

Citizen Science Helps Botany Flourish.....	10
Botanical Society Engagement in Citizen Science	16
RETurn to the Classroom: Linking Science Teaching and Science Experience for Pre- and In-service High School Teachers.....	25

ANNOUNCEMENTS

In Memoriam - F. Thomas Ledig (1938–2015).....	30
#OhiaLove Campaign to Help Save Hawaii's Forests	33

SCIENCE EDUCATION

Welcome to Dr. Jodi E. Creasap Gee, BSA's Education Technology Coordinator.....	34
PlantingScience continues to expand	36
Seeking Volunteers to staff outreach booth at USA Science and Engineering Festival in Washington D.C.....	37

STUDENT SECTION

Conversations about Grad School and What Happens Next	38
---	----

BOOK REVIEWS

Ecological	43
Genetics.....	44
Historical.....	46
Physiology	48
Systematics	50



Submit your abstract and register now for the
conference you don't want to miss!
www.botanyconference.org



SOCIETY NEWS

The BSA Public Policy Quarterly

Big Policy Year for Science

Presidential election cycles are exciting times for public policy, and 2016 is moving forward on the heels of an incredibly important year for both national and international science policy. One of the most important of these developments was an increase in federal funding for US science programs. Compared to the fiscal year 2015 budget, 2016 received important gains that will help sustain important biological research. The Consolidated Appropriations Act of Fiscal Year 2016 was signed into law on December 18, 2015, and it includes \$7.463 billion for the National Science Foundation (1.7% above FY2015).

President Obama's budget for Fiscal Year 2017 was released on February 9, 2016. AIBS has completed their annual Budget Report for Biological Sciences Research and Education, which identifies several important updates. Their summary indicates that the administration is proposing \$152 billion for federal

research and development, which translates into a \$6 billion increase over FY 2016. We recommend you look at the AIBS Budget Report and see how this proposed budget might impact your research activities by visiting https://www.aibs.org/public-policy/budget_report.html!

New Funding Opportunity

The BSA Public Policy Committee has teamed up with the ASPT Environmental Science and Policy Committee to craft a new \$1000 funding opportunity—the **Botany Advocacy Leadership Grant!** One successful applicant for this award will receive \$1000 toward developing new (or enhancing existing!) botanical advocacy projects. Such projects may include founding a new native plants society, facilitating local plant conservation events (e.g., invasive species removal or planting a native garden), or developing a campaign for local, state, or regional representatives to benefit botany programs. For more information, go to http://cms.botany.org/file.php?file=Site-Assets%2Fawards%2FBSA_BAL_Call.pdf.



By Marian Chau (Lyon Arboretum University of Hawai'i at Mānoa) and Morgan Gostel (Smithsonian Institution), Public Policy Committee Co-Chairs

“IUCN Red List Assessment Training and Bioblitz” Workshop at Botany 2016

BSA Public Policy co-chair, Marian Chau, is facilitating a Botany 2016 workshop led by George Schatz of the IUCN Species Survival Commission. Participants will become Red List Assessors for their specialty area and have an assessment ready to submit to IUCN by the end of the workshop. Read the article on the following page to learn more!

AIBS Policy News Reminder

If you haven't already, join the AIBS Legislative Action Center (<http://policy.aibs.org/>) and stay up to date on important developments regarding federal science policy by signing up for Public Policy Reports (<http://www.aibs.org/public-policy-reports/>).

FROM THE *PSB* ARCHIVES

60 years ago: Victor A. Greulach discusses the academic origins of American botanists. A survey of 2015 botanists indicated that the top five American universities for granting Bachelor's degrees to botanists were (1) The University of Wisconsin, (2) The University of California, (3) The University of Minnesota, (4) Cornell, and (5) The University of Nebraska. The top five universities granting doctorates were (1) The University of Wisconsin, (2) The University of Chicago, (3) Cornell, (4) Harvard and (5) The University of Minnesota. Forty-six universities provided 98% of the doctorates earned by botanists. (*PSB* 2(1): 4 -7)

50 years ago: Lawrence I. Crockett reported on the status of the *American Journal of Botany*: “Five years ago we were publishing approximately 80 pages per issue, and it is hoped that in the coming five years this figure will double. However, if we are to publish 160 pages per month, the editor of that day will be editing the equivalent of 20 issues of the 1959-1960 period! The burden on the editorial office will be staggering.

...

Advertising during the last two years has shown signs of improving. . . Circulation increases can also be planned on during this period. Smaller institutions are growing and expanding their libraries. The government will no doubt continue to pour money into higher education.” (*PSB* 12(1): 5)

Hawai'i Botanists Complete IUCN Red List Assessments for 90 Endemic Species (and Counting!)

The International Union for the Conservation of Nature (IUCN) “helps the world find pragmatic solutions to our most pressing environment and development challenges.” The IUCN Red List of Threatened Species is important because it allows experts to evaluate the risk of extinction for any given species, providing open-source data that can be used for research, funding, and conservation prioritization. The IUCN World Conservation Congress will convene in Honolulu in September 2016, which will be the first time the Congress is held in the United States—so this is an exciting time for American botanists to become more involved with plant conservation at a global level.

Hawai'i has the unfortunate distinction of being “the endangered species capital of the world,” but a positive aspect of this is that Hawai'i is home to an incredible array of biodiversity. Approximately 90% of flowering

plants and 70% of ferns are endemic to Hawai'i, found nowhere else in the world (Figures 1-3). Over 30% of the flora is state and federally listed as threatened or endangered, and nearly 10% of the flora is already extinct. In the late 1990s, a group of botanists came together to form the Hawaiian Rare Plant Restoration Group. In the 2000s, this group officially became the Hawaiian Plant Specialist Group under the IUCN Species Survival Commission. We come from various federal and state agencies, NGOs, universities, and other organizations, with a shared goal to enhance collaborations and facilitate successful restoration of rare plant species. After Honolulu was announced as the location for the 2016 World Conservation Congress, we decided to make Red List assessment of our incredible endemic flora a high priority.

In August 2015, the National Tropical Botanical Garden (NTBG) hosted Hawai'i's first ever Red List workshop, at its headquarters in the Botanical Research Center on Kaua'i. Nearly two dozen participants from state, federal, and private agencies across the islands, as well as three participants who flew in from the continental U.S., convened for five days. The workshop was led by Dr. George Schatz, Curator in the Africa and Madagascar Department at the Missouri Botanical Garden, and member of the IUCN Species Survival Commission's Plants Conservation Sub-Committee. During the first two days, we learned how to



By Seana Walsh, Maggie Sporck-Koehler, and Marian Chau



Figure 1. *Asplenium dielmannii*, endemic to the island of Kauaʻi, is an extremely rare species with fewer than 50 wild individuals remaining. This species had not been seen in the wild since around 1900, but remarkably it was rediscovered in 2003. The natural habitat for *A. dielmannii* has been significantly degraded by introduced plant and animal species that pose a constant threat to the remaining individuals. The species is managed by Hawaiʻi's Plant Extinction Prevention Program (PEPP), and recent collaborative efforts to recover the species have been promising.

conduct a thorough Red List assessment. This followed weeks of preparation, in which many participants completed the online IUCN Red List training course. The last three days of the workshop, we put what we learned into practice by working together to complete assessments for selected species. Those on Kauaʻi got together to assess plant species endemic to Kauaʻi, the island with the highest number of single-island endemics at about 250 taxa. Those from the neighboring islands got together to work on select plant species from the other Hawaiian Islands. It was inspiring to see

how much was accomplished in such a short time. The whole group was lively and enthusiastic, and everyone had a great time.

Within two weeks after the workshop, Red List assessments and reviews were completed for a total of 90 plant taxa. These were submitted to the IUCN Red List Unit for final review and eventual publication on the IUCN Red List of Threatened Species. The idea, drive, and support for the workshop came through the foresight, inspiration, and determination of NTBG President, Director and CEO Chipper Wichman. Chipper says, "Red Listing Hawaiʻi's plants is important because, even though Hawaiʻi is already globally recognized as a distinct floristic region, doing so raises awareness and interest in the flora, which underscores threats but can also potentially lead



Figure 2. *Cyanea grimesiana* subsp. *obatae* is a member of Hawaiʻi's largest radiation resulting from a single species colonization event. The lobelioids in Hawaiʻi include 6 genera and ≈ 130 species, all of which are endemic to the islands. *Cyanea* is the most species-rich genus in the radiation, comprised of 80 currently recognized taxa (54 of which are state and federally listed as threatened or endangered). *C. grimesiana* subsp. *obatae* was discovered in 1964 in the Waiʻānae Mountains and is one of two subgenera of *C. grimesiana*. The Oʻahu Army Natural Resource Program leads the management for this beautiful and exceptionally rare member of the bell-flower family.



Figure 3. *Silene perlmanii* was discovered on O‘ahu in 1987 by expert botanist, Steve Perlman. The species is endemic to O‘ahu, and very narrowly endemic to a small habitat range in the Wai‘anae Mountains. *Silene perlmanii* apparently went extinct in the wild in 1996. Luckily, fruit had been collected from this species before was lost forever. Several outplanting attempts have been made, but so far none have proven to be long-term success stories. The Plant Extinction Prevention Program continues to try new approaches to attempting to restore this species in the wild.

to new sources of funding for greater conservation efforts.”

The work wasn’t over when the workshop came to an end. This was only the beginning. Going through the whole process together gave us a clear idea of what Red Listing takes, allowing us to establish realistic goals on how to continue assessing the hundreds of other Hawaiian plant species in a strategic and timely way, with a push to get as many done before the World Conservation Congress convenes in September. The groups on Kaua‘i and O‘ahu continued working throughout 2015 to compile necessary information on additional plant species for assessments (e.g., number of subpopulations, area of occupancy, etc.) and got together during scheduled meeting days

to conduct Red List assessments and reviews. We are continuing these efforts in 2016 as well.

In light of this positive experience, the BSA Public Policy Committee is facilitating a workshop for Botany 2016: “IUCN Red List Assessment Training and Bioblitz” (<http://www.botanyconference.org/workshops.html#WS2>). As botanists in the BSA and other national societies, we can participate in an important global biodiversity initiative and contribute to international conservation goals by conducting Red List assessments of the species that we know best. The workshop will be a full day, led by Dr. Schatz, with sponsorship from BSA. Prior to the workshop, participants will be required to complete online training in Red List assessment methodology, and come prepared with data on their species, including occurrences, population size, and threats. The morning session will include a review of terms, categories, criteria, concepts, and some examples. In the afternoon session, participants will assess species on their own or in small groups with assistance from the workshop leader. By the end of the workshop, each participant should have a Red List assessment ready to submit to IUCN. If you are interested in becoming an official Red List Assessor for your specialty region or taxonomic group, please consider attending!

Important Links

- **International Union for Conservation of Nature (IUCN):** <http://www.iucn.org/>
- **IUCN Red List:** <http://www.iucnredlist.org/>
- **IUCN Red List Assessment Training and Bioblitz workshop at Botany 2016 Workshop:** <http://www.botanyconference.org/workshops.html#WS2>

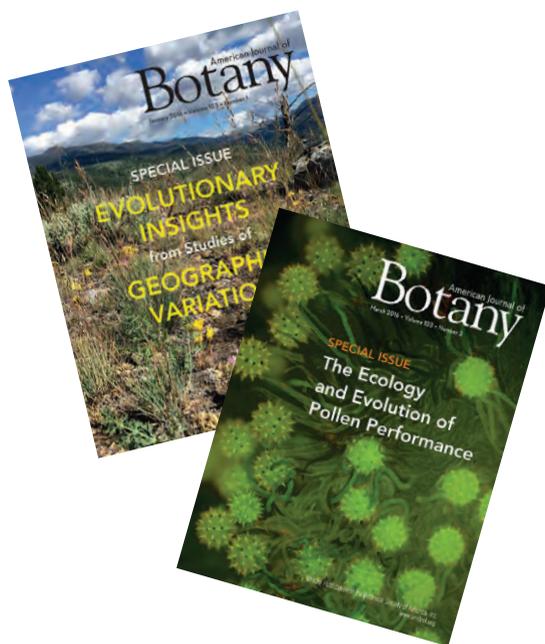
The *American Journal of Botany* Kicks Off 2016 with Two Special Issues

The *American Journal of Botany* features not one, but two, special themed issues in the first quarter of 2016—with another on its way by the end of the year.

In January 2016, *AJB* published “Evolutionary Insights from Studies of Geographic Variation.” The issue editors assembled a set of original research articles and reviews with the goal of underscoring the unique insights that can be obtained through the complementary and distinct studies of plant populations across species’ geographic ranges. The papers in this issue use diverse approaches, both classic and contemporary, to illuminate patterns of phenotypic and genetic variation, probe the underlying evolutionary processes that have contributed to these patterns, build predictive models, and test evolutionary hypotheses.

“In 50 years, I hope that researchers will look back with appreciation for the effort we have made to establish a baseline of information, push the envelope with new modeling approaches, and provide a seed resource that has created research opportunities that otherwise would not have been possible,” said lead Special Issue Editor Julie Etterson.

AJB published another Special Issue in March, “The Ecology and Evolution of Pollen Performance.” This issue, under the direction of editors Joseph Williams and Susan Mazer, highlights new (and seemingly disparate) insights into the ecology and evolution of pollen performance. Broad areas include macro- and micro-evolutionary studies, ecology, and especially mechanistic studies of pollen development and growth as they relate to performance.



“From pollination through fertilization, male gametophytes engage in or experience almost every ecological and evolutionary process for which there are many examples among their sporophytic counterparts, including allelopathy, competition, facilitation, natural selection, and sudden death,” said Mazer. “We expect that this special issue will hold surprises for those who haven’t been closely tracking research on variation in pollen performance and its evolutionary potential since its earlier heyday in the 1970s and ’80s.”

Be on the lookout for yet another *AJB* Special Issue later this year, “The Evolutionary Importance of Polyploidy,” with Special Issue Editors Michael Barker, Brian Husband, and J. Chris Pires, as well as more to come in 2017. Be sure to check out our “On the Nature of Things” essays and Highlights in other issues throughout the year.

Special Issue editors work under the guidance of Editor-in-Chief Pamela Diggle. If you have suggestions for Special Issues, or essays that explore new ideas, new research directions, or established areas with the potential for new questions, please contact Pamela at ajb@botany.org.

New bush tomato species is the link between botany and an Oscar-nominated Hollywood movie

(Note: This press release was originally posted online by Pensoft Publishers on February 25, 2016 at http://www.eurekaalert.org/pub_releases/2016-02/pp-nbt022316.php.)

A new Australian bush tomato species, discovered by a team of researchers led by biology professor Chris Martine of Bucknell University, has been named after main character Mark Watney from the book and film *The Martian*. The authors, among whom is the undergraduate student Emma Frawley, have published the new species in the open-access journal *PhytoKeys*.

Martine announced the new name, *Solanum watneyi*, in *The Huffington Post* last year when he described it as a tribute to the heroic portrayal of Watney as a NASA botanist and engineer who saves himself with plant science expertise after being stranded on Mars.

In fact, Matt Damon's botanist character impressed both the audience and the critics so much that it resulted in several Academy Awards nominations to the whole production team. The actor himself received a Golden Globe among many other prestigious recognitions including the BAFTA for Best Actor and the Critics' Choice Award for Best Actor.

"This is a botanist portrayal that turns an unusually bright spotlight on authentic scientific endeavor," Martine explains the choice. "Scientist heroes are already unusual in Holly-

wood, but a space-deserted protagonist who studies plants as a profession is something extraordinary."

However, according to Martine, the decision to name the species after Watney also has some taxonomic relevance.

"The plant that Watney manages to grow on Mars is none other than *Solanum tuberosum* (the potato), a member of the same genus as our new species," he says.

This connection was not missed by Andy Weir, author of the book-turned-movie and father of the Watney character, who expressed his approval of the name on his Facebook page.

"What higher honor could a botanist like Watney ask for than to have a plant named after him?" writes Weir. "And to have it be a relative of the potato as well? Perfect!"

Martine collected specimens of the new species during a six-week expedition to the Northern Territory of Australia with his wife, Rachel, and their two children. Rachel drew the illustration of the species that appears in the *PhytoKeys* paper.

In order to make sure the new species is not in fact a previously known and closely related *Solanum* species, the family team collected hundreds of seeds of both species. Thus, the plants could be grown and compared side-by-side in a research greenhouse.

In the summer of 2015, Bucknell undergraduate student Emma Frawley, class 2017, studied

the plants, ultimately gathering and analyzing enough morphometric data to confirm the distinctiveness of *Solanum watneyi*. This is how Frawley, a double major in environmental studies and Spanish, became a co-author of the present paper.

The new species occurs in and around the western part of Judbarra/Gregory National Park, where it was occasionally encountered by regional botanists who nicknamed the oddball plant “Bullita” after the cattle station that once operated in the area.

“The nickname started being applied in the 1970s,” said Martine, who studied historical collections of the plant at the Northern Territory Herbarium. “But no one had yet done statistical comparisons between that plant and its similar relative.”

Watney is not the only one being recognized by the botanical community following the release of *The Martian*. In recognition of his botanist star turn, the Botanical Society of America has extended an honorary membership to actor Matt Damon, who portrays the space botanist in the film.



A bush tomato specimen of the new species Solanum watneyi.

Photo by Dr. Christopher Martine



Citizen Science Helps Botany Flourish¹

Abstract

Citizen science involves the participation of the public in supporting scientific research. With the advent of online data collection and the digitization of information about specimens, citizen science has burgeoned. This article deals with how the botanical community is responding to this surge, what kinds of projects are being developed, and why this is important to the future of natural history collections, environmental studies, and the creation of a public interested in plant research.

Key Words

citizen science; climate change; data collection; phenology; specimen digitization

Footnotes

¹ Manuscript received 15 October 2015; revision accepted 17 December 2015.

² The author thanks Gordon Uno and Mackenzie Taylor for encouragement of this project, and Kim Watson, Mari Roberts, and Liz Kiernan at New York Botanical Garden for their patience in making me into a citizen scientist.

doi: 10.3732/psb.1500003

By Maura C. Flannery

St. John's University, Jamaica, NY

I first became aware of the surge of interest in citizen science in 2010 with an article in *BioScience* by Amy Mayer on volunteer efforts to document phenology. The term “citizen science” probably originated at Cornell University, where amateur birders have long been an important part of the Cornell Lab of Ornithology’s projects in tracking avian populations and their behaviors (Mayer, 2010). However, age-old involvement of nonspecialists in natural history is at the very foundations of citizen science. From the 16th to the 19th centuries, there were very few specialists, but there were many people living with nature and keeping mental if not written records of their observations. Particularly in the 19th century, as more people became literate and had at least some leisure time, observing—and collecting—organisms was a popular pastime (Barber, 1980). The specimens collected and the notes taken are now a valuable record of the natural world at that time, and many of these records were kept by farmers and laborers, businessmen, doctors, and lawyers (Keeney, 1992). Often the motivation was religious or at least moral: Studying nature was a way to know nature’s creator and to lead an upstanding life away from the lures of vice.

Today, citizen science has different but related motives: to document nature in order to assist in efforts to preserve and protect it. This is just one of several reasons for the current surge in interest. The ever-more-apparent effects of global warming have encouraged people to do something about the problem. One way is to learn more about nature, particularly close to home. While for some, nature means wilderness, more individuals are valuing organisms they encounter close to home; they realize these living things can tell us much about environmental change. Another of the major spurs for present-day citizen science is the ubiquity of digital devices and the resultant ease of recording observations and participating in large-scale efforts to document nature. In response to this availability, an increasing number of interactive websites allow observers to input observations. The proliferation of such sites has led to a need to coordinate them. This is one aim of projects like iNaturalist (<http://www.inaturalist.org/>) from the California Academy of Sciences and the National Phenology Network, a federally sponsored program with the Nature's Notebook project (https://www.usanpn.org/natures_notebook). This is an online program where amateurs and professional naturalists record observations of plants and animals to generate long-term data sets.

There are also projects created by natural history museums, botanical gardens, and other institutions to digitize the information on specimen labels, and often including images. Entering data from hand-written labels and photographing herbarium sheets are both labor-intensive processes that don't require a great deal of expert knowledge; they are perfect for citizen science. More and more such databases exist, especially since the National Science Foundation began the 10-year, mul-

timillion dollar program Advancing Digitization of Biological Collections (ADBC; <https://www.idigbio.org/content/advancing-digitization-biodiversity-collections-adbc-overview>), in an effort to make specimens available to larger and more diverse audiences. I myself have a small part in the Tri-Trophic Thematic Collection Network at the New York Botanical Garden (<http://tcn.amnh.org>).

This funding has led to still another major spur to public participation, the creation of several web-based projects for hosting digital citizen science projects. One of the largest is Zooniverse (<https://www.zooniverse.org>), which administers projects in a number of fields. As far as botany is concerned, there are portals within Zooniverse for transcribing herbarium specimen label data as well as ones that deal with recording natural history field observations such as flowering times or occurrence of invasive species. All of these activities can also be pursued through other sites, including DigiVol (<http://volunteer.ala.org.au>), based in Australia but with instances in many other countries, and Herbaria@home (<http://herbariaunited.org/atHome/>) in Britain. There are even projects, such as one on rare British orchids, that involve both field observations and digitizing existing records (<http://www.theguardian.com/science/grrl-scientist/2015/jul/21/orchid-observers>).

The retirement of baby boomers now seeking interesting and worthwhile ways to spend free time makes for an increasing audience for such sites. Citizen science projects can be intriguing and lead to closer observation of and greater involvement with nature. At the other end of the age spectrum are teenagers and college students who use such projects to fulfill service learning requirements and to gain online experience, providing market-

able skills (<http://microplants.fieldmuseum.org/#/education>). If citizen science programs both in the field and online are to become sustainable, young people are particularly important. Their engagement could lead to lifetime involvement in such work and interest among their children and grandchildren. The Microplants project (<http://microplants.fieldmuseum.org/>) at the Field Museum is a particularly sophisticated example of having students, both in high school and college, become citizen investigators. They are taught to identify and measure liverwort structures in photographs taken under the microscope; the aim is to obtain data from a large sample in an effort to sort specimens into different species.

The last, but certainly not the least, important reason for citizen science's rise is that the free labor it provides is attractive to researchers who are always on tight budgets. In the current funding environment, this becomes an even more significant factor, especially with the enormity of the job that needs to be done. There are literally billions of natural history specimens stored away in collections around the world. Their labels contain information on what was living where at a particular time—information that becomes more significant as the pace of environmental change quickens.

Projects

One area that has been particularly popular in online citizen science is the transcription of field notes and other records. The Smithsonian Institution has a Transcription Center (<https://transcription.si.edu/>), a hub for their projects that include many types of historical records. This center highlights the similarities between citizen science projects and those in the digital humanities. The Smithso-

nian's multi-year Field Book Project (<http://www.mnh.si.edu/rc/fieldbooks/about.html>), administered through the National Museum of Natural History, involves digitization of hundreds of field books created by Smithsonian scientists. Having them available online is a tremendous boon, but their value increases when their content is transcribed and made searchable. Public participation in these efforts has become so popular that administrators have to keep posting new notebooks since transcribers often finish the job quickly. Lorna Hughes (2014) notes that the greatest benefit of such endeavors might be not the transcribed documents but rather the transformation of people's experience of interaction with digital collections and of collaborating to produce new knowledge. With greater engagement in primary sources can come a democratization of research, something that was very much the case in 19th-century natural history, when women in the Great Plains were sending specimens to Asa Gray and Australian pioneers were corresponding with Joseph Hooker.

The Field Book Project now has become allied with the Biodiversity Heritage Library (BHL; <http://www.mnh.si.edu/rc/fieldbooks/about.html>), a massive repository for online biodiversity literature. Many libraries and natural history institutions around the world have contributed to BHL, but here again, transcription and tagging can make this repository even more useful. In this regard, BHL has several citizen science initiatives including Science Gossip (<http://www.sciencegossip.org/>), a Zooniverse project to tag images in 19th-century popular science journals including *Science Gossip*, *The Intellectual Observers*, and *Recreative Science*. BHL also has teamed with the gaming company, Tiltfactor, to produce two online games, Smorball and Bean-

stalk, that combine transcription work with gaming to keep volunteers interested and involved (Duke, 2015).

Attention to volunteers is an important aspect of citizen science projects. Most online projects require a simple registration process to screen out the truly marginal; however, if the work is not fun or interesting, or in some way rewarding, people will not stick with it long enough to make a significant contribution. Most projects have “power users,” a small percentage of participants who contribute a significant percentage of the output. Learning the motivation of these individuals—whether filling idle time, learning more about the living world, or using prior knowledge—is important in developing ways to attract more participants. Projects often provide incentives such as invitations to onsite events, conversations with scientists, free books or t-shirts, or online badges or certificates.

Another important issue is ensuring the quality of the information that volunteers are providing, whether it be nature observations or transcriptions. In some cases, observers are trained either online or in person in the correct way to record data. For transcriptions, many sites are set up so that the same material is transcribed two or three times, and the versions then reconciled. These approaches are time-intensive and require input from experts, but they are vital to the integrity of the data. New forms of datametrics and other data-quality tools are making evaluating this information more sophisticated (Peaker, 2015). Many working on these projects argue that the way to ensure integrity is to treat volunteers as collaborators by providing training support, recognition, and opportunities for dialogue. Efforts in this area have become more sophisticated, and participants are now seen as more

than sources of cheap labor. As portals such as Zooniverse become more advanced, the opportunities for collaboration increase (Jordan et al., 2015). For example, there are online discussion forums where participants can get their questions answered and their difficulties ironed out.

Broadening the Field

Many projects now have apps for mobile devices, especially those dealing with field observations. These devices make data entry much easier and more timely, and mapping apps provide simple means to record the precise location of an observation or a specimen collection. There are efforts worldwide to enlist the public in entering information about sites of pollution problems or other environmental concerns. Some observers contend that the success of the UN’s Sustainable Development Goals (SDGs) will depend on masses of environmental information that can only be provided by large cadres of volunteers around the world (Hsu et al., 2014). For example, the World Water Monitoring Challenge relies on the public to record local water quality and share results. There are even projects that encourage fishermen and boaters to monitor plankton abundance. Mobile apps make projects attractive to the young and also to those who are seriously committed to environmental protection (Bonney et al., 2014). This accessibility does bring up an issue that worries some in the field: Are a few participants *too* interested, in the sense that they come to this work with an axe to grind or a political agenda to advance? When Australian scientists asked volunteers monitoring koalas how the animals should be managed, the views of the citizen sciences did not reflect those of the population at large (Rise of the Citizen Scientist,

2015). Such biases could call into question the integrity of the data, although data analysis as quality control should be able to guard against this problem.

As with any data, that generated by citizen scientists will not be perfect; however, if data are abundant enough, anomalies become less problematic. It's important to keep in mind that many citizen science initiatives, particularly those that are web based, are relatively new, and therefore they are sure to improve in the years ahead, both in terms of design and administration. Citizen science components now are being built into many grant proposals, not only to increase the amount of work that can be accomplished, but also to ensure that the public becomes more aware of the outcomes and challenges of scientific research (Bonney et al., 2014). Volunteer participation may turn out to be a particularly effective way to create a citizenry more positive about spending money on science. They will come to understand that science is something that not only affects them, but also to which they can make a significant contribution. In addition there is evidence that collecting data about the natural world makes the collectors more precise observers of nature (Mayer, 2010). They see more and therefore come to appreciate the complexity and beauty of the life around them.

Plants are particularly good objects of observation, especially for the novice, since they do not flit or fly way before the observation is complete. Also, not to be botanically chauvinistic, but there is just much more plant than animal life to see on a walk in the woods, whether looking up, down, or straight ahead. For example, consider focusing on tree bark lichens. They are easy to miss, especially in speeding auto or being pulled along by a dog. However, on closer examination, there is a

Citizen science, no matter its institutional framework, can be a powerful force for bringing natural history back into the cultural limelight...Making careful observations of nature, digitizing information from natural history collections, and transcribing the literature in libraries are ways to promote the public good.

wonderful, textured world on the bark of many trees. It can be so fascinating that taking mental notes on observations can easily lead to keeping more permanent records, and even to joining a citizen science project to share them.

Citizen science has grown sufficiently and has become such a broad area that many now see it as a distinct discipline (Jordan et al., 2015). They argue that the close partnership of experts and amateurs makes this field unique: It possesses unique capacities and faces challenges that need to be carefully explored by practitioners as well as by those in such fields as science studies. There is now a Citizen Science Association (<http://citizenscienceassociation.org/>) that is planning a peer-reviewed journal. I would like to argue that citizen science, no matter its institutional framework, can be a powerful force for bringing natural

history back into the cultural limelight. In the 19th century, many people studied nature as a way to approach God. Today, theologians like Elizabeth Johnson (2014) are presenting arguments for preserving nature as necessary for our spiritual as well as physical well-being. There are also biologists such as Ursula Goodenough (1998) who are making similar points. The Evangelical Lutheran Church in America's "Caring for Creation" is an environmental movement that melds natural history with spirituality (<http://www.elca.org/Faith/Faith-and-Society/Social-Statements/Caring-for-Creation>).

I am not going to take that tack, but instead argue from the emphasis today on civic engagement. Making careful observations of nature, digitizing information from natural history collections, and transcribing the literature in libraries are ways to promote the public good. They are good things to do, and just as in the 19th century when what was good was also healthy and fun, the same can be true today. Programs such as iNaturalist and Project Budburst (<http://budburst.org/>) provide outdoor exercise, entertainment, and education opportunities for people of all ages who in addition are making a contribution to knowledge about the environment. The success of these endeavors bodes well for this movement in the future.

Literature Cited

- Barber, L. 1980. *The Heyday of Natural History*. Garden City, NY: Doubleday.
- Bonney, R., Shirk, J. L., Phillips, T. B., Wiggins, A., Ballard, H. L., Miller-Rushing, A. J., & Parrish, J. K. 2014. Next steps for citizen science. *Science* 343: 1436–1437.
- Duke, G. 2015. Smorball and Beanstalk: Games that aren't just fun to play but help science too. Website <http://blog.biodiversitylibrary.org/2015/08/smorball-and-beanstalk-games-that-arent.html> [accessed 4 October 2015].
- Goodenough, U. 1998. *The Sacred Depths of Nature*. New York: Oxford University Press.
- Hsu, A., Malik, O., Johnson, L., & Esty, D. C. 2014. Mobilize citizens to track sustainability. *Nature*, 508: 33–35.
- Hughes, L. 2014. Digital Collections as Research Infrastructure. Website <http://www.educause.edu/ero/article/digital-collections-research-infrastructure> [accessed 4 October 2015].
- Johnson, E. A. 2014. *Ask the Beasts: Darwin and the God of Love*. New York, NY: Bloomsbury.
- Jordan, R., Crall, A., Gray, S., Phillips, T., & Mellor, D. 2015. Citizen Science as a distinct Field of Inquiry. *BioScience* 65: 208–211.
- Keeney, E. 1992. *The Botanizers: Amateur Scientists in Nineteenth-Century America*. Chapel Hill, NC: University of North Carolina Press.
- Mayer, A. 2010. Phenology and citizen science. *BioScience* 60: 172–175.
- Peaker, A. 2015. Crowdsourcing and community engagement. *Educause Review* 50 (6): 90-91. Rise of the Citizen Scientist. *Nature* 524: 265.

Botanical Society Engagement in Citizen Science

There is no doubt that fostering public engagement in botany is becoming an integral part of the job for many professional botanists. As Maura Flannery discusses in her essay (previously in this section), projects that enlist the general public in a significant and authentic way yield numerous rewards for both the researchers and the participants involved. Many members of the Botanical Society of America are developing such projects or are partnering with organizations that oversee them. In this issue of *Plant Science Bulletin*, we are proud to showcase a selection of these projects.

Collaboration Engages Local Citizen Scientists

Riverside Citizen Science (RCS) is an environmental education and stewardship program that engages the community in scientific observation and research in order to better connect people to the natural world. The program was created by a partnership of agencies that teamed up to facilitate natural resource documentation and research through hands-on science activities and community participation. The partners represent national, regional, and local organizations and include: the Riverside-Corona Resource Conservation District; the University of California at Riverside; the USDA, Forest Service, Pacific Southwest Research, Riverside; the Riverside Metropolitan Museum; and the City of Riverside Parks, Recreation, and Community Services Department. The partners developed a strategic plan and made a long-term commitment to work together by signing a Memorandum of Understanding.

Funding

The strategic planning process was facilitated by the National Park Service through a Rivers,

Trails, and Conservation Assistance Program grant that provided two years of assistance from a project manager to lead the development of the plan.

A major milestone was reached with the construction of the city's first nature center which serves as a field station for the RCS program. Funding came from the Prop 84 Nature Education Facilities Program. A second grant through the California State Parks provided initial staffing of the facility.

Currently, RCS partners share intellectual and physical resources. For example, the museum curator of natural history may call upon a local partner to help identify a plant or animal for the Nature Spotter app. But to date, one or another partner has taken the lead on coordinating and providing staff time/funding for each new endeavor. Each agency has been able to bring some resources to support RCS, but the partners are currently working to:

- Develop diverse funding sources to provide ongoing support for the citizen science program
- Recruit and train volunteers that can help lead programs

- Form collaborative relationships with new stakeholders, especially researchers at local colleges.

Because the museum has recently received funding to facilitate local California Naturalist training, one of our strategies is to solicit participation from the graduates of the program to assist with leading RCS projects.

Projects

Some current RCS projects include: Riverside Nature Spotter, Operation Tree Canopy (now Focal Trees), Bluebird Nest Box Monitoring, and local Bio-Blitzes.

The Riverside Nature Spotter smartphone application was developed by Riverside's Innovation and Technology Department. With the app (or with a camera), citizen scientists photograph animals and plants and submit the photos that are then identified (if needed), mapped, and stored at www.inaturalist.org/projects/riverside-citizen-science. The app is available for free download for both iPhone and Android systems.

The RCS collaborative approach has been effective at raising awareness about the multitude of citizen science projects that are available to the public.

Operation Tree Canopy was the local initiative to support Earthwatch Institute's Urban Forest Resiliency project. Operation Tree Canopy involved citizen scientists who collected research data to help scientists study the cool-

ing effect of different species of urban trees. During the summer of 2015, an RCS partner the Riverside-Corona Resource Conservation District hosted training and coordinated local volunteers who collected leaf samples and tree data including location, size, species, and condition. The ground data were used by UC Riverside scientists to verify photos that were taken during high altitude fly-overs by NASA. Thanks to the work of citizen scientists, research data were collected from over 1300 trees in 45 urban spaces throughout the greater Los Angeles region, including Riverside (Figure 1).

Focal Trees is the newest phase of the Urban Forest Resiliency project, and it is focused on collecting data from 10 specific tree species. RCS is helping to promote and facilitate for the Focal Trees Program locally (Figure 2).

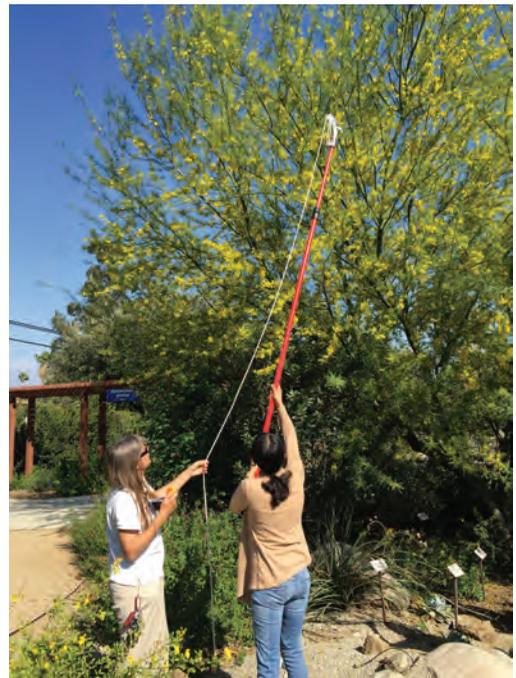


Figure 1. RCS volunteers learned to measure trees and collect leaf samples for Earthwatch Institute's Urban Forest Resiliency project at the LandUse Learning Center in Riverside, California.

RCS partners have conducted Bio-Blitzes (with many partners) to help document local resources, as well as to help US Forest Service researchers collect data about how to plan and deliver more effective events to connect youth with nature.

The RCS collaborative approach has been effective at raising awareness about the multitude of citizen science projects that are available to the public. The partnership has also brought together stakeholders to help with local to international projects that educate citizens and help researchers collect data. As RCS is still in its infancy, the partners continue working together to achieve their mission: “...to engage our community in observing and documenting Riverside’s natural environment. This program fosters appreciation and stewardship by staging and supporting nature centered activities. Science, through community participation and collaboration, becomes a permanent part of our city’s culture and identity” (Figure 3).

*By Diana Ruiz
Riverside-Corona Resource Conservation District, ruiz@rcrcd.org; www.rcrcd.org*



Figure 2. Riverside’s Envirothon team from Arlington High School helped collect data and leaf samples that were then delivered to UC Riverside scientists.



Figure 3. The Inland Urban Forest Council helped local volunteers identify tree species for the Focal Trees data collection program.

Citizen Science Projects and Platforms

There are a variety of projects available for people of all ages and interests who desire to participate in crowd-sourced science. The websites below provide information about a sampling of those projects, both for those interested in getting involved as a participant and for researchers who are interested in designing a “people-powered” project.

- Citizen Science Alliance: <http://www.citizensciencealliance.org/>
- eBird (Cornell Lab of Ornithology): <http://ebird.org/content/ebird/>
- FrogWatch USA: <https://www.aza.org/frogwatch/>
- Herbaria@home: <http://herbariaunited.org/atHome/>
- Les herbonautes: <http://lesherbonautes.mnhn.fr/>
- Monarch Larva Monitoring Project: <http://www.mlmp.org/>
- Notes from Nature: <http://www.notes-fromnature.org/>
- Riverside Citizen Science <http://www.inaturalist.org/projects/riverside-citizen-science>
- Scientific American: <http://www.scientificamerican.com/citizen-science/>
- SciStarter: <http://scistarter.com/index.html>
- The Smithsonian Transcription Center: <https://transcription.si.edu/>
- Symbiota: <http://symbiota.org/docs/>
- WeDigBio: <https://www.wedigbio.org/>
- Zooniverse: <https://www.zooniverse.org/projects>

Internet-Scale Citizen Science Through the Worldwide Engagement for Digitizing Biocollections (WeDigBio) Event

The inaugural Worldwide Engagement for Digitizing Biocollections (WeDigBio) Event engaged hundreds of volunteers onsite and online in transcribing biodiversity specimen labels. Over four days (October 22–25, 2015), volunteers around the world completed more than 30,000 transcription tasks using online transcription platforms. Many volunteers attended onsite events at one of 25 institutions including the Smithsonian Institution’s National Museum of Natural History, Australian Museum, Field Museum, Florida State University, Natural History Museum of Los Angeles County, Chicago Academy of Sciences, Belgium Botanic Garden Meise, Yale University, New York Botanical Garden, and Florida Museum of Natural History (Figure 1). At these events, many volunteers played transcription games, such as Habitat Bingo and GeoLocator, won small prizes, and received stickers and temporary tattoos. Additionally, individuals in more than 50 countries participated online. All of this activity generated an exciting media buzz. Event organizers, hosts, and volunteers shared photos, stories, and highlights of specimens on the WeDigBio Twitter and Facebook pages.

The transcribed specimens covered a wide variety of taxa: plants, insects, crabs, and birds, to name a few. Thanks in part to the relative ease of imaging herbarium specimens, many online transcription platforms offered botanical projects, and WeDigBio volunteers were



Figure 1. Citizen scientists around the world volunteered in the event. Orange dots show where people were participating and blue circles indicate that numerous people were participating at a given location.

therefore able to transcribe labels from plants collected local to them as well as from exotic locales.

In the months leading up to the event, leaders and programmers made enhancements to the participating online transcription centers—Les Herbonautes (<http://lesherbonautes.mnhn.fr/>), Herbaria@Home (<http://herbariaunited.org/atHome/>), Atlas of Living Australia's DigiVol (<http://volunteer.ala.org.au/>), Smithsonian Institution's Transcription Center (<https://transcription.si.edu/>), Notes from Nature (www.notesfromnature.org/), and Symbiota (<http://symbiota.org/docs/>)—and established connections with the WeDigBio website, wedigbio.org. During the event, the WeDigBio website showed dynamic visualizations of where in the world volunteers

were working, a total tally of activity from each transcription platform, live updates of social media posts, and images of recently transcribed specimens. Information for participants, such as locations of local onsite events and links to taxa-specific online projects, were made available. It was also a place for onsite event hosts to find games, planning and logistical documents, and press materials.

We are developing new resources, educational materials, and improved technologies to provide a richer experience for all of our hosts and volunteers. WeDigBio is open for everyone in the community to participate. Information about participating in WeDigBio 2016, for collections managers, onsite hosts, and participants, will be made available on wedigbio.org, Twitter, and Facebook. Feel free

to contact Libby Ellwood (ellwood@bio.fsu.edu; iDigBio, Florida State University) or Paul Kimberly (kimberlyp@si.edu; Smithsonian Institution) directly.

WeDigBio 2016 is slated for October 20-23, 2016 and we are developing new resources, educational materials, and improved technologies to provide a richer experience for all of our hosts and volunteers.

Additionally, iDigBio hosts two working groups relevant to this topic: the Interoperability for Public Participation in Digitization Working Group (https://www.idigbio.org/wiki/index.php/Interoperability_for_Public_Participation_in_Digitization_Working_Group) and the User Engagement for Public Participation in Digitization Working Group (https://www.idigbio.org/wiki/index.php/User_Engagement_for_Public_Participation_in_Digitization_Working_Group). Contact Libby Ellwood or Austin Mast (amast@bio.fsu.edu; iDigBio, Florida State University), if you are interested in joining those groups.

All are welcome.

*By Libby Ellwood and Austin Mast,
Florida State University*

Volunteer Trufflers

In 2010 and 2011, I had contracts with the Interagency (Forest Service and Bureau of Land Management) Special Status and Sensitive Species Program to look for rare truffles in federal lands in southern Oregon. I stood up at a Native Plant Society meeting, described the project, and asked for volunteers. Three people volunteered. One had driven a UPS truck—he knew all the roads. One had worked for the county looking at sites for rural septic systems—she did dirt. And one was an interested student who turned out to be fantastic in the field. We traveled two counties over several months each year, had a great time, and brought in 600 truffle specimens. When I told them they were “citizen scientists,” they were very pleased. No downside, no problems. I would do this again.

*By Darlene Southworth
Southern Oregon University, Ashland*

Fairchild's Million Orchid Project Aims To Reintroduce Endangered Native Florida Orchids

Native orchids used to cover Florida. Today, their numbers have dwindled so dramatically that they can't recover on their own. Fairchild Tropical Botanic Garden in Coral Gables, FL, aims to solve this problem with the launching of the Million Orchid Project. The project aims to have the first generation of reestablished orchids blooming throughout public spaces in South Florida within five years. Scientists and volunteers at Fairchild have joined with the community in the pursuit of generating a limitless supply of native orchids using micropropagation techniques. These orchid species include the butterfly orchid (*Encyclia tampensis*), cowhorn orchid (*Cyrtopodium punctatum*), cockleshell orchid (*Prosthechea cochleata*), and pine pink orchid (*Bletia purpurea*). More will be added as the project progresses.

Beginning in the late 1800s, native orchids were torn from the trees they grew on and were shipped across the U.S. to those who coveted their exotic-looking blooms. Now, it is rare to see native orchids growing in the wild. Fairchild's Micropropagation Lab (Figure 1), which is where the project began when it opened in December 2012 as part of the Jane Hsiao Laboratories in the DiMare Science Village, is where the majority of the Million Orchid Project is taking place to ensure the repopulation of native species. Volunteers who have diverse backgrounds in science and horticulture are donating their time and knowledge testing different growing conditions in the lab to see which ones work best.

First, the seed pod—which can generate more than 12,000 seeds—is sterilized to ensure no contamination. Once it is opened, the seeds are placed in flasks containing a mixture including agar, charcoal, and banana powder. It takes about three months before the seeds begin to sprout. Once they outgrow their bottles, the seedlings are carefully transferred by hand to larger bottles. Then, they are transplanted to the Fairchild Nursery, where they continue to grow in mulch-filled baskets until they are ready to grow on trees. There are currently more than 1000 flasks in the lab at Fairchild. The model for the project is inspired by the one used by Singapore Botanic Gardens, where they found that propagated orchids grew just as well on city trees as they did in natural areas.

Dr. Carl Lewis, Director of Fairchild, is spearheading the Million Orchid Project. What makes this project different from other micropropagation initiatives is its focus on reintroducing native orchids into urban environments—schools, roadways, neighborhoods, etc.—to balance the work being done in natural areas. Thus, the public will be directly involved in the process. “The community will play a large part in the reintroduction,” Dr. Lewis said.



Figure 1. Native orchids seedlings in the Micropropagation Lab at Fairchild Garden.

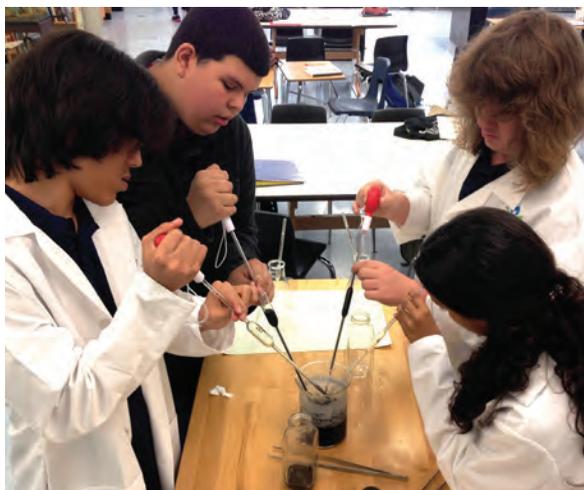


Figure 2. *BioTECH and Richmond Heights High School students prepare a solution for propagating orchids.*

The educational component of the project is one of large scale. Terra Environmental Research Institute, a public high school in Miami-Dade County, was the pilot school for integrating the Million Orchid Project into a classroom setting. In October 2013, Fairchild installed 10,000 orchid seedlings in the school for students to observe and grow. They continued to thrive and were then planted in the trees around the school in July 2014, where they are estimated to produce flowers in three to five years. Due to its success, the project was replicated in October 2014 in more than 30 Miami-Dade County schools that participate in The Fairchild Challenge, the multidisciplinary environmental education outreach program that more than 130,000 students compete in each year. To date, Fairchild has provided lab units to more than 100 middle and high schools (Figure 2).

For more info, please visit the Million Orchid Project webpage at <http://www.fairchild-garden.org/science-conservation/the-million-orchid-project>.

By Brooke LeMaire, Marketing Associate, Fairchild Tropical Botanic Garden

Fairchild Garden Launches Partnership with NASA

Fairchild Tropical Botanic Garden is pleased to partner with the National Aeronautics and Space Administration (NASA). For the 2015-2016 academic year, scientists and educators at Fairchild and NASA are administering plant experiments for middle and high school students participating in The Fairchild Challenge (Figure 1), an award-winning environmental science competition based in Miami, to determine which edible plants might be suitable for growth in microgravity aboard the International Space Station's plant growth facility, Veggie. As the project develops, it may help to provide a more sustainable food supply for future long-term missions, perhaps even those en route to Mars.

“Since ancient times, people have been moving plants and adapting them to new environments,” said Dr. Carl Lewis, Fairchild’s Director. “It’s thrilling to think that plants grown in South Florida classrooms may someday help sustain human life in space, on Mars, and beyond.”

The purpose of the experiments designed by The Fairchild Challenge students is to expand food options and increase plant diversity by testing multiple edible plants that meet NASA’s criteria for size and edibility. Using equipment that mimics the environmental conditions aboard the International Space Station, students test factors that may influence plant growth, flavor, and nutrition. NASA will use students’ data to determine which plants they should begin growing in space on the Veggie facility.



Figure 1. *Teacher participants of The Fairchild Challenge identify seeds to use in their botany labs at the NASA-Fairchild workshop.*

Veggie is a compact, LED-lit plant growth facility in the International Space Station jointly developed by NASA and Orbital Technologies Corporation. On August 10, 2015, astronauts in the International Space Station livestreamed a video of themselves harvesting and eating the first produce grown in microgravity: red romaine lettuce.

“The Veggie team is excited to think that The Fairchild Challenge students will help to find new crops that will nourish astronauts in the future on the International Space Station and someday when we explore Mars,” said Dr. Gioia Massa, Project Scientist at NASA.

Dr. Massa and her colleagues Trent Smith, Dr. Wanda Jones, and Dr. Lester Morales joined Fairchild staff in introducing the project to interested teachers on August 29 at The Fairchild Challenge Teachers’ Information Brunch. A dedicated NASA-led teacher workshop was then held at Fairchild on September 26 to provide teachers from 124 South Florida schools with the necessary training to carry out the project in their classrooms. Each school was given shelving units, seeds, lights, and other equipment needed for students to conduct research.

“This is an innovative and groundbreaking program that will give students an opportunity to participate in authentic research that has practical importance and long-term ramifications,” said Amy Padolf, Director of Education at Fairchild. “This is the new face of science education.”

Offered free of charge, The Fairchild Challenge was created in 2002 as an environmental science outreach program for elementary, middle, and high school students. Designed as a competition that appeals to students’ intellectual curiosity, The Fairchild Challenge encourages students to appreciate the beauty and value of nature and learn about environmental issues, to research possible solutions and evaluate them critically, to modify their own behavior, and to become actively engaged citizens. It currently involves more than 130,000 students from more than 300 schools including global satellite partners.

For more information, please visit www.fairchildgarden.org/Education/The-Fairchild-Challenge.

By Brooke LeMaire, Marketing Associate, Fairchild Tropical Botanic Garden

RETurn to the Classroom: Linking Science Teaching and Science Experience for Pre- and In-service High School Science Teachers

We all hope, I think, that our work might have some impact on the world we live in. This is also the expectation of funding agencies, such as the National Science Foundation, and their expectation is formalized in the broader impacts sections required for NSF grant proposals. I have not always managed to produce compelling broader impacts sections, but I want to tell you about our current funded project where we are working to improve high school science education, together with some of the successful strategies and pitfalls we have discovered along the way.

Let me start off by saying that I believe we need scientifically literate citizens who understand the motives, practice, and mind-set of science, because the ability to use and understand science is vital to successfully resolving many of the issues that face us as individuals, as a society, and as a planet. But clearly a scientific mindset is not used, or even valued, by large sections of our society. My feeling (supported by data) is that at the root of this is a fear of science and scientists and a real ignorance of the nature of science (Schwartz & Lederman, 2008). Movements like citizen science seek to dispel this ignorance by actively involving the public in real science, but I still think that without addressing the central issue of the attitudes and belief of the public about science, even these movements will only be partially effective. These problems are what we hope to

positively affect through our education efforts.

We have been involved in a relatively novel experiment to train high school in-service science teachers and pre-service science teachers (science education majors) to better understand and inhabit the scientific world they are or will be teaching, as a result of posing the question, “What are the barriers to a critical understanding of science and scientific issues?” In part because I work with a wonderful and deeply experienced professor of high school science education, I have come to see that students lack understanding about just what science is and how it works. The education community has realized this and has created the newly released Next Generation Science Standards (NGSS) (NGSS Lead States, 2013), which explicitly link content standards to science and engineering practices and are embedded with aspects of the nature of science. The NGSS are awesome, connecting ideas across disciplines and encouraging students to *do* science rather than just *hear* about it. Twenty-six states helped design the NGSS, and I believe that, properly implemented and taught, the NGSS will be instrumental in changing students’ (and by extension, the general public’s) views about science and scientists.

The question really is, however, *who will properly implement and teach them?* Are today’s in-service and pre-service science teachers sufficiently trained and experienced to give students the support they need to implement the pedagogy addressed in the NGSS? We think, in some ways at least, that they are

By Andrew Doust
Oklahoma State University

not. Studies have shown that, in general, high school science teachers are effective at teaching science content but struggle to articulate the views of the nature of science accepted by the education community or to model what it feels like to actually *do* science (Abd-El-Khalick & Lederman, 2000; Akerson, Abd-El-Khalick & Lederman, 2000; Lederman, 1992). This is a key area in which scientists and science teacher educators can improve the understanding and acceptance of science by high school students. These students may or may not be on a scientific career path, but they will all form part of the general public that needs to be able to use scientific principles to judge what courses of action are most appropriate for the many problems that beset the world today.

Understanding views on the nature of science and appreciating what research feels like are

We need scientifically literate citizens who understand the motives, practice, and mind-set of science, because the ability to use and understand science is vital to successfully resolving many of the issues that face us as individuals, as a society, and as a planet.

attitudes that can only be cultivated through a combination of research experiences and reflection on those experiences. In the sciences, we bring students into the lab in order

for them to experience research, and a similar motivation is behind the well-established NSF Research Experience for Teachers (RET) program. Such programs can definitely offer a glimpse of authentic research, but it turns out that a research experience alone is rarely enough to promote understanding about what science is. In addition, it is also difficult to translate research experiences into classroom curricula. With this in mind, we set out to address the question of how to instill in teachers the sense of what it means to be a scientist, and how teachers might best convey that sense to their students.

Our teacher education goals are embedded in the broader impacts section of an NSF Plant Genome grant, whose scientific goals are focused on understanding the genetic regulation of branching (tillering) in panicoid grasses, including maize, sorghum, and millets. As a result of earlier collaborations between myself and co-PI Julie Angle, director of the secondary science education program at Oklahoma State, we knew that we had to combine multiple practices to reach our education goals, including authentic research experiences, weekly reflections on research experiences, and explicit instruction on the nature of science. These practices allowed us to help RET participants develop lesson plans that incorporate research into the school science curriculum. Such a combination of practices stems from Julie's earlier work in organizing STEM research experiences for pre-service science teachers in her science methods courses.

Apart from the RET experience, we have also focused on encouraging teachers to develop extra-curricular science fair programs where teachers mentor their high school students in science research and compete in science fair competitions. As our program has evolved we

have encouraged collaborative links between in-service and pre-service teachers to support the in-service teachers to develop a science fair program, as well as soliciting support for teachers from their administration. Our motivation is that if we can make an impact on teachers, then that will influence multiple students over multiple years—a very cost-effective way to impact citizen science literacy.

Some specifics of our approach include a competitive application process, a five-week RET experience at OSU, four follow-up sessions over the course of the following school year to reflect on what's working and what's not, realistic stipend for in-service teachers, funds for classroom supplies, and a commitment from the teachers to get five students to a regional science fair. In terms of the benefits to my research and the scientific aims of the grant, the RET projects have enabled us to examine the effects of environment on branching, including light attenuation, simulation of shading by other plants, the effect of restricted root volumes on shoot growth, and the effects of changing photoperiod and temperature. These projects are outside the main focus of the grant but will be very useful data for our grant renewal proposal in two years' time.

So, how have the RET experiences worked out in terms of teacher education? Even with authentic research experiences and professional development, it turns out that obstacles still exist to teachers truly modeling what it is to be a scientist for their classes. The main obstacle is time: time to plan, time to implement, and time to understand how research experiences might be translatable into the tightly defined set of topics that teachers have to teach. These pressures prevented our first set of teachers from being able to start a science fair program to which they had committed.

Therefore, in the summer of 2015, we experimented with pairing teachers with senior pre-service science teachers in the teacher preparation program, with much better results. After the summer RET was over, each pre-service teacher has continued working with their high school teacher partner, helping them set up a science fair program in their school. Currently, we have two in-service/pre-service teacher pairs who have successfully implemented a science fair program at their respective schools, and they are working with middle and high school students in conducting research and preparing for the upcoming science fair competition season. We are learning how to help teachers, and thus to really help students in middle and high school understand not only what science is about, but also what it feels like to be a scientist (Figure 1).

Several aspects of our program have contributed to its success. Most importantly, I think the RET works because we really believe that we might make a difference to science literacy in Oklahoma. It was also very important to the proposal that we could demonstrate that we had access to the audience we wanted to impact. Crucial to attracting teachers to our RET program was the competitive nature of our RET application process and proper compensation for those teachers. Also important were well thought-out assessments and follow-up plans, both for the success of the program and to convince NSF that we were serious about the outcomes of the program. This included an adequately justified budget including stipends, living costs, materials, etc. for our RET participants.

Designing projects for the short five-week program can be tough, but I am fortunate that my main study organism, green foxtail (*Setaria viridis*), grows very quickly! We also

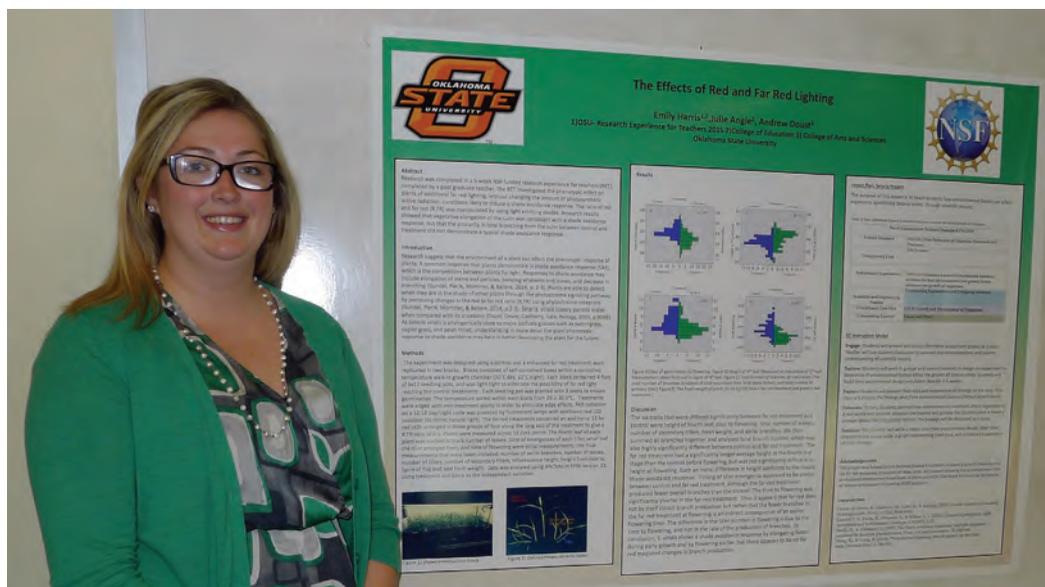


Figure 1. One of our in-service teachers, Emily Harris (Stillwater Public Schools), with the poster she presented on her work at our research symposium at the end of the RET experience.

get around limited time constraints by germinating plants up to a week before the teachers arrive, eliminating wait time and allowing the teachers to begin the research process during the first few days of the RET experience. It is difficult to conduct a longer RET with teachers because they only have two months' vacation over the summer, with schools having different end and start dates.

Even with authentic research experiences and professional development, it turns out that obstacles still exist to teachers truly modeling what it is to be a scientist for their classes.

We have been really amazed by the progress so far. The fact that we have facilitated the initia-

tion of science fair programs in several schools will be important for helping students do real science. The teachers who have gone through our RET program also report that they have more confidence in doing science with their students because they have a better understanding of its tentative and empirical nature. One of my favorite comments was from an enthusiastic middle school teacher who marveled at the sheer tediousness of measuring plant height and branching in her shading experiments, stating that the experience changed her view of the nature of the scientific enterprise from flashy results to the nitty gritty of getting good data. Another was from the classroom of one of our teachers who was starting a science fair program who overheard the following conversation between two students. Student A said, "We need a scientist." Student B said, "But we have one—Mrs. X, our teacher!" After the RET and follow-up sessions, teachers feel like they have experience as scientists and can articulate their knowledge and understanding of the nature of science (Figure 2).

Is it possible to replicate this model? We are attempting to do this with our other co-PIs at two other universities this summer. We are also extending this model to college STEM students, as I feel that science students also need authentic research experiences combined with explicit reflection on aspects of the nature of science to really know what science is.

The effects on their students are also starting to show: Two of the teachers just had all four of their students win regional science fairs and advance to the state competition. Just as importantly, there appears to be growing support for the teachers' efforts on behalf of their students from other teachers and the administration in their school.

Literature Cited

Abd-El-Khalick, F. & Lederman, N.G. (2000). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education* 22(7), 665-701.

Akerson, V.L., Abd-El-Khalick, F., & Lederman, N.G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conception of nature of science. *Journal of Research in Science Teaching* 37(4), 295-317.

Lederman, N.G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching* 29(4), 331-359.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington DC: The National Academies Press.

Schussler, E.E., Bautista, N.U., Link-Pérez, M.A., Solomon, N.G., and Steinly, B.A. Instruction Matters for Nature of Science Understanding in College Biology Laboratories. 2013. *BioScience* 63: 380-389.

Schwartz, R., & Lederman, N. (2008). What scientists say: Scientists' views of nature of science and relation to science context. *International Journal of Science Education* 30(6), 727-771.



Figure 2. Middle school students planting seed for an experiment on the effect of changing photoperiods on flowering time in green foxtail.



ANNOUNCEMENTS

In Memoriam



F. Thomas Ledig
(1938–2015)

After overcoming two separate assaults of cancer over a span of 20 years, Tom succumbed to metastatic melanoma at his home in Vallejo, CA. He will be missed sorely by his family, former students, and many personal friends—from home, office, and around the world. The collegium of forest geneticists and evolutionary biologists will miss his keen insights into population biology that he described in his papers with such clarity and cogency. These intellectual contributions were

translated into practical strategies, policies, and action for conservation of forest genetic resources, including genes, populations, and threatened species. Tom was a luminary in all of his professional undertakings. A cum laude graduate from Rutgers, he went on to get his MS and PhD degrees from North Carolina State University, supported in part by a National Science Foundation Fellowship. His first major job was as Assistant Professor at Yale, where he rose to Full Professor and Member of the Board of Permanent Officers, before leaving in 1979 to become Director of the Institute of Forest Genetics at the U.S. Forest Service's Pacific Southwest Experiment Station in Berkeley, California. While there, he was also appointed Adjunct Professor at the University of California, Davis, where courses he taught in plant conservation genetics were often oversubscribed. Professional recognition was accorded him by several universities, governments, and professional organizations; especially notable were Fellowship in the AAAS, and the Society of American Foresters prestigious Barrington Moore Memorial Award for "outstanding achievement in biological research leading to the advancement of forestry." But the tribute he cherished most personally was a remark in a letter signed by former colleagues at Yale: "We miss the *joie de vivre* that left when you left."

An early and leading apostle of conservation of forest genetic resources, Tom gave abun-

dantly of his time and energy to many institutions and organizations. He served over two decades as Secretary of FAO's North American Forest Commission's Forest Genetics Working Group. Under his leadership the Commission was active in habitat protection and seed collection of fast-growing and stress-adapted populations of tree species important to world forestry. His service was recognized with two awards for "significant and long-standing contribution" to the Commission. Because of his familiarity with forest conditions on every continent and broad perspective on conservation issues, he was able to contribute to many national programs and was often invited as a keynote speaker for symposia and Distinguished Professorships at several universities at home and abroad. He wrote extensively and poignantly of the depredations humankind has caused to biodiversity historically, while proposing strategies for mitigation and remedy. Above all, perhaps, were his deep feelings for the spiritual and ethical dimensions of conservation: "Aesthetic reasons are the hardest to pin down, but I believe that diversity is necessary to the health of humanity. Some sense of diversity seems necessary for sanity."

Tom's research spanned an unusually broad area of forest genetics, from the physiological genetics of photosynthesis and growth, to practical tree improvement, population genetics and taxonomy. Tree species he investigated were equally diverse, including pines, spruce, oak, and eucalyptus. But his main focus was on the genetic structure of tree populations: their diversity, origins, adaptations, mating systems, and migration patterns, especially as these properties might be affected by climate change.

His research often took him to isolated and relict populations in remote, almost inacces-

sible locations, such as the Sierra Oriental and Sierra Occidental for the rare Mexican pines and spruces; Brewer spruce in the Klamath Mountains of northern California; Engelmann and blue spruce from the mountains and sky islands of the Rockies; and Torrey pine from the Channel Islands of California. Some of Tom's colleagues, of a more timber-beast persuasion, needled him for his seeming preoccupation with non-commercial "trash trees" (as they called them). But Tom's vision was strategic: he chose subjects most likely to lead to insights into the evolutionary dynamics of populations, that would in turn inform policy guidelines for conservation. Of course, he also loved the excitement of the chase, and its physical challenges; one time, during a field trip to the parched and rugged Ventana Wilderness of California, he alarmed staff when he failed to show up for a meeting he had scheduled. But a day later, exhausted, hungry, scratched and bleeding—but smiling defiantly—he and crew stumbled out of the tall brush, holding the bagged quarry in hand: cones of the rare Santa Lucia fir from the high peaks. Even Indiana Jones might have been envious.

A main concern was about how population fragmentation, whether through climate change, habitat loss, or logging might affect genetic diversity and integrity of tree populations, and their ability to continue to evolve and adapt. The rare and endangered Mexican spruces and pines were thus of special interest, because they represented natural experiments of populations under severe disruption and selection pressure. Paleontological evidence had shown spruce to be much more widespread in Mexico during the Pleistocene, extending down into the lowlands. Tom and co-workers showed how climate warming in the Holocene caused wholesale retreat of spruce popu-

lations northward and higher in elevation. As they migrated, individual populations became highly disjunct and often decimated. Some of the genetic consequences documented were overall loss of diversity through genetic drift; the positive association of heterozygosity with population census; highly increased homozygosity in some populations, leading to inbreeding depression severe enough to threaten the continued existence of populations; and in an extreme case, evidence that *Maxipinion*, a species with only a single existing population, also had a maximum of two alleles per locus, most at intermediate frequencies—suggesting its possible origin from a single seed! A major accomplishment, coincident with these individual investigations, was bringing taxonomic coherence, using molecular markers, to the complex and long-unresolved relationships among the six species of western and southwestern spruces of North America. In both pines and spruces, his work showed that migration patterns could be tracked with molecular genetic data: populations migrating north from different glacial refugia after the last ice age lost diversity as a result of founder effects and genetic drift. This of course had important consequences for identifying contemporary centers of diversity for conservation purposes. He provided empirical evidence that heterozygosity was positively related to fitness, and the negative effects of inbreeding on reproductive health of populations.

His research ended where it began as an Assistant Professor at Yale, over 40 years earlier, on the Pine plains and Pine Barrens of New Jersey, in a common garden of range-wide provenance sources of pitch pine (*Pinus rigida*). One of the most variable of eastern conifers, pitch pine had long intrigued forest ecologists

ever since Gifford Pinchot first described the strange pygmy forest (Pine Plains) embedded within the tall forest (Pine Barrens) of New Jersey. For its innovative design and far-reaching objectives, his study proposal was awarded a National Science Foundation grant for its implementation and several other grants over the years for its continuation and completion. Numerous publications were forthcoming, with some still in press. Some outstanding insights from this study included demonstration of the positive relationship between the degree of heterozygosity and fitness; evidence from genetic data of the origin of pitch pine from at least three widely spread refugia following the last glacial maximum, including one on the exposed continental shelf; and, most interestingly, a remarkable example of natural selection: that in spite of potentially massive gene flow from the surrounding forest, the dwarf form of pitch pine derived from a suite of heritable traits associated with reproduction, culminating in the evolution of a distinct fire ecotype.

Not a bad legacy for trash trees. *Vale*, Tom.

By Bohun B. Kinloch, Institute of Forest Genetics, Pacific Southwest Research Strn., Berkeley, CA



#OhiaLove Campaign to Help Save Hawaii's Forests

Hawai'i is facing a very serious threat to its native forests. Rapid 'Ōhi'a Death (ROD) is a fungal disease that has already killed 34,000 acres of endemic 'ōhi'a trees (*Metrosideros polymorpha*). 'Ōhi'a is the keystone of our forests and perhaps the most important tree in Hawai'i. Currently there is no known treatment for ROD, and it is spreading on one of our islands.

Lyon Arboretum's Seed Conservation Laboratory has launched a crowdfunding campaign, #OhiaLove, to raise funds to collect and store 'ōhi'a seeds at our seed bank during this crisis. Our collection program will be systematic and strategic, to preserve genetic diversity of both at-risk populations as well as those that are potentially ROD-resistant, for use in future forest restoration.

To learn more and donate, visit www.ohialove.com!

-By Marian Chau, Seed Conservation Laboratory Manager, Lyon Arboretum



SCIENCE EDUCATION

Welcome to Dr. Jodi E. Creasap Gee, BSA's Education Technology Coordinator

The Botanical Society of America is excited to announce the addition of Jodi E. Creasap Gee, Ph.D. to the BSA Education team! She will serve as the Education Technology Coordinator and report to Dr. Catrina Adams.



Passionate about science, and biology in particular, Jodi grew up in Ohio, where she spent many spring, summer, and fall seasons in her grandparent's Central Ohio vineyard. After graduating from Hiram College in 2000 with a B.A. in Biology, she moved to the Finger Lakes in New York to attend Cornell University. Jodi's Ph.D. dissertation project at Cornell

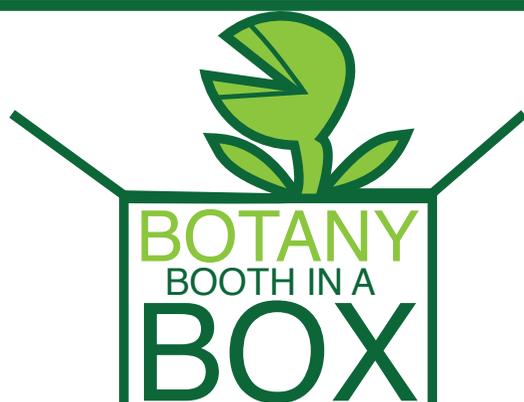
University's Plant Pathology Department focused on the mechanism of biological control of grape crown gall.



*By Catrina Adams,
Education Director*

BSA Science Education News and Notes is a quarterly update about the BSA's education efforts and the broader education scene. We invite you to submit news items or ideas for future features. Contact Catrina Adams, Education Director, at cadams@botany.org.

In 2006, after she completed her Ph.D., Jodi started a post-doctoral research position in Michigan State University's Plant Pathology Department. There, her projects focused on bacterial diseases in fruit trees (apples, cherries). From 2007-2012, Jodi worked for Cornell Cooperative Extension as an Extension Educator for the Lake Erie Regional Grape Program in Western New York and North-western Pennsylvania. Covering the 30,000+ acres of grapes in the region, she provided information, recommendations, research re-



Have you ever wanted to bring your love of botany to the public but weren't sure what to do?

It's time for the BSA to help!

2016 Botany Booth In A Box Competition

Booths at STEM outreach events such as science festivals, Fascination of Plants Day, or other public gatherings provide excellent opportunities for informal education about plants. However, the activities and materials needed for an effective booth can be difficult to develop, organize, produce, and gather. To address this important issue, the Botanical Society of America Education Committee is sponsoring its first Botany Booth In A Box Competition.

Prizes:

Overall Grand Prize	\$300.00
Runner-up	\$100.00
Student Grand Prize	\$300.00
Student Runner-up	\$100.00

The objective of the contest is for groups or individuals to produce booth activities for these types of events that could be easily stored and shipped to BSA members who want to use them at different types of events. The activities will be judged on the following criteria:

- *Is it factually accurate with a clear learning objective?*
- *What is its breadth of use and applicability?*
- *Is it engaging and interesting for the target audience or age group?*
- *Can it be completed in a short period of time?*
- *Is it easy to store, ship, set up, and use? (Ideally, all materials for the activity should be easily obtained locally or able to fit in a standard USPS shipping box).*

All BSA members are eligible to submit an activity for the competition. Student members are eligible for the student prize. A panel of judges will review applications.

Finalists will be invited to set up and share their booth during the opening mixer of the 2016 BSA Annual Meeting.

Apply by April 22: <http://goo.gl/forms/PBYX8JAXqd>

Winners will be chosen by a panel of judges and the BSA membership.

All finalists will receive a t-shirt and are encouraged to submit their activities to PlantEd Digital Library (<http://planted.botany.org>).

sults, and extension programming to Concord grape growers as well as wine grape growers.

From 2013 to 2015, Jodi served as the Ohio State Coordinator for VESTA and the Program Director for the Viticulture and Enology Program at Kent State University Ashtabula. Most recently, after her family moved to the Kansas City area, Jodi changed positions within VESTA and took over the role of Instructional Designer for the nationwide program. She managed online course content for up to 25 courses each semester, recorded and edited lecture videos, and provided online technological assistance to instructors and students.

Jodi has volunteered as a scientist mentor for Planting Science for 4.5 years and is thrilled to have the opportunity to work with the team that brings plant biology to the middle and high school classrooms. Contact her at jcreasapgee@botany.org.

PlantingScience continues to expand, seeking 100 new scientist mentors to begin August 2016 for Fall session

This spring, seven Canadian teachers and their students join 22 teachers from the USA and one teacher from the Netherlands in investigations on themes ranging from seed germination to *Arabidopsis* genetics. PlantingScience is gaining attention in Canada, and the Digging Deeper professional development project will bring in 40 new teachers for the Fall 2016 session, doubling our typical session size.

To meet the new demand, we are hoping to recruit 100 new scientist mentors to help

with the Fall 2016 session (mid-September to mid-November).

Mentoring a team or two takes only about an hour a week, can be done from anywhere with an internet connection, and is a great way to connect with middle- and high-school students to share your passion for plants and science. If you have not yet gotten involved as a mentor, we'd love to have you. If you gave PlantingScience a try years ago, this would be a great time to come back to see what's new. And if you have been a mentor for many years, please help us by recruiting colleagues! New mentors can learn more and register at <http://plantingscience.org/newmentor>.

Finally I'd like to thank all of our current and past mentors who have given your time over the years to mentor student groups through the process of an investigation, learning more about how real science is done and how scientists think, and sharing with the students the joy of discovery and the wonder of plant biology with the next generation. Students tell us every year how impactful the experience was to them, and what a difference it makes in their perspectives on plants and science.

"I really liked all the interesting things that I learned about plants, but more than that, I liked how we could ask the mentor anything and he would be able to tell us more. In class, we usually follow a curriculum and have set things to learn. However, on PlantingScience



we were able to find out more about what interested us and I was able to learn about things that I didn't even know I didn't know about plants.” – PlantingScience student

“I liked the end part the best, and tying together our information from this lab to previous information. Trying to figure out what the data means, why it is important and why we are doing this is the most interesting.” – PlantingScience student

Seeking Volunteers to staff outreach booth at USA Science and Engineering Festival in Washington D.C. this April

This year, the BSA has partnered with a team of botanical societies that the U.S. Botanic Garden has brought together to create new hands-on botany activities, and to share them at a large plant outreach booth at this year's USA Science and Engineering Festival, held at the Walter E. Washington Convention Center in Washington D.C. The USA Science & Engineering Festival is a national grassroots effort to advance STEM education and inspire the next generation of scientists and engineers.

If you are in the D.C. area, we would love to have your help at the booth, sharing your love of plants with the public.

The festival will run for three days:

- Friday, April 15 is a preview for local schools
- Saturday, April 16 (10 am-6 pm) and
- Sunday, April 17 (10 am-4 pm) will be open to the public and to families.

The overall theme of the booth will be plant movement, and we will have several interactive activities and demonstrations set up for visitors to learn more about plant adaptations and plant movements, and to help open their eyes to the presence and importance of plants in their lives. We're hoping visitors will leave our booth with a greater appreciation for plants as active organisms.

The BSA component of the booth will focus on how plant leaf movements (whole leaf and movement of small parts like stomata and chloroplasts) help plants survive different environments. We'll have an area set up for visitors to explore plant leaf adaptations, a Venus fly trap interactive, and an origami “plant fortune teller” game describing how different plants fare under different environmental conditions for visitors to make and take home.

The festival is very large, and we expect tens of thousands of visitors to stop by our booth. If you can volunteer, please use the Doodle poll at <http://doodle.com/poll/pmq67tfp2qwmibrx> to let us know which day and time you would like to help. We'd like to have 4-5 local volunteers to help during each time slot. We will provide a quick training on the activities and demos at the beginning of each shift.

If you have any questions, please direct them to Catrina Adams, BSA Education Director, at cadams@botany.org.



STUDENT SECTION

Conversations about Grad School and What Happens Next

Grad school is full of challenges, including figuring out how to finish your project and what to do afterwards. These are intensely personal and complex subjects, full of questions like “What are my options?”, “What career is right for me?” or “How will this choice affect the people in my life?” Even if you have a plan, there is still “Can I get the money I need to do that?” and “How do I actually get there?” However, it’s important to remember you’re not the first person to have these questions. That’s why we are starting a series of interviews with graduates about what life after grad school is like—what they are doing with their degree, and what they’ve learned along the way.

We’re starting with a conversation with **Dr. Laura Lagomarsino**, who combines phylogenetic analysis, field and herbarium work, and pollination biology to study the evolutionary

history of Neotropical clades of Lobelioideae. She graduated with her Ph.D. in Organismic and Evolutionary Biology from Harvard University in 2015, and is currently enjoying her position as an NSF Postdoctoral Research Fellow in Biology, working with her advisors in St. Louis and Gothenburg, Sweden. We talked about what actually finishing her dissertation was like, how she figured out her next step, and then a little about what’s happened since she started it.

Becky and Angela: To set the stage, tell us a little about what your Ph.D. dissertation was on.

Laura Lagomarsino: I study the systematics and evolution of the 550 species in the centropogonid clade of Neotropical Lobelioideae, which grow throughout montane Latin America. During my dissertation, I resolved the phylogeny of the group, described four species new to science, and applied various diversification models and phylogenetic comparative methods to determine that rapid diversification in this clade was driven by multiple factors, including Andean uplift and frequent shifts between bat and hummingbird pollinators.

Thanks for summing up so much hard work in just a few sentences. What was the hardest part about finishing up your disserta-



By Angela McDonnell and Becky Povilus, BSA Student Representatives

tion? If you could go back and give yourself one piece of advice during that time, what would you say?

Toward the end, time management became the hardest part—there were seemingly more things to get done than time would permit! I wish I had dedicated myself to writing one year earlier. Writing takes so much longer than you expect.

What is one thing that you wish you had done while you were still in grad school?

Outside of those few highly recommended Boston area restaurants I never visited, I wish I had had more interaction with my dissertation committee members. Their advice always improved my thesis, but I only actively sought it once a year.

What is one thing that you did in grad school that turned out to be a really good idea, and that you would recommend everyone should think about or try?

I am so happy that I combined field and herbarium work, which allowed me to develop a comprehensive understanding of the centropogonid clade. If relevant to your system, I would recommend this to all biology graduate students, even if fieldwork and museum study do not seem directly relevant (and especially if your work is primarily in the lab or at the computer). It will enrich your grasp of your study taxa and their interactions and may inspire new trajectories for your dissertation (and beyond).



The Next Step – Life after Grad School

You had your post-doc position lined up before you finished your dissertation. Looking back now, do you think that was a good idea?

Yes. It was such a relief to know where I was heading after grad school in the already stressful lead-up to my defense.

When it comes to looking for a post-doc position, what is one resource that you found really helpful?

The other senior grad students in my department were my most important resource! They were figuring out their next career stages before me, and ultimately inspired me to do the same. They pointed me toward relevant fellowships and postdoc advertisements, and to-

gether we commiserated about the uncertainty of that particular moment in our academic careers.

Did you consider taking a non-academic route after graduation? If so, what helped you decide to take a post-doc position (and set yourself on an academic trajectory)?

I briefly considered leaving academia, but I'm such an herbarium junkie that the academic trajectory seems most appropriate for me. However, I suggest that all graduate students take advantage of their universities' career counseling services before they graduate. Their staff will help put your six years of narrow academic focus into a broader context, including by alerting you to very marketable skills you may not realize you've acquired: project management, budgeting, problem solving, intellectual rigor, to name a few.

Your current position is an NSF-funded post-doc fellowship that involves collaboration between labs at the University of Missouri, St. Louis and the University of Gothenburg in Sweden. Can you tell us a little bit about how you formed this collaboration?

My two postdoctoral advisors, Nathan Muchala and Alexandre Antonelli, have both studied various aspects of the biology of the centropogonid clade, and were both collaborators of mine during my Ph.D. The intersection of their labs' principal focuses—bat pollination and drivers of Neotropical biodiversity, respectively—almost perfectly match my interests. Working with them was an intuitive match. With significant help from them, I put together an application for the NSF fellowship about six months before I graduated.

I would recommend thinking five years ahead when you start planning for your postdoc. If you are on an academic track, what skills are going to be marketable when you go on the job hunt, and which would you like to bring to your own lab one day?

What are some challenges that are unique to organizing an international collaboration like that, and how did/do you address them?

I am still figuring out how to best organize this collaboration. The principal challenge, unsurprisingly, is the physical distance between my two labs. I am lucky to belong to two large labs full of smart and capable scholars, but this also means that I have to be very motivated and independent to stay on top of my project so as not to get lost. Frequent meetings with my two advisors keep me on track.

When thinking about a post-doc position, you have to find a balance between working on something you know you'll enjoy, and learning new skills. What advice do you have about finding that balance?

I would recommend thinking five years ahead when you start planning for your postdoc. If you are on an academic track, what skills are going to be marketable when you go on the job hunt, and which would you like to bring to your own lab one day? For me, these were field pollination biology and next-generation

sequencing techniques and bioinformatics. Of course, aim to develop these new skills in a system that excites you and with a PI with whom you can see developing a positive relationship. Also, talk to your Ph.D. advisor about how to plan for your postdoc. They have been in your shoes and are likely to have great insight into labs, projects, or fellowships that are up your alley.

If you don't mind us getting personal, we would like to ask about how you juggled the post-graduation transition and your personal relationships. You and your husband (who is also a botanist!) both moved from Boston to St. Louis when you started your postdoc. How did you address the challenge of negotiating the pull between both of your careers and goals?

Fortunately, my husband and I are both herbarium-based botanists, so moving between two of the best collections in the world, from the Harvard University Herbaria to the Missouri Botanical Garden, was not at all a compromise for us! It may not always be such an easy transition, but we are ultimately going to go wherever my career takes us. For better or worse, you and your partner need to be very flexible in the early stages of an academic career. Open and honest communication is probably the easiest way to manage the transition periods: between grad school and postdoc, postdoc to junior faculty position, etc.

What is one thing that has helped you to get settled in your new job?

My new delightful colleagues at the three (yes, three!) institutions I am now affiliated with made me feel welcome almost immediately, and it is quite fun to begin to understand the dynamics in a new lab. That being said, I think

the continuity between my dissertation and my postdoc project has made my transition particularly easy: I'm finally digging into the questions that my PhD research generated! It may have been bumpier if I had changed my focal group.

What are you most excited about with your new project?

I can't wait to get to Bolivia and start observing who is pollinating *Centropogon incanus*, whose polymorphic flowers suggest some individuals are bat pollinated while others are hummingbird pollinated! Though I've been intrigued by vertebrate pollination ever since working on the hummingbird-pollinated genus *Heliconia* as an undergraduate, I have never performed proper field-based pollination biology, and now I get to do it with a leader in the field. I'm stoked.

Any last words for those of us grad school right now?

Above everything, enjoy graduate school; it is a rewarding and fun period. But I would recommend that all grad students be aware of their timelines as they head towards graduation and to have an open line of communication with your advisor during the last stretch of the dissertation. If you are interested in a career in academia, also keep in mind that most postdoctoral fellowship applications have only one call a year, and that it is common for the funding agencies to six months (or more!) to get back to you. This means that, if at all feasible in your situation, you should be thinking about post-graduation plans a year out from defense. And good luck!

You can find out more about Laura's research (and see gorgeous pictures of her field sites and the species that she works on) at www.lauralago.net.

Want to learn more about NSF's Post-Doctoral Fellowships in Biology? They currently have special focus on projects relevant to (1) Broadening Participation of Groups Under-represented in Biology, (2) Research Using Biological Collections, and the (3) National Plant Genome Initiative (NPGI), so check them out at www.nsf.gov!



Student events At BOTANY 2016:

Monday, August 1, Noon -1:00 pm

Careers In Botany: Interactive Career Panel & Luncheon

Monday, August 1 9:00 pm - 11:00 pm

Student Social and Networking Event sponsored by the *International Journal of Plant Sciences* at Moon River Brewery

Both events are only \$5 (and include food/drink!) so be sure to register for these events when you register for the conference.

Reminder: BSA Student Travel Awards Deadline is April 10

You might be almost done applying for grants this season, but don't forget about the BSA Student Travel Awards. These are still seven different awards available to students from the Botanical Society of America, including some awards given by sections. The awards include the Pteridological Section & American Fern Society Student Travel Awards, the TRIARCH "Botanical Images" Student Travel Award, the Vernon I. Cheadle Student Travel Awards, the Developmental & Structural Section Student Travel Awards, the Ecological Section Student Travel Awards, the Economic Botany Section Student Travel Award, and the Genetics Section Student Travel Awards.

These awards are meant to help defray the costs to students of attendance at Botany 2016 in Savannah, Georgia from July 30 to August 3. Each award offered has different guidelines for applying. Visit BSA at <http://cms.botany.org/home/awards.html> for links to each award and details on how to apply.



BOOK REVIEWS

Ecological

Forest Plans of North America 43

Genetics

Plant Genes, Genomes and Genetics 44

Historical

A Natural History of English Gardening: 1650–1800 46

Physiology

Mineral Nutrition of Rice 48

Systematics

Flora of Colorado 50

Carnivorous Plants of Australia: Magnum Opus 52

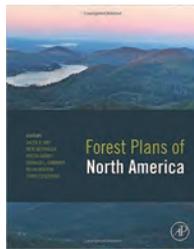
Plant Life of Southwestern Australia: Adaptations for Survival 53

Plant Guide: Maritime Succulent Scrub Region, Northwest
Baja California, Mexico 55

ECOLOGICAL

Forest Plans of North America

J. P. Siry, P. Bettinger, K. Merry, D. L. Grebner, K. Boston, and C. Cieszewski, editors
2015. ISBN-13: 978-0-12-799936-4
Hardcover, US\$109.00. 482 pp.
Academic Press, Cambridge, Massachusetts, USA



Forest Plans of North America is an excellent volume that captures the successes, opportunities, and challenges of efficiently executing forest management plans across the North American continent. The volume has a detailed preface that nicely illustrates

the purpose of the volume and the logic of the book design. The central content of the volume is divided into 49 chapters, of which 48 are dedicated to specific forest plans in different forest zones across the study area. The last chapter is an excellent synopsis of forest plans of North America and a must read for those interested. The majority of the contributors, as expected, are from the United States, Canada, and Mexico, and include foresters, rangers, biologists, academics, researchers, managers, and dedicated individuals who are credited in developing the individual comprehensive forest plans. The volume is engaging but is also technical where necessary.

The detailed color maps, figures, graphs, and summary tables used in each chapter will help the readers not only to understand individual

case studies, but also to vividly visualize the forest zones discussed. Helpful features include a list of general abbreviations provided at the beginning of the volume, along with specific abbreviations pertaining to individual chapters; a selected bibliography following each chapter, which will be extremely handy for readers who wish to dig deeper into the case studies and related studies; additional references for some of the individual chapters; and a nicely organized index at the end of the volume. It is important to mention that English (or U.S.) customary units are used in chapters related to the U.S. studies, while the metric system has been followed in the Mexican and the Canadian studies.

Although there is some obvious overlap as expected in a multi-author edited volume, the reading never felt monotonous due to the precise and uniform presentation style of the volume. Each chapter is divided into four major parts: (i) Management Settings and Backgrounds, (ii) Planning Environment and Methodology, (iii) Outcomes of the Plan, and (iv) Discussions and Conclusions. The language of the volume is simple, concise, and to the point. The authors have represented individual case studies with precision, and have objectively highlighted both the successes and challenges explored under individual plans.

Although the volume covers the forest plans of the North American continent, the greatest emphasis is given to the U.S. examples, representing 75% of the case studies, followed by Canada (11%) and Mexico (5%). Forest plans on the primeval boreal forest zone of Canada would have been greatly appreciated. It would have been easier for the readers if the arrangement of various case studies (chapters) would have been subdivided by country, and a glossary of technical terms would have also been helpful. The volume

will be useful for undergraduate and graduate students of general and applied forestry, forest management, environment management, botany, and plant sciences, as well as to professional foresters, rangers, biologists, academics, and researchers working in forest or ecosystem management, forest conservation, forest planning, and for those working in developing forest policies. This will be also suitable for enthusiastic readers, journalists, and lawyers interested in learning about forest management plans related to their specific professions.

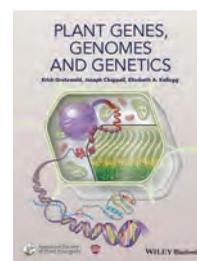
—*Saikat Kumar Basu, University of Lethbridge, Lethbridge, Alberta, Canada*

GENETICS

Plant Genes, Genomes and Genetics

Erich Grotewold, Joseph Chappell, and Elizabeth A. Kellogg
2015. ISBN-13: 978-1-119-99888-4

Paperback, US\$75.00. 264 pp.
John Wiley & Sons, Chichester, United Kingdom



As an undergraduate majoring in botany, I was often frustrated that biology courses tended to generalize concepts to animal models—even then I knew that much research has been performed in plants. I was sometimes left wondering, “How does that work in plants?” As I moved into upper-level courses that were plant-focused, many of those questions were indeed answered. However, there was no course that focused on plant genetics. If there had been, *Plant Genes, Genomes and Genetics* would have been an excellent text for the course.

The book is divided into three parts, “Plant Genomes and Genes,” “Transcribing Plant

Genes,” and “From RNA to Proteins,” and contains 17 chapters, each of which is further broken down into several subsections and ends with a paragraph-long chapter summary. As the volume totals 264 pages, the chapters are short, averaging 11.5 pages, including references at the end of each. This makes it simple to cover a chapter or so per week. The book is designed for upper-level undergraduates and graduate students; it is not a beginner’s book. There is a short introduction that reviews basic plant anatomy and morphology. The first chapter, “Plant Genetic Material,” could be considered a review of general genetics, e.g., describing nucleotides and the structures of the double helix and chromosomes, but the rest is written as if the reader should understand basic concepts of transcription, translation, and protein expression. It even covers topics that my undergraduate genetics course did not, such as transposons (Chapter 3), organellar genomes (Chapter 5), small RNAs (Chapter 11), and protein targeting (Chapter 16).

The language of the book is not as formal as one would expect from the primary literature, so it reads fairly easily, even in the heavier chapters of transcription factors and RNA processing. This may make it more understandable to the undergraduate. Likewise, the use of metaphors helps to convey concepts. For instance, the space shuttle and launch pad are used to illustrate the RNP-II pre-initiation complex (sec. 8.4) and the structure of the university is used to explain the hierarchical nature of transcription factor regulatory networks (sec. 9.9). To cover all of these topics, the authors do not delve too deeply into them. Many times a concept or example is explained but not necessarily the evolutionary sequences that may have led to it nor how it fits into the larger picture. Although the book is plant-specific, animal examples are used freely,

generally to contrast plant examples, but I would have preferred fewer animal examples in some cases to present more of the diversity within plants. This characteristic of the book might necessitate the use of primary research articles as a supplement to dive deeper into the concepts and bring in more examples.

Nearly every page contains at least one color illustration or table presenting data. Each are placed close to where they are referenced for easy browsing. All tables and figures from the text are available from the companion website in PowerPoint format, which would greatly facilitate an instructor’s course design. Also on the website are answers to problems posed to the reader after the summary at the end of each chapter. Figure 3.7 is a picture of snapdragon flowers, and the text refers to it twice—once when naming a *hAT* element that was found in the species and again a few pages later when describing disruption of genes. I think this second reference may be a typo and should instead refer to Figure 3.9, a diagram of maize pigmentation variations due to the insertion of *Ac* elements at various positions in the gene.

There are some other typos, too. On page 18 the word “and” is used in place of “an” before the word adenosine; on page 35 an “o” is left out of “*homoeologous1*”; fungi is spelled “funig” in a reference on page 96; *Arabidopsis* is not italicized on several pages; and a few punctuation errors caught my eye. I also found one content error. Bisulfite sequencing is the process in which non-methylated cytosines are deaminated to form uracil, whereas methylated cytosines remain unchanged. By comparing the sequences before and after treatment, it is possible to determine which cytosines are methylated or not (Hayatsu, 2008). Page 8 states, “The non-methylated cytosines are not affected by the bisulfite

treatment, and thus remain the same (Figure 1.5b).” The caption for Figure 1.5 does indeed word this correctly, as does the discussion on bisulfite sequencing on page 178, “In this technique DNA is treated with sodium bisulfite, which converts all unmethylated C, but not m⁵C, residues to U.” In addition, the text states the size range of the mitochondrial genomes of plants is 200–2740 kb, and there are no mentions of chromosomes in organellar genomes. Recently, the upper range limit has been extended to 10 mb, and some are now calling parts of the mitochondrial genome chromosomes (Wu et al., 2015).

Taken for content, though, this is a nice book. It is a bit condensed in some areas, but looking to the primary literature for extra material would easily supplement the text. This would also help to bring in the latest findings that were not known at the time of publication.

Anyone considering designing a course on plant genomes should consider this text. It briefly, but thoroughly, covers many diverse topics, and the tripartite design offers a natural three-unit course. I, for one, will keep it in mind when I have the opportunity.

–Adam J. Ramsey, Department of Biological Sciences, University of Memphis, Memphis, Tennessee, USA; adam.ramsey@memphis.edu

Literature Cited

Hayatsu, H., M. Shiraishi, and K. Negishi. 2008. Bisulfite modification for analysis of DNA methylation. Unit 6.10, Chapter 6 in *Current Protocols in Nucleic Acid Chemistry*. John Wiley & Sons, Hoboken, New Jersey, USA.

Wu, Z., J. M. Cuthbert, D. R. Taylor, and D. B. Sloan. 2015. The massive mitochondrial genome of the angiosperm *Silene noctiflora* is evolving by gain or loss of entire chromosomes. *Proceedings of the National Academy of Sciences* 112(33): 10185–10191.

HISTORICAL

A Natural History of English Gardening: 1650–1800

Mark Laird

2015.

ISBN-13: 978-0-300-19636-8

Cloth, US\$75.00. 440 + xxi pp.

Yale University Press, London,

United Kingdom



“The garden,” Mark Laird writes in *A Natural History of English Gardening: 1650-1800*, exists “at the intersection of the wild and domesticated” (p. 349). In this book, Laird presents a thorough, thoughtful account of the relationships—between plants, people, animals, and ideas—that characterized gardening and linked it with natural history in late 17th- and 18th-century England. As with his previous work on English gardening (e.g., Laird, 1999), the author approaches his subject as a story of people, exploring 150 years of gardening by weaving together the stories of the individuals whose gardens, books, art, and letters reveal the horticultural trends of their age.

The book progresses in a generally chronological manner, although Laird takes care that strict adherence to chronology does not interfere with the natural flow of his storytelling. Accordingly, and as the author fully admits, this book at times “inclines to the fragmentary” (p. 329); this is, however, one of its strengths, as it allows individual fragments of history to gradually gain significance in relation to each other. Laird uses as his primary sources paintings, drawings, other botanical and natural history illustrations, historical maps and garden diagrams, personal journals, and a plethora of letters. These letters, sent between garden owners, garden designers, botanists, and others, are extensively quoted

throughout the book and provide a window not only on the human interactions on which gardening depends but also on a detailed record of meteorological and phenological events.

Over the course of the book's seven chapters, Laird elegantly lays out the connections between horticulture and natural history in England in the years 1650–1800. Each chapter focuses primarily on a set of distinct (but not discrete) ideas: Chapter 3, for example, centers on the importation of exotic plants for British horticulture and the art depicting those plants, topics which remain important throughout the entire book. Other threads that tie the book together include the conscious rejection of a history of gardening defined by famous garden designers (Walpole, 1780) in favor of one that emphasizes the people, plants, and creatures that inhabit garden spaces, and constant attention to the role of (mainly aristocratic) women as leaders in gardening and natural history, as the financial patrons of botanical gardens and excursions but also as instigators and investigators who decided what plants to feature in their landscapes or became accomplished botanical illustrators and taxonomists.

The connections between gardening and natural history explored in this volume are wide-ranging. They include such straightforward matters as the origins of the Royal Botanic Gardens at Kew in the private gardens of the Prince and Princess of Wales and the impact of the importation of exotic plants from Britain's colonies in the Americas, Asia, and elsewhere—initially for horticultural purposes—on the burgeoning science of Linnaean plant taxonomy. Some of the links, though, are less obvious. For example, Gilbert White's celebrated collection of natural history data concerning plants,

animals, and weather (White, 1789) began as a record of his garden. The role of the garden as a “laboratory of empirical science” (p. 349), on the other hand, is perhaps exemplified by the constant, creative efforts of horticulturists to see what exotic plants would grow in the English climate.

The majority of the book's 341 figures are botanical illustrations by artists including Mark Catesby, Georg Dionysius Ehret, Jacobus van Huysum, Thomas Robbins the Elder, Alexander Marshal, Everhard Kick, and James Sowerby. Other illustrations include maps, portraits, and depictions of animals. I was particularly struck by the gorgeous cut-paper collage botanical illustrations of Mary Delany. And I would be remiss if I did not also mention the author's beautiful reconstructions of historical gardens, drawn from written descriptions and garden plans, which begin each chapter.

Laird's use of botanical nomenclature is, for the most part, accurate and current. I only noticed a few nomenclatural errors, viz.: *Myrica cerifera* rather than *Morella cerifera* (p. 240), *Eugenia suborbiculare* [sic] rather than *Syzygium suborbiculare* (p. 274), and *Aster cordifolius* and *A. dumosus* rather than *Symphotrichum cordifolium* and *S. dumosum*, respectively (p. 306). The book concludes with 38 pages of endnotes, including full citations of all works mentioned in the text, followed by an index. The 15-page index, prepared by Meg Davies, is comprehensive. My only, albeit minor, complaint is that many plants are indexed under common names only, with parenthetical references to scientific names.

A Natural History of English Gardening: 1650–1800 is likely not of direct professional relevance to most botanists; as a scholarly work, it will primarily be of importance

to historians of English horticulture. Nevertheless, I think that many botanists will find this to be an enjoyable read, particularly if they are intrigued by the role of the garden as a place to study both the wild and the cultivated, where curious mixtures of native and exotic plants mediate connections between humans, other animals, and the vegetative world. This is, in multiple ways, a book “about the nature of gardening” (p. 5), and I recommend it to anyone interested in the history or practice of horticulture.

—Ian D. Medeiros, *College of the Atlantic, Bar Harbor, Maine, USA*

Literature Cited

Laird, M. 1999. *The Flowering of the Landscape Garden: English Pleasure Grounds 1720–1800*. University of Pennsylvania Press, Philadelphia, Pennsylvania, USA.

Walpole, H. 1780. *The History of the Modern Taste in Gardening*. Strawberry Hill Press [published by the author], London, United Kingdom.

White, G. 1789. *The Natural History and Antiquities of Selborne*. Printed by T. Bensley for B. White and Son, at Horace's Head, Fleet Street, London, United Kingdom.

PHYSIOLOGY

Mineral Nutrition of Rice

Nand Kumar Fageria

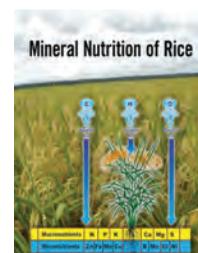
2014.

ISBN-13: 978-1-4665-5806-9

Hardcover, US\$157.95. 586 pp.

CRC Press, Taylor & Francis Group,

Boca Raton, Florida, USA



Plant growth and development require the supply, uptake, and utilization of essential nutrients. Efficient utilization of mineral nutrition is critical for crop production practices, including yield increase, cost reduction, quality improvement, and control of environmental pollution. An excellent textbook (Epstein and Bloom, 2005) and a general reference (Marschner, 2012) are available on the subject of plant mineral nutrition; however, no monograph has been specifically devoted to rice (*Oryza sativa* L.), one of the most important crops in the world. *Mineral Nutrition of Rice*, an interesting volume written by Dr. Nand Fageria, aims to fill this gap. Unlike other major food crops such as wheat and corn, the majority of rice varieties are grown in lowland regions or under flooded soil conditions. Dr. Fageria's book effectively examines the unique features of mineral nutrient requirements in rice plants.

The volume is logically arranged into 15 chapters. An introductory chapter provides essential background knowledge of rice ecophysiology, including plant growth stages, external cultivation conditions, yield analysis, and responses to biotic and abiotic stresses. The first set of chapters (Chapters 2–4) cover the three most yield-limiting macronutrients: nitrogen (N), phosphorus (P), and potassium (K). The next set of chapters (Chapters 5 and 6) focus on the other three macronutrients:

calcium (Ca), magnesium (Mg), and sulfur (S). The eight chapters (Chapters 7–14) that follow examine the essential micronutrients one by one: zinc (Zn), copper (Cu), manganese (Mn), iron (Fe), boron (B), molybdenum (Mo), chlorine (Cl), and nickel (Ni). The last chapter (Chapter 15) is devoted to silicon (Si), which is the most important beneficial (but not essential) element for rice growth.

The 14 nutrient chapters (Chapters 2–15) have similar organizational structures. Every chapter includes an introduction, followed by sections addressing nutrient cycling in soil-plant system functions, deficiency symptoms, uptake in plant tissue, management practices, and a conclusion. Additionally, sections on use efficiency and harvest index are included in most chapters. Iron toxicity in lowland rice is particularly discussed in Chapter 10. The management practice section covers effective nutrient sources, appropriate application methods and timing, adequate rates, the use of efficient genotypes, and more element-specific information. The conclusion section summarizes take-home messages distilled from each chapter. Most of the knowledge and data presented are specific to rice. Research examples from various rice cultivation ecosystems are integrated in the volume. The differences of mineral nutrient requirements in multiple lowland and upland rice cultivars are compared and discussed in detail. As an internationally recognized expert in mineral nutrition for crop plants, Dr. Fageria proposes valuable recommendations for the judicious use of fertilizers throughout the book.

This volume contains plenty of useful information for rice researchers and breeders. It includes 247 illustrations, 200 tables, and numerous research examples. Most of them are adapted from important research papers and review articles in the field. In order to

clearly display the phenotypes caused by diagnosed nutrient deficiencies and toxicities, 31 illustrations are presented as high-quality color figures. The index has been carefully designed to contain both primary terms and sub-terms, which facilitates the efficient search of any given topic. Every chapter contains detailed citations and a complete reference list. Readers can easily find additional information on their topics of interest by looking up the relevant literature in the reference list.

The writing style of this book is rather practical. Theoretical explanations of general principles in plant mineral nutrition research have been kept to a minimum. Data presented in the book are largely descriptive, with very little discussion of the molecular mechanisms of nutrient transport and function. On the other hand, research topics relevant to agricultural practices have been emphasized throughout the book. For example, in the discussion of the role of nitrogen in rice growth, multiple research examples are presented to explain the influence of nitrogen supply on key agronomic traits, such as plant height, tiller number, panicle length and density, spikelet sterility, root length, and dry weight. In addition to summarizing our current knowledge on rice mineral nutrition, this volume focuses on its practical applications in grain production. The book successfully connects research investigations in the lab with real-world agricultural practices.

Overall, this book is a valuable and comprehensive guide on the management practices of rice mineral nutrition. Rice researchers and breeders should have this volume on their bookshelves as a reference. The book is not suitable for classroom use as a primary textbook as it would be difficult for beginners in the field to fully digest its content. Instead, the volume may serve well as

a complementary reference text for students. Depending on the aims of a given course, selected chapters or sections could be assigned as materials for further reading.

There is room for improvement when the author prepares the next edition. Individual mineral nutrition elements have been adequately discussed, but a new chapter could be added to further describe the relationships and interactions among those elements. The physiological and biochemical effects of multiple mineral nutrients on rice plant growth and grain yield should be investigated in an integrative way.

–Hao Peng, *Department of Crop and Soil Sciences, Washington State University, Pullman, Washington, USA.* hao_peng@wsu.edu

Literature Cited

Epstein, E., and A. J. Bloom. 2005. *Mineral Nutrition of Plants: Principles and Perspectives*, 2nd ed. Sinauer Associates, Sunderland, Massachusetts, USA.

Marschner, H. 2012. *Marschner's Mineral Nutrition of Higher Plants*, 3rd ed. Academic Press, San Diego, California, USA.

SYSTEMATICS

Flora of Colorado

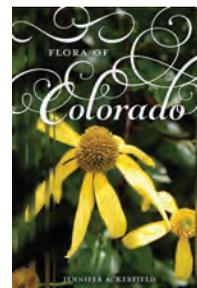
Jennifer Ackerfield

2015.

ISBN-13: 978-1-889878-45-4

Paperback, US\$78.00. 818 pp.

Botanical Research Institute of Texas Press, Fort Worth, Texas, USA



There were two substantial manuals or floras of Colorado published during the last century (Rydberg, 1906; Harrington, 1954, 1964). Moreover, in 1987, William A. Weber started to publish two partial floras/guides: *Colorado Flora: Eastern Slope* and *Colorado Flora: Western Slope* (4th edition, Weber and Wittmann, 2012a, b). Obviously, a flora of the whole state has been overdue for some time. Last year, a new flora of the whole state was published by a curator of the Colorado State University herbarium, Jennifer Ackerfield. The total numbers of native and alien vascular plant species recognized in these treatments can be summarized in the following table.

<u>Flora/manual</u>	<u>No. of species</u>
Rydberg, 1906	2912
Harrington, 1954, 1964	2794 (3135 taxa)
Weber & Wittman, 2012a	ca. 2300
Weber & Wittman, 2012b	ca. 2100
Ackerfield, 2015	3006 (3324 taxa)

After clarifying the numbers with the author, the total number of native species in her flora is 2481 (2670 unique taxa), and the total number of introduced species is 525 (526 unique taxa). Included introduced taxa (called “invasive” on p. 13) are mostly naturalized species (many of them spreading and, therefore, “invasive” [*sensu* Pyšek et al., 2004]), but some are just

cultivated (*Salix matsudana*) or escaping only temporarily (*Zea mays*). The largest native genera are *Carex* (113 species), *Astragalus* (96), and *Penstemon* (56). The treatment mostly follows the contemporary taxonomy, but Amaranthaceae and Chenopodiaceae are still separated, *Lotus* includes both introduced and native (*Acmispon*) species, and *Rhamnus* includes both *Frangula* and *Rhamnus*. A larger number of recently used synonyms should probably be used.

Plants are illustrated by 912 color photographs, mostly by the author. Many detail photos of grass spikelets, *Carex* perigynia and pistillate scales, Boraginaceae nutlets, and fern sori will be very helpful. Some pictures of whole plants, however, are not sharp enough to be useful for identification. Distributions of almost all species are illustrated by county presence maps. The book includes a short review of Colorado botanical history, a short description of the major plant communities, a glossary, and an extensive list of references. Keys look user-friendly (dissection of ovaries is almost completely avoided), and I can't wait to use the Flora the next time I am in the Colorado Rockies. It would be helpful to include an extra key (I would like to see this in all recent manuals) to segregate families in the traditional Liliaceae (e.g., Tennessee Flora Committee, 2014, p. 123). Inevitably, for a work of this kind, many mistakes will be recognized. Corrections and suggestions for improvements are being collected at <http://floraofcolorado.weebly.com/#/news/> and will be used in the next edition.

The *Flora of Colorado* is a monumental achievement. The volume fulfills the needs of professional botanists, students, and amateurs in Colorado. Furthermore, this is the first whole state flora written exclusively by a woman, not only in the United States,

but in the Western Hemisphere! I know of only about three other state floras written completely, or almost completely, by women botanists (Curtis, 1956–1994; Ramenskaya, 1960; Tackholm, 1974). This Flora is a must have for anyone interested in Colorado plants.

–*Marcel Rejmánek, Department of Evolution and Ecology, University of California, Davis, California, USA*

Literature Cited

- Curtis, W. 1956–1994. *The Student's Flora of Tasmania*. Government Printer, Hobart, Tasmania, Australia. [Vol. 4b in collaboration with D. I. Morris]
- Harrington, H. D. 1954. *Manual of the Plants of Colorado*. The Swallow Press, Denver, Colorado, USA.
- Harrington, H. D. 1964. *Manual of the Plants of Colorado*, 2nd ed. Sage Books, Denver, Colorado, USA.
- Pyšek, P., D. M. Richardson, M. Rejmánek, G. Webster, M. Williamson, and J. Kirschner. 2004. Alien plants in checklists and floras: Towards better communication between taxonomists and ecologists. *Taxon* 53: 131–143.
- Ramenskaya, M. L. 1960. *Opredelitel vysshich rastenij Karelii* [Key to the Higher Plants of Karelia, 485 pp.]. Ghosudarstvennoe Izdatelstvo Karelskoj ASSR, Petrozavodsk, Russia.
- Rydberg, P. A. 1906. *Flora of Colorado*. The Agricultural Experiment Station, Fort Collins, Colorado, USA.
- Tackholm, V. 1974. *Student's Flora of Egypt*, 2nd ed. Cairo University Press, Cairo, Egypt.
- Tennessee Flora Committee. 2014. *Guide to the Vascular Plants of Tennessee*. University of Tennessee Press, Knoxville, Tennessee, USA.
- Weber, W. A. 2012a. *Colorado Flora—Eastern Slope*, 4th ed. University Press of Colorado, Boulder, Colorado, USA.
- Weber, W. A. 2012b. *Colorado Flora—Western Slope*, 4th ed. University Press of Colorado, Boulder, Colorado, USA.

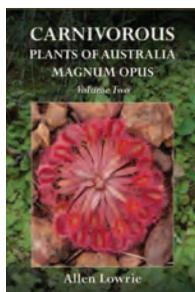
Carnivorous Plants of Australia: Magnum Opus

Allen Lowrie

2013. ISBN-13: Vol. 1: 978-1-908787-11-8; Vol. 2: 978-1-908787-12-5; Vol. 3: 978-1908787-13-2

Cloth, £34.99/volume (3 volumes). 1355 pp.

Redfern Natural History Productions, Poole, Dorset, England



The publication of a self-styled “magnum opus” is unusual, but so are Australia’s carnivorous plants. Approximately one third of the world’s more than 750 species of carnivorous plants are native to Australia, including a large number of narrow endemics. Allen Lowrie has devoted his career to studying Australia’s carnivorous plants, and this informative, lavishly illustrated, beautifully produced, and surprisingly affordable three-volume set is a welcome addition to the rapidly growing literature on these botanical marvels.

The predecessor to the *Magnum Opus* was Lowrie’s three-volume *Carnivorous Plants of Australia*, published between 1987 and 1998 by the University of Western Australia. Despite its importance as the first complete survey of Australia’s carnivorous flora, this shorter (690 pages in total vs. 1355 for the *Magnum Opus*) and smaller (octavo vs. quarto) work had a small print run and rapidly went out of print. In the intervening quarter-century, Lowrie and his colleagues have found and described many more carnivorous plant species from Australia and dramatically expanded our knowledge of these plants in their native ranges.

The *Magnum Opus* itself introduces readers to the different types of carnivorous plants and the varieties of traps. Although this material covers no new ground, it is important to note

that all trap types, except for the “lobster-pot” trap of *Genlisea*, can be found within Australia’s carnivorous flora, and most within the southwestern region of Western Australia. Lowrie continues the *Magnum Opus* with a photographic journey through the various habitats and localities where carnivorous plants are found in Australia. These include alpine meadows, coastal heathlands (“wallum”), billabongs, lagoons, ephemeral pools, deserts, gorges, swamps, lakes, and some forests. The unifying characteristic of these habitats is that they all tend to be very low in nutrients and (at least seasonally) very bright, and many *Drosera* species grow only on silica-sand soils.

The meat of the *Magnum Opus* (>1000 pages), however, consists of keys, drawings, photographs, and descriptions of all of the Australian carnivorous plants known as of ca. 2010 (several more have been discovered and described since this book was published). These include *Aldrovanda* (1 species), *Byblis* (8), *Cephalotus* (1), *Drosera* (163), *Nepenthes* (3), and *Utricularia* (66). Each species gets a four-page spread on heavy, glossy paper, and includes a standard species description with historical, etymological, and ecological notes; a detailed set of line drawings showing salient characteristics; a GIS-derived range map; and a set of field photographs. Eighteen of these species are described for the first time in the *Magnum Opus* (additional information on each of these, as required by the *International Code of Nomenclature for Algae, Fungi, and Plants*, is provided in an Appendix). Four natural hybrids are also described. Lowrie also clarifies some nomenclatural issue (11 species are revised from varieties to full species status and 12 are recalled from synonymy), erects three new sections for *Drosera*, and clarifies the application of names for species in *Drosera* section *Arachnopus*.

As the *Magnum Opus* seems written and produced not only for professional botanists, but also for field naturalists, carnivorous-plant aficionados, and individuals who enjoy large, lavishly illustrated coffee table books, the use of the Appendix to describe new species and resolve nomenclatural issues seems out of place. Although these would have been better published in the peer-reviewed literature, their inclusion here may provide non-specialists with a window on how taxonomy and systematics evolves as new knowledge accretes.

In that vein, a very nice addition to the book is a compilation of biographies of the 54 botanists who have described one or more of Australia's carnivorous plants. These include not only very well-known taxonomists (e.g., Bentham, de Candolle, Hooker [both father and son], Linnaeus, and Planchon), but also a host of others—54 in total. All but one of the biographies are accompanied by a painting, etching, or photograph (the one exception is Francis Buchanan-Hamilton, who described *Drosera lunata* in 1824), and a list of the Australian carnivorous species that they described. Reading through these biographies provided a wonderful historical overview of more than three centuries of botanical exploration in Australia.

Finally, although the keys, drawings, and photographs will ensure accurate identification of Australia's carnivorous plants in the greenhouse, lab, or herbarium, the *Magnum Opus*—weighing in at more than 10 kg—is not likely to be carried in my field pack. For that, I await an app. But on my desk, the *Magnum Opus* will be the standard starting point for studies of Australia's carnivorous plant flora.

—Aaron M. Ellison, Harvard University, Harvard Forest, Petersham, Massachusetts, USA

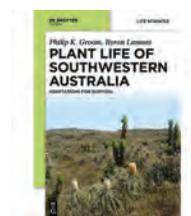
Plant Life of Southwestern Australia: Adaptations for Survival

Philip Groom and Byron Lamont
2015.

ISBN-13: 978-3-11-037016-4

eBook, open access. 268 pp.

De Gruyter Open, Warsaw,
Poland



Plant Life of Southwestern Australia: Adaptations for Survival is an equally valuable resource for enthusiasts in exotic and endemic flora—especially botanists, ecologists, taxonomists, phyto- and phylogeographers, and those involved in the bioprospecting-based biotechnology industry. Written for an audience expected to be well-versed in botanical, biological, and environmental terminologies, scholars from graduate students onward will find it immensely useful. Moreover, a long list of –omics researchers will appreciate the potential for generating new data for the described species using the information regarding adaptive strategies, mechanisms, advantages against calamities, soil types, and interactions with environment and fauna.

The prologue reveals that the inspiration behind this volume is Dr. Friedrich Ludwig Diels. A quick browse hints that the book promises to be an interesting read, offering informative insights on the region's flora evolution and diversity, anatomical pictures, landscape images, plant-animal interactions, ecology, socio-economic challenges, plant stress biology, and so on.

The first chapter gives an overview of plant evolution in the context of the southwestern Australian flora, providing a summary of much of the current literature. The topics covered include plants with fire-adaptations, unsurprisingly for the Australian flora. Chapter 2 will be of immense interest to

researchers worldwide and especially in places where fire is a socio-economic challenge, ranging from Californian deserts to the Indonesian archipelago. With global climate change running havoc, the catalog of drought avoiders and resisters offered in Chapter 3 will form a phytoresource for future researchers to exploit the genetic mechanisms for stress-tolerance in plants.

Chapter 4 focuses on carnivorous plants, which, with eye-catching images, their unique anatomy, biology, ecology, and related descriptions, are of interest to both beginners and experienced enthusiasts. Chapter 5 moves on to parasitic plants. The region is home to a unique set of these, including the commercially important sandalwood, *Cuscuta*, and mistletoes. Chapter 6 looks at specialized nutrient uptake mechanisms, and the discussed symbionts and mycorrhizae will form a unique library for microbiologists investigating these domains. An interesting sub-section is Chapter 6.5 on “The Bizarre Root System of *Kingia australis*.”

Chapters on pollination strategies and syndromes (Chapter 7 and 8), on seed release and dispersal (Chapter 10), and on seed storage, germination, and establishment (Chapter 11) are excellent reads for undergraduates studying entomology or carpology/pomology and will likewise be of interest to specialist researchers. Taxonomists and ecologists will find the chapter on leaves (Chapter 9) immensely useful, especially for sections on sclerophylly, heterophylly, and mimicry. An interesting section looks at the demonstration of mimicry in leaves of *Hakea trifurcata* in response to a mummified avian granivore such as Carnaby’s black cockatoo (Figure 9.11).

The book is nicely prepared, illustrated, and clearly written. What is even more appealing is the fact that the book is open access on De

Gruyter Online. In addition, I must note that interested readers may bump into another useful resource addressing similar themes in a book entitled *Plant Life on the Sandplains in Southwest Australia: A Global Biodiversity Hotspot*, edited by Hans Lambers, published by University of Western Australia Press (ISBN-13: 978-1-74258-564-2).

Some tables are exhaustive and wordy, but are immensely informative for generating interest in young researchers. Likewise, some schemes could have been updated but, understandably from a taxonomy and phytogeography perspective, they are simple and informative. Many sections such as those on stomatal distribution, seed size, and mycorrhizae are very pertinent to present-day researchers and, although brief, are thought-provoking. With citations updated to 2013 and spread over 37 pages, the original works are well cited. In short, for Australia enthusiasts, this book has all the kangaroos and platypuses of the flora side of life!

The book boasts countless breathtaking pictures—including *Cephalotus* pitchers, *Macrozamia* seeds, *Caladenia* flowers, and *Banksia* inflorescences fed upon by the honey possum. Many of the landscape images are stunning and of excellent quality, demonstrating the immense diversity of the southwestern Australian landscape. Two improvements that can be noted: the scales are missing for the pictures, which would have been useful to show the dimensions of flora ranging from gigantic trees to small flowering herbs, and a glossary of terms may have been helpful for non-professional readers. Overall, the volume will be a valuable addition to any herbarium, library, or departmental book shelf, as well as to one’s personal collection.

—Biswapriya B. Misra, University of Florida,
Gainesville, Florida, USA

Plant Guide: Maritime Succulent Scrub Region, Northwest Baja California, Mexico

Jim Riley, Jon Rebman, and Sula Vanderplank
2015. ISBN-13: 978-1889878-44-7

Flexbound, US\$35.00. 218 pp.
The Botanical Research Institute of Texas Press, Fort Worth, Texas, USA



Published by the Botanical Research Institute of Texas Press, this is No. 42 of their Botanical Miscellany series. The book is a photographic guide to over 210 plants that occur in the botanically rich Maritime Succulent Scrub Region of Baja California, Mexico. The guide is bilingual, with both English and Spanish text.

The Maritime Succulent Scrub Region (MSSR) of northwest Baja California is known for its interesting mix of succulent plants and Coastal Sage Scrub plants. According to this guide, this unusual ecotone has allowed for the development of over 100 endemic plants. This guide mainly includes plants of this region but also covers some from riparian, salt marsh, and dune habitats. It is lavishly illustrated with primarily high-quality photographs showing many aspects of the listed plants (e.g., leaves, flowers, fruits).

As I read through the guide I got the impression that it was almost trying to include too many features and could have used some more editing. The book starts by stating its purpose and scope: to give the reader an appreciation for this region, which I feel it does. After a brief description of the region, there are two reserves listed that one may visit to see these plants. This is followed by brief descriptions of other habitats in the region. I

would have liked for the habitat descriptions, especially of the MSSR, to have been more thorough—providing more background on geology, ecology, etc. Then follows one of the oddest things I have ever seen in a field guide: a brief timeline of plant evolution and when complex life forms evolved. I did not quite understand why this was included. There is then a diagram of the parts of a flower and a short introduction to modern angiosperm classification. Here there are quibbles with terms (e.g., quillworts and lycopods are called Lycophytes on one page and “fern allies” on the next) and a misunderstanding of evolution, i.e., “angiosperms evolved first with the Magnoliids & other Basal Eudicots, followed by Monocots... Later the Eudicots evolved with two seed leaves.” These kinds of errors should have been caught by an editor.

The bulk of the guide focuses on what I assume are the most common or interesting plants of the region (it is not explained why these taxa were chosen). There is a “Quick Guide to Plant Families” with brief descriptions of the most diverse, and therefore most likely to be encountered, families in the region such as the Asteraceae, Fabaceae, and Cactaceae. Here, the bilingual nature of the book is confusing in that it is not consistent. Opening to the Boraginaceae and Cactaceae in the Quick Guide, one can read their descriptions in English on page 20 and in Spanish on page 21. The descriptions are identical (I assume, since I can’t read Spanish) but the photos used to depict the families are different. On the next two pages, covering the Chenopodiaceae and Polygonaceae, the photos are identical on the two language pages. On this second set of pages there are English photo captions for the Spanish page, whereas on the previous page there were Spanish captions for the Spanish page.

Next are the species descriptions with angiosperm families arranged alphabetically. Monocots are very sparingly covered and then come the eudicots. In the upper-right corner of each page is a header with the family and the informal Angiosperm Phylogeny Group (APG) grouping it occupies. Rosids and Asterids are listed the most (although for many pages Fabaceae are erroneously listed as Asterids), but then families like Cactaceae and Chenopodiaceae are listed as Core Eudicots rather than Caryophyllids. Again, a quibble, but these errors and inconsistencies are common. The photos are great and I enjoyed looking at them and reading the brief descriptions of the plants. Here, consistency is a problem once more. Sometimes the photos show multiple parts of the plant and other

times just multiple photos of the flowers. Sometimes there are photo captions telling the reader what is depicted, but not always. There are also no scale bars to allow the user to know the size of the parts. Sometimes a penny or dime is used for scale but not for every plant.

If one is looking to take an “armchair trip” to this region then this is a good book for that. The photos are copious and nicely done and would instill a sense of appreciation for the region, as the book intends. For a scientific guide for field identification or taxonomic information, a user should look elsewhere.

*–John G. Zaborisky, Botany Department,
University of Wisconsin–Madison, Madison,
Wisconsin, USA; jzaborisky@wisc.edu*



ISSN 0032-0919

Published quarterly by
Botanical Society of America, Inc.
4475 Castleman Avenue
St. Louis, MO 63166-0299

Periodicals postage is paid at
St. Louis, MO & additional
mailing offices.

POSTMASTER:

Send address changes to:
Botanical Society of America
Business Office
P.O. Box 299
St. Louis, MO 63166-0299
bsa-manager@botany.org

The yearly subscription rate
of \$15 is included
in the membership

**Address Editorial Matters
(only) to:**

Mackenzie Taylor, Editor
Department of Biology
Creighton University
2500 California Plaza
Omaha, NE 68178
Phone 402-280-2157
psb@botany.org

The Botanical Society of
America is a membership soci-
ety whose mission is to: pro-
mote botany, the field of basic
science dealing with the study
& inquiry into the form, func-
tion, development, diversity,
reproduction, evolution, & uses
of plants & their interactions
within the biosphere.

Plant Science Bulletin Featured Image



Hot Air Balloon flower

Gentianella is a genus of flowering plants that comprises 275 species distributed over the Americas, Eurasia, Australia, and New Zealand. A group of 51 species of the genus have evolved on the high altitudes of the Andes reaching up to 4,700 m above sea level (15,400 f). The miniature flowers portrayed in the photo are about to open, their bright colors and the globular shape makes them seem like miniature hot air balloons.

Photo by: Oscar Vargas, The University of Texas at Austin
Submitted for the 2015 Triarch Student Travel Award

Celebrating our History, Conserving our Future

Botany 2016

July 30 - August 3
Savannah, Georgia



Savannah International Trade and
Convention Center

Symposia, Posters, Exhibits,
Field Trips, Workshops

Submit your abstract and sign up to attend this
premier botanical conference!

www.botanyconference.org

