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Combating Plant Blindess and a Plant Invasion through Service-Learning

by Carol Goodwillie and Claudia Jolls

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From the Editor

Greetings,

I am writing this on a cold, icy day in Omaha, but I am happily looking ahead to the summer. Abstract submission and registration is currently open for BOTANY 2018 in July in Rochester, MN. If you haven't attended a Botany meeting in a while (or ever), I encourage you to think about attending this summer. You can find information about this year's conference at http://2018.botanyconference.org and on page 8 of this issue. There is an exciting line-up of diverse special lectures and an array of colloquia, workshops, and symposia.

I want to personally encourage graduate and undergraduate students to attend the meeting. I attended my first meeting just after my sophomore year in college and my experience significantly contributed to my choosing to pursue a career focusing on plant science. I have since encouraged several of my undergraduates to attend and have continually been pleased with their experiences. There are several travel grants to support student travel. Information about these, as well as many other resources for students, can be found in this issue's Student Section.

In this issue, we also tackle issues of diversity and inclusion in plant science (p. 18) and present a case study in combating plant blindness (p. 11). Both of these address challenges that we, as botanists, face.

I hope to see many of you in Rochester. As always, if you have an idea for a *PSB* article or a news item of interest to the society, please do not hesitate to contact me.

Mackenzie

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Public Policy News

Last year, the ASPT Environment and Public Policy Committee (EPPC) and the BSA Public Policy Committee (PPC) awarded $1000 to fund a workshop titled "Plant Conservation and Sustainable Management by Women in the Jaragua-Bahoruco-Enriquillo Biosphere Reserve, Dominican Republic: Community Workshop and Local Capacity." These funds—the 2017 Botany Advocacy Leadership Award—provided the necessary compensation for supplies for the workshop, travel, and compensation for the teachers involved. This annual award organized by the Environmental and Public Policy Committees of BSA and ASPT aims to support our members' efforts that contribute to shaping public policy on issues relevant to plant sciences.

The workshop, held on August 31, 2017, in Oviedo, Perdenales, Dominican Republic, was a great success; participants and garden instruction can be seen in the figures on the following page. Jaragua-Bahoruco-Enriquillo is the only biosphere reserve in Hispaniola Island and is located in the southwest of the Dominican Republic, near the boundary with Haiti—including some of the poorest regions of this island. However, this is a very rich area in biodiversity and plant endemism, many of which are valued for their medicinal properties. All the biodiversity of the area is threatened by human activities, mainly deforestation for charcoal making, low-yield cattle ranching, or subsistence agriculture. These factors put at risk many locally endemic species, such as *Pimenta haitiensis*, a medicinal plant widely used in the country.

The first essential step in biodiversity conservation in any threatened area is to integrate the local communities. By working closely with rural populations who are in contact with the biodiversity of the reserve, programs like this can help promote the educational and economic development that will alleviate poverty in the region. This workshop promoted the conservation of endemic and native plants in the Jaragua-Bahoruco-Enriquillo Biosphere Reserve and encouraged the sustainable use of native plants by women of local communities. Most of the plants that were used for planting at the garden are endangered and rare species, traditionally used by local communities as sources of fruits, as well as medicinal and aromatic plants.



By **Ingrid Jordon-Thaden** *(University of California Berkeley), ASPT EPPC Chair,* **Krissa Skogen** *(Chicago Botanic Garden), and* **Kal Tuominen** *(Metropolitan State University), BSA PPC Co-Chairs*

The Botany Advocacy Leadership Award (BALA) is in its third year of supporting a project like this. The deadline each year is the end of March, and announced in mid-April. See the BSA and ASPT award sites (https://cms.botany.org/home/awards.html and https://aspt.net/award/#.WphggIJG0_U, respectively) for application details.

In Memoriam

Elizabeth Farnsworth (1962-2017)

On October 27, 2017, Dr. Elizabeth Farnsworth died unexpectedly at her home in Amherst, Massachusetts. She was 54. For those who knew and worked with her, who played music, paddled, or hiked with her, who cleaned seeds beside her while swapping stories at the long tables at Garden in the Woods and Nasami Farm, who took her online courses or heard her lectures, "unexpectedly" is a vast understatement. The words "Elizabeth" and "died" do not belong on the same page. That she was in her prime, radiating warmth and vitality, a vivid picture of apple-cheeked, wild-maned health, makes this notion profoundly hard to accept, and bitterly unacceptable.

After all, as one can imagine her shouting in the face of whatever stopped her heart that day, she still had so much *to do*.

She already had packed a lot of achievement into her foreshortened life, as at least one grieving colleague observed. She was an accomplished botanist, educator, and scientific illustrator. At the time of her death, Elizabeth was co-leading the New England Wild Flower Society's effort to conserve seeds of hundreds of rare plant species throughout New England. But Elizabeth's many contributions to the Society started more than two decades ago. Recent members might know that she wrote, constructed, and taught the Society's first set of online botany courses and wrote the ground-breaking "State of the Plants" report. A few years earlier, she co-led the National Science Foundation grant for developing Go Botany, the Society's interactive online guide to the entire New England flora, and then won an additional grant from the same source to support student research in conservation biology. She coordinated planning for the conservation and management of more than 100 species of rare plants. She illustrated dozens of entries in *Flora Novae Angliae* by Arthur Haines, the Society's research botanist. And with a grant from the Institute of Museum and Library Services, she conducted an assessment of seed banking and collections practices at the Society and published a model protocol by which to prioritize target populations for seed collection. A natural and passionate teacher, Elizabeth jumped in to serve as interim education director in 2013, arranging all the courses the Society offered.

The Society is not the only institution that will miss her and her scholarly contributions. When she died, Elizabeth was serving as senior editor of the botanical journal *Rhodora* and on the graduate faculties of the University of Massachusetts Amherst and the University of

Rhode Island. Before that, she also had taught at Smith, Mount Holyoke, and Hampshire colleges and the Conway School of Landscape Design. As a writer, she displayed the rare ability to address both academic peers and novice botanists with equal clarity—and not a whit of condescension for the latter. To date, she had published 54 peer-reviewed scientific journal articles and 61 invited publications for public media. She also co-authored the award-winning *A Field Guide to the Ants of New England*, which she also illustrated; the *Connecticut River Boating Guide: Source to Sea*; and the *Peterson Field Guide to the Ferns*. Her delicate, precisely rendered illustrations also grace the pages of *Natural Communities of New Hampshire* and three other books.

How, then, did she find time to deliver more than 230 invited presentations throughout the world, much less to sing and play guitar semi-professionally and paddle her prized hand-built kayak? Alas, it is too late to ask. She loved to travel, preferably in further exploration of the natural world, and, at various times in her career, she conducted research on ecosystems all over the globe, focusing on conservation, plant physiology, mangroves, and climate change. She served as a scientific consultant to the United Nations, the National Park Service, The Trustees of Reservations, the U.S. Forest Service, the Massachusetts and Connecticut Natural Heritage programs, and the Mount Grace Land Conservation Trust.

Brilliance marked her early: At Brown University, Elizabeth earned her B.A. in environmental studies in seven semesters, graduating with honors. She went on to study at University of Vermont, receiving her M.S. in field botany. While earning her Ph.D. at Harvard University, she was awarded a Bullard Research Fellowship and a National Science Foundation Postdoctoral Fellowship. Her dissertation on mangrove seedlings launched a journey to 17 countries as a Harvard Traveling Scholar, to conduct a comparative survey of mangroves. She was honored to be chosen as a teaching assistant to E. O. Wilson, with whom she shared a passion for ants.

Elizabeth, a gifted storyteller, enjoyed sharing tales of her travels and other adventures—about the time all the members of the Grateful Dead crashed at the house she shared with roommates in college, about sitting around camp with David Attenborough in a South American rainforest, about leeches invading unmentionable places (which, of course, she mentioned). Now her friends, colleagues, and students are seeking solace by sharing our memories and stories about her.

"She was that rare human being who was talented in both the sciences and the arts, who excelled in everything she did," said Director of Conservation Bill Brumback, the person at the Society who has worked most closely with Elizabeth over the years. "And she made the world a little better for those who knew and worked with her."

For those who would like to honor Elizabeth's legacy with a donation, her family suggests sending donations to:

- *New England Wild Flower Society (https://46858.blackbaudhosting.com/46858/Memorial),*
- *Hitchcock Center for the Environment (https://donatenow.networkforgood.org/elizabethfarnsworth),*
- *or any other conservation organization of the donor's choice.*

(Reprinted with permission from the *New England Wild Flower Society: http://newenglandwild.org/elizabeth-farnsworth.html.)*

Traveling to South Korea for Fieldwork (not involving plants)

Fieldwork, in my mind, conjures up images of long journeys to interesting places, often-inclement weather, sleeping in tents, exhaustion at the end of the day, and the exciting possibilities of discovering something new. Fieldwork for an editor is similar in some ways but is usually a little less outdoorsy. In late November of 2017 I went "into the field" to meet with editors halfway around the world to talk about publishing: specifically, about what a managing editor of a scientific journal does. The destination: Seoul, South Korea.

The email invitation arrived in mid August, soon after I returned from the International Botanical Congress in Shenzhen, China, which was a fascinating experience (and my first trip to Asia). The Korean Council of Science Editors (KCSE) and Korean Federation of Science and Technology Societies (KOFST) are two organizations headquartered in Seoul, which are allied with the Council of Science Editors in the States. They had invited my friend and colleague Patty Baskin, of the American Academy of Neurology, to present on aspects of publication management, and she invited me to accompany her. In Korea, many journal editors work on their own, but there is great interest in setting up editorial offices with managing editors or assistants.

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I was thrilled to be invited and accepted straightaway. And then a bit of anxiety set in. News headlines were sounding the alarms of rising tensions between the leaders of the U.S. and North Korea throughout the fall months. Would a trip to South Korea be advisable in these uncertain times?

I planned my presentations, purchased travel insurance (just in case), and left on an airplane on November 28, 2017, bound first for Atlanta, then on to Seoul. Despite my concerns, and the uncertainty of the political climate, it was an interesting, productive, and altogether enjoyable trip. [Note to self: To relax while traveling, turn off news alerts on your cell phone. It does not help to know that impressive intercontinental ballistic missile tests are taking place close to where you have just landed.]

My colleague and I took a long journey to an interesting place, with somewhat inclement weather, and were exhausted at the end of the day. The flight from Atlanta to Seoul is over 15 hours long, and the ride from the airport to our hotel in the Gangnam District took another hour. Seoul is a vibrant, fast-moving, high-tech city of over 10 million people (over 25 million if you include the sprawling metropolitan area, according to the World Population Review). The Gangnam District is a hip, upscale, modern area that attracts

young people by the thousands on a Friday night. The metro was beyond crowded. The two days of meetings were cold (–3° C), and we experienced one of the first snows of the winter. The long flight, the intense days of meetings, and the considerable jet lag led to exhaustion at the end of the day, and that odd limbo when your body and mind don't know whether to be awake or asleep.

Even though it was a very short trip, there was much to share and discover. I presented on journal metrics and spoke on the duties of a managing editor, which are essentially to oversee the smooth day-to-day running of the editorial office, and everything that comes with that. We manage the publication process, working with authors, reviewers, and editors from before submission through post-publication; we copy edit manuscripts and handle production; we work with vendors and publishers; we keep up to date on all the various trends and concerns in the publishing arena; we handle ethics, copyright, plagiarism, permissions, instructions for authors, and requests for information; we seek out special papers and facilitate special, themed issues; we work on our publications and for the societies we serve; we promote articles, authors, and society members via social media; and we do it all in a professional manner.

What I discovered was that our Korean counterparts were handling many of these tasks themselves and were also maintaining full-time positions in their research areas. They are concerned with the same issues we are, including journal Impact Factors and other evaluation metrics (but with emphasis on IFs); writing peer reviews for academic journals; establishing and following journal style; distinguishing between predatory and non-predatory Open Access journals; and managing scientific investigations involving ethics, copyright, and plagiarism (and beyond). They are also deeply concerned with their publications programs and are looking to compete on a much more international scale—and I have no doubt they are going to succeed.

Outside of the formal lectures and presentations, we spent time drinking coffee and eating delicious food (stunningly delicious, fresh seafood!) and talking about publications, yes, and also about our cultures and current tensions between and among North and South Korea and the United States. It was fascinating to discuss the state of the world in which the concerns were real for all of us—immediate political concerns, but also the realities of climate change, the importance of education, and the necessity of global solutions to some of the problems we all face. I discovered during that trip hope for a better way forward. I left Korea with new friends and colleagues: we have a lot to learn from each other, and I look forward to future collaborations.

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- Visit Mystery Cave State Park
- Walk through the Minnesota Landsape Arboretum and then Prince's private estate - Paisley Park
- Discover the New Bell Museum, the MIN Herbarium and Surly Brewing Company

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- See the Karst bedrock and tour the Whitewater Valley
- Another chance to go Kayaking on the Cannon River

Photo by Jason Hasweth

Minnesota Landscape ARBORETUM

Combating Plant Blindness and a Plant Invasion Through Service-Learning

Abstract

Inspired by a critical deficit in field botany experiences in higher education, we developed an undergraduate service-learning program in invasive plant biology that introduces students to botany while they contribute to solving a local ecological problem. Since 2014, undergraduate biology students at East Carolina University (ECU) have worked with the city recreation and parks department to control an invasion of sericea lespedeza (*Lespedeza cuneata*) along a local greenway. Service-learning is incorporated into sections of an existing lecture course in plant biology, with invasive plant removal accomplished in sessions outside of assigned class time. During fieldwork, observations of plant structures and native plants reinforce lecture material on plant biology. In turn, invasive plant biology is used as a theme throughout lectures to illustrate concepts in plant physiology and reproduction. Our efforts appear to be have been effective in slowing the invasion of lespedeza and inspiring students to explore botany and environmental issues.

"Plant blindness" is a confirmed bias, with significant implications for conservation and management (Wandersee and Schussler, 2001; Balding and Williams, 2016). This bias against plants is further exacerbated by limited appreciation for and experience with the out-of-doors, argued to result in a range of negative consequences, the so-called "nature-deficit disorder" (Louv, 2005). Outdoor settings are preferable for teaching species identification and concepts in ecology (Randler, 2008; Stagg and Donkin, 2013). Direct field experience also has potential to help promote what Balding and Williams (2016) termed as "empathy" with plants for

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greater botanical literacy. Yet biology programs worldwide place increasing focus on molecular biology, often at the expense of organism- or species-level knowledge and field-based approaches, particularly in botany (Jacquemart et al., 2016). Inspired by this critical deficit, we initiated an undergraduate service-learning program in invasive plant biology to introduce students to field botany and simultaneously engage them in solving an ecological problem in our local community.

Service-learning involves students in experiential education to combine service activities with reflective assignments (Eyler, 2002). This method contributes to the community and cultivates civic responsibility "through active participation and thoughtfully organized service" (US National and Community Service Acts of 1990; Jacoby, 1996). The concept of "community service" has been extended to ecological communities and their interface with humans, and it has been proposed as an approach to environmental education (Clayton, 2000). "Research service-learning" engages students, faculty, and the public in partnerships to ask research questions relevant to their community (e.g., environmental issues related to invasion biology) (Reynolds and Loman, 2013).

Invasive species management is an obvious focus for service-learning. Non-native invasives are responsible for losses of biodiversity, other negative ecological consequences, some human health threats, and economic damages estimated in the billions of dollars (Pimental et al., 2005). Invasive plants, as primary producers, can be particularly damaging as threats to habitats, native species, crop yields, fire regimes, interactions, and associated ecosystem services (e.g., pollination). Control of plant invasions is challenging; yet in some cases, simple manual removal can be an effective solution (Kettenring and Adams, 2011) requiring only a willing workforce. The energy and enthusiasm of undergraduates can be harnessed for this effort.

A SERVICE-LEARNING PROJECT IN INVASIVE PLANT BIOLOGY

The problem

Soon after a 2.5-mile greenway was established in Greenville, NC, it was invaded by sericea lespedeza (*Lespedeza cuneata* (Dum. Cours.) G. Don). Sericea, a semi-woody forb in the pea family, was introduced from China to North Carolina in 1896 for erosion control and forage (Ohlenbusch et al., 2001). The species grows aggressively in the introduced range and poses increasing threats to grasslands and other natural areas, where it outcompetes native species (Quick et al., 2016). The sericea invasion along the Greenville greenway was evident soon after the trail was constructed in 2011; we suspect that seeds were present in sand that was brought in for fill during construction of the paved trail. By 2014, dense patches of sericea could be seen along the trail (Fig. 1) and the invasion appeared to be expanding rapidly.

Service as a solution

A service-learning program was created to involve students at East Carolina University (ECU) in efforts to stem the sericea invasion. Service-learning activities are integrated into sections of a lecture course in plant biology that we previously developed. Offered as a junior-level elective for biology and science education majors, the course covers plant

Figure 1. *Three years after construction of the greenway, dense populations of sericea lespedeza were present in some areas.*

structure, function, and diversity, including physiology, metabolism, reproduction, genetics, evolution, ecology, and human use. Since 2014, students in service-learning sections of the course have been working in collaboration with the City of Greenville Recreation and Parks Department to control the invasion of sericea along a greenway located just a mile from the ECU main campus. During field sessions, students work in teams to remove sericea plants by simple manual pulling (Fig. 2). Although extracting the entire root system is often difficult, removing at least the woody caudex is relatively easy and prevents the formation of multiple branches in the following year. To maximize our success in managing the invasion, we supplement removal efforts with herbicide treatment when necessary. Each year we have identified a few small patches (2-8 m^2 in size) where the plants are too large or densities too high to make manual removal feasible. The Greenville Recreation and Parks crew applies glyphosate to these. Service fieldwork is accomplished outside of class time, and students are required to attend at least two 3-hour sessions. Multiple sessions are scheduled throughout August and September, often in late afternoons or weekends, to ensure that all students can participate. Field time is compensated by a canceled lecture period. Importantly, all plant removal and herbicide application is done at the start of the fall semester before sericea lespedeza seeds mature and are dispersed.

Removal of plants is complemented by data collection. One student per team serves as a scribe in each session, recording the number of plants removed. Because we attempt to remove all sericea plants present, these data serve as a record of changes in population size throughout our project. The counts also motivate students to work harder, as teams often compete informally to see who can remove the most plants.

How service contributes to learning

Service-learning as a pedagogy is built on the idea that service can provide motivation and context for classroom learning; in turn, content learned in the classroom makes the service component a deeper and more meaningful experience (Jacoby, 1996; Eyler, 2002). We use this interplay of field and classroom experiences in our program. During field sessions, removal work is interrupted intermittently to illustrate terminology and concepts learned during lectures using sericea and other plant species along the trail (Fig. 3). Inspection of nitrogen-fixing root nodules on sericea plants reinforces class material on plant nutrients and mutualisms. Lateral buds visible on the sericea caudex prompt

Figure 2. *Pulling can remove sericea roots as well as stem and caudex, as demonstrated by this undergraduate student.*

discussions of plant anatomy and perenniality. Other species along the greenway provide great opportunities for exploration of plant structure and function. Students inspect doubly-compound leaves (mimosa) and tendrils (muscadine grape). They are asked to think about why bark peels (river birch), how epiphytes survive (Spanish moss), why a parasitic plant is not green (dodder), and what might be the benefits of seed dispersal mechanisms (jumpseed).

During traditional classroom lectures, invasive plants are integrated as a theme throughout the course. During the evolution and diversity section of the course, students are introduced to angiosperm plant families that contain many invasive members and even examples of invasive mosses and ferns. We ask students to apply and test their knowledge of basic plant biology as they consider which species become invasive and how invasive species spread. The primary literature is rich with studies on the physiological and ecological properties of invasive plants. For example, studies compare the invasiveness of species with different breeding systems (e.g., Hao et al., 2011) and consider the role of C4 vs. C3 photosynthesis (Martin et al., 2014) or mutualistic associations (e.g., Hu et al., 2014) in plant invasions. These studies are presented as capstones to lectures on each topic, with in-class group activities that ask students to interpret and discuss the results shown in published graphs.

Figure 3. *Field sessions are interrupted occasionally to observe and explore plant structures.*

PROJECT OUTCOMES

Getting a handle on the invasion

Our cumulative data suggest that we are making progress in controlling sericea along the greenway. During the three years of the project, counts of stems pulled by students have declined from 6,932 in 2015 to 3,952 in 2017—a 43% reduction. The removal data give us only a rough estimate of the effectiveness of our efforts. Students are somewhat inconsistent in how they report data; multi-stemmed individuals are occasionally counted as more than one plant. More importantly, because our primary goal was to manage the invasion rather than to quantify the results of our work, we have not retained an untreated control area for comparison. Observations of sericea at nearby sites suggest that, without control efforts, the invasion would have advanced during these three years beyond the point at which manual removal was feasible. Moreover, demographic modeling of sericea lespedeza predicts that unmanaged populations can increase by more than 20-fold per year (Schutzenhofer et al., 2009). Despite the limitations of our quantitative data, documenting our results is an important motivator for students. Students are particularly engaged in their contribution to a longer-term dataset. In light of the insurmountable environmental problems we face, seeing that small efforts can have real positive effects may be the most important lesson that students learn.

Stealth Botany!

The course lends itself to a lecture-plus-lab format, but we were concerned that requiring a 3-hour lab each week would whittle our clientele down to a small group of students already committed to field biology. To reach a broader group, we offer it instead as a lecture course with required service fieldwork done outside of class, at times arranged to accommodate student schedules. More than 100 undergraduate students have participated since 2015, a diverse group heading for careers in health care, science education, and many other disciplines. In return for the inconvenience of leading multiple sessions to work around students' complicated schedules, we have had the satisfaction of seeing pre-med and molecular biology students get excited about native plants and enjoy themselves in the natural world. Hearing of our approach, fellow plant biologist Paulette Bierzychudek offered, "Aha, a stealth botany course!"

Indeed, the observations integrated into plant removal work appear to be powerful learning opportunities. Students are not required to memorize natural history information presented in the field and rarely take notes during these sessions. Yet they often recount their observations of the native plants in accurate detail in the reflection papers they write on their service experiences. To be sure, we are lucky to have some especially fascinating and charismatic plants at our site (baldcypress, dodder, resurrection fern, Spanish moss). We argue, though, that most plants are quite good at communicating their own magic; our job is mostly to get students outside to look at them.

Anecdotal evidence suggests that our program has broader impacts on student interest and attitudes as well. In both verbal and written comments, students frequently express their new awareness of the problems posed by invasive species and the satisfaction they feel about "making a difference." We have seen students go on to other plant courses in the curriculum, suggesting that the program instills interest in botany. Students also have

moved on to research work in faculty labs and internships in science education outreach.

WHERE TO FROM HERE?

With the project now in place, we are exploring opportunities for expansion. The current anecdotal, qualitative data can be supplemented with more formal course evaluation. The plant biology course is offered with and without the service-learning component in alternate semesters, and we have an opportunity to design a controlled study to assess its pedagogical effectiveness. Questionnaires to track learning outcomes or evaluate targeted aspects of the course can be developed with the expertise of other colleagues in social science or education to promote trans-disciplinary collaboration among faculty. While our experiences to date suggest positive student outcomes, rigorous assessment will provide greater insight into how service-learning in invasive plant management affects student attitudes about plants, conservation and civic engagement and mastery of basic concepts in plant biology.

We are also working to expand our engagement with community partners. Students often express a desire to educate and involve the public in their efforts. These discussions led to a project by the 2016 class to design educational signage that is now installed along the greenway, a further collaboration with Greenville Recreation and Parks Department and a non-profit community organization. In future semesters, we will explore the possibility of students leading teams of community volunteers to remove plants. We are fortunate to have supportive city resource managers and university Ground Services staff. The invasive plant project has complemented campus wetland restoration, University Tree Campus USA initiative, and a Bayer CropScience Feed A Bee Program project to use native plants in landscaping to promote pollinator forage and habitat.

Successful long-term management of invasive species often involves restoration of natives in addition to removal efforts (Kettenring and Adams, 2011), and we plan to use this approach in our project. A promising observation from the 2017 season is that native plant species (largely *Symphyotrichum dumosum* (L.) G.L. Nesom and *Eupatorium semiserratum* DC.) are beginning to colonize areas where sericea lespedeza has been removed. In a pilot study this year, we are supplementing natural colonization by seeding open areas with native plants found on the trail. Long-term data can be collected on this process as well, to gauge the effectiveness of the strategy.

Service-learning programs in invasive plant management can be readily implemented at other institutions. The good and bad news is that most school campuses (K-12 and college) have adjacent properties with plenty of invasive plants and potential for restoration. The program requires little financial support and can build valuable relationships with the community and city partners. Service-learning using invasive plants has enabled our students to overcome their plant blindness, gain awareness of a critical environmental problem, and recognize their own power to solve problems and to contribute to something larger and longer lasting than themselves.

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Humanizing the Academic Science Career Pipeline: Interdisciplinarity in Service to Diversity and Inclusion

Key Words

broadening participation; culture of science; epistemology of science; human diversity; institutional change; interdisciplinary research; intersectionality

Academic scientists have discussed the progressive loss of human diversity at each STEM career stage using the metaphor of the "leaky pipeline" (e.g., Barr et al., 2008; Chesler et al., 2010; Miller and Wai, 2015). Data on the underrepresentation of women, people of color, and people who experience disability in STEM degree completion and workforce participation are updated every two years (National Science Foundation, 2013, 2015, 2017). Women now complete a greater proportion of graduate degrees in the biological sciences than men (National Science Foundation, 2017), although evidence of overt and unconscious gender bias continues to be documented (Moss-Racusin et al., 2012; Clancy et al., 2014). African Americans, Latin Americans, and Indigenous Americans (Native Americans and Alaska Natives) make up an increasing proportion of bachelor's and master's degree students in the biological sciences, but also leave STEM undergraduate programs at least 60% more often than white students (Koenig, 2009; National Science Foundation, 2017). The proportion of PhDs completed by members of these populations has also stagnated, despite increasing representation in the U.S. working-age population (National Science Foundation, 2017).

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The view of academic science as a pipeline with differential demographic leakage hints at underlying assumptions that have influenced those of us seeking to broaden STEM participation. First, the idea of a pipeline belies a normative position that scientific career development should be a continual linear progression (Cohen et al., 2004). This appears to derive partly from outdated ideas that a professional success is achieved in a single career, which consists of an unbroken series of jobs with increasing responsibilities in one field. The metaphor can thus, at minimum, facilitate men's access to STEM careers and perpetuate barriers to women's (Wonch Hill et al., 2014; Makarova et al., 2016).

Next, the concept of a pipeline leak suggests that the location and causes of divergence from the normative goal can be found at

specific parts of the career progression, observed, and diagnosed through data collection. For instance, a pipeline might leak due to "punctures," such as experiences of overt bias (e.g., Ferguson Martin et al., 2016; Clancy et al., 2017; Miner et al., 2017); "loose connections," such as poor mentor-protégé matching (e.g., Buzzanell et al., 2015; Dennehy and Dasgupta, 2017); or "high pressure," such as balancing research time with caretaker responsibilities (e.g., Grunert and Bodner, 2011; Sallee et al., 2016; Tower and Latimer, 2016). Finally, diagnosed leaks can be targeted so that the "plumbing" can be repaired using different approaches for populations facing different sorts of challenges (e.g., Tull et al., 2012; Wilson et al., 2012). For these interventions, the pipeline has typically been viewed at the institutional level, whether that institution is a university, professional society, or government; rhetorically, a key phrase invoked in efforts to reduce leakage is *institutional transformation* (e.g., Handelsman et al., 2007; Fox, 2008; Whittaker and Montgomery, 2014). This troubleshooting process also creates new opportunities for research and publication among scientist-plumbers who pursue this much-needed area of study. It's all wonderfully *scientific*—and how else would we expect scientists to act?

Putting scientific training to this use is not a bad instinct, yet we should remain concerned that pipeline troubleshooting efforts have not been as successful as we have hoped. Institutional efforts can improve retention of students from underrepresented backgrounds (e.g., Tull et al., 2012; Wilson et al., 2012), but these do not appear to be scaling up to the national level. The gap in the share of STEM and non-STEM degrees completed by underrepresented minorities has been growing during the past decade, indicating that these students preferentially choose against the sciences (National Science Foundation, 2017). Such data suggest that academic science may be begging the question of underrepresentation: after studying the problem empirically and making empirically driven interventions at the institutional level, underrepresentation for several groups is increasing. Why believe that continuing the same strategy will yield success?

NATURAL SCIENTISTS IN A SOCIAL WORLD

Sociologists of science tell us that becoming a scientist is partly a matter of socialization into the *culture* of science (Roth, 2001; Eames and Bell, 2005; Clark et al., 2008). What assumptions do students make about scientists when they view this culture from the outside? Recent stereotyping tests show that undergraduates still most often identify scientists as older white men (e.g., Miele, 2014; Schinske et al., 2015). Students generally assume scientists are intelligent (e.g., Schinske et al., 2015). These stereotypes have relevance for students' decisions. Pursuit of a science major is related to the alignment between students' ideas about scientists and their self-conceptions (e.g., Lane et al., 2012; Guy, 2013). Furthermore, many students believe intelligence is a fixed trait; those who do tend to avoid challenging themselves with courses they perceive as more difficult (Dweck, 2000).

Meanwhile, new graduates with STEM degrees gain an economic advantage as they enter the workforce (Koc et al., 2016). From cell phones and social media to evidence-based reporting requirements for nonprofit funding, the public is surrounded with, even regulated by, the results of scientific thinking. The number

of U.S. jobs requiring college-level knowledge in science and engineering is approximately triple the number of jobs formally categorized within these fields (National Science Board, 2016a). Americans believe the benefits of scientific research outweigh its harms, that the government should fund basic research, and that leaders of the scientific community are more trustworthy than leaders of all American institutions other than the military (National Science Board, 2016b). Although it may not always feel that way to us scientists, the stereotypes, surveys, and the ubiquity of science all suggest having scientific training is a form of social privilege in American society.

This raises some questions highly relevant to supporting diversity at every level of academic science. How many academic biologists have formalized knowledge about the meaning and implications of social privilege for the classroom? Could a lack of knowledge or training on this topic be connected to well-intentioned, but functionally counterproductive, classroom or mentorship behaviors? Could the ubiquity and social status of the natural science paradigm itself contribute to the challenge of supporting human diversity in biology, perhaps through the assumption that "scientists know best" even outside their expertise? Could our own scientific training potentially interfere with our goals of supporting human diversity?

For concision, I will consider only this last question. Good scientific training encourages certain behavioral tendencies while discouraging others. First, we natural scientists are enculturated to value *objectivity*, which is useful to help us avoid cognitive biases. This focus can come at the cost of discounting individuals' subjective experiences. Second, we are enculturated to focus on *weight of evidence* from (increasingly) *large sample sizes*. The benefit is the more accurate inference of general principles about a target population. The cost is discarding statistical outliers and discounting results from small samples, both of which may provide unique insights. Third, a focus on *general cause-and-effect patterns* allows for the creation of interventions that can be applied at the level of a target population. Yet knowledge of general patterns and population-level solutions do not necessarily provide useful insights about how to best support a particular student who is considering leaving science.

As an example of how the trade-offs of scientific enculturation can manifest, consider the implications of NSF's demographic reporting on participation in science (National Science Foundation and National Center for Science and Engineering Statistics, 2013, 2015, 2017). National-scale data on underrepresentation by race, gender, and disability are crucial to our understanding of diversity in STEM. However, the demographic categories focus mainly on large populations. The report does not provide clear data on individuals who transcend categories, such as biracial, transgender, or intersex individuals, nor is the highly heterogeneous category of disability further disaggregated. Other groups, such as immigrants, LGBQ individuals, first-generation college students, and students entering at a nontraditional age or lower economic status, are simply not considered. This homogenized view of who is in the pipeline precludes the possibility of "engineering" changes attuned to the needs of individuals whose identities are not represented. Most of these populations experience marginalization in American society at large, but scientific expectation and financial realities hold that we should disprove the null hypothesis that "everything is fine in STEM" before considering action. When anecdotes are not considered evidence, the lack

of quantitative data itself can become a barrier to discussions about underrepresentation (Patridge et al., 2014).

The NSF's reporting on the interactive effects of gender and race in its most recent reports are illustrative of an additional need to consider intersectionality (i.e., the effects of multiple aspects of identity on a person's life experiences). The results demonstrate that men of color have had lower rates of science and engineering degree completion than women of color for nearly 20 years, while the opposite is true of white men and women (National Science Foundation, 2017). If we look only at gender in the same report, we see approximate parity in the biological sciences. If we look at race, we see that African Americans complete biology degrees at lower rates than their presence in the American population would lead us to expect (National Science Foundation, 2017). These two graphs would not be enough to prompt many white scientists to think about addressing the unique needs of African-American men or the pressures these students often face outside the classroom. Only the intersectional graphs prompt a reader to consider these features. In this way, intersectional data can help de-homogenize our thinking about students from a wide variety of backgrounds.

A well-designed quantitative study can identify underlying patterns specific to intersectional identities (Guy, 2013; Clancy et al., 2017). Nevertheless, quantitative methods will break down for populations, such as transgender and gender-nonconforming individuals like myself, that are not represented widely in the general population, let alone within the scientific community (Patridge et al., 2014; Pryor, 2015). Another population to which I belong, that of individuals experiencing disability, is so heterogeneous that the practical applicability of quantitatively driven solutions is subject to question. Quantitative surveys require that researchers generate ideas *a priori* that respondents can numerically rank. Researchers' beliefs may constrain or bias which ideas are considered relevant and the types of solutions proposed. Finally, statistical analysis emphasizes the most common patterns within a group, excluding outliers at quality control steps. Thus, quantitative methods can erase at least some experiences of underrepresented individuals.

Let us return to the normative expectation of scientific epistemology, that the null hypothesis ("everything is fine in STEM") must be disproven before taking action. This can place a particular burden of disproof on scientists with stigmatized experiences. We who experience stigma have both deep awareness of how far from reality this hypothesis may be and the greatest incentives to avoid disclosure. For example, LGBTQA respondents who were open to few or none of their colleagues or students also reported a higher perception of their workplaces as unsafe, hostile, and lacking in support for LGBTQA employees (Yoder and Mattheis, 2016). More broadly, anecdotes have long suggested that sexual harassment and assault are endemic in science, but a research study was necessary to highlight their seriousness as systemic issues in field research (Clancy et al., 2014). Pressure to avoid disclosure for the sake of job security can seriously affect a scientist's quality of life. Furthermore, non-disclosure means that colleagues are far less likely to have information dissuading them from the null hypothesis, allowing assumptions about both work climate and stigmatized experiences to go unchallenged.

Instances like these are where the leaky pipeline metaphor misdirects us: researchers

can study those at risk of leaking without fully recognizing the way our own ideas have been shaped by the pipeline. Individuals and institutions are reduced to data, as opposed to humans experiencing subjectively mediated breakdowns in relationships, responsibilities, and ethics. Placing empiricism first can send the implicit message that science is more important than our colleagues' well-being, particularly when outlier feedback is interpreted as a personality difference rather than observation from a different social location. We who face oppression within broader society and are minoritized in science often cannot wait for research to demonstrate to other scientists what we already know. While empiricism catches up, supporting us *in practice* requires personal conversations about the locations of career pitfalls that are, to some extent, inherently subjective.

TO SUPPORT DIVERSITY, BE MORE HUMAN... OR PERHAPS A FISH

Attempts to fix pipeline leaks solely through reliance on natural science can cause us to miss epistemological gaps that our methods do not address (Roth, 2001). In particular, applying the scientific lens too broadly or without sufficient awareness of social factors may lead us to discard the *human* part of science, to base our efforts on statistically "validated" stereotypes, or to erase certain forms of experience. While we can begin to address inclusivity and diversity using natural science methods, we must remain open to the possibility that some best practices to support diversity and inclusion may not be scientific. I suggest we can further improve our efforts by (1) improving our knowledge of the dynamics of social privilege, (2) collaborating with social scientists trained in qualitative research methods, and (3) telling our own stories of navigating career challenges in science.

Social privilege makes daily life easier in ways that are often invisible to one who holds it. Graduate mentoring is an illustrative example of how this manifests in scientific training. Students of color report a preference for a mentor of their own race significantly more often than white students (Blake-Beard et al., 2011). While racial matching for all students appears to be correlated with higher student rankings of mentor support, the rate at which such matching actually occurs for students of color is about half that for white students (Blake-Beard et al., 2011). As a white graduate student, I was privileged in two senses: first, it did not occur to me to consider whether I wanted a white mentor. Second, it would not have required much effort to make such a match had I wanted it. Learning that many students prefer and perceive benefits from racial matching encourages me to ask undergraduates of color about their preferences when discussing future plans.

We who belong to groups underrepresented in STEM must often navigate cultural and structural barriers in institutional and social systems. This results in greater cognitive loads relative to the privileged minority by and for whom higher education was initially constructed. For instance, Indigenous students must reconcile cultural and Western understandings of science, typically within a Western pedagogical framework (Abrams et al., 2013; Wall Kimmerer, 2015). African-American graduate students report questioning their reasons for pursuing STEM degrees after lethal police actions (Patton, 2014), and completing a graduate degree does

not end experiences of racial discrimination (Andrist, 2013). Most transgender individuals have experienced at least one instance of life-disrupting discrimination such as severe bullying, assault, job loss, or denial of accommodations; nearly one in four have experienced at least three of these (Grant et al., 2011). Individuals with disabilities may face pedagogical and physical barriers to equitable access, even when taught by faculty supportive of universal design (Lombardi et al., 2011; Vreeburg Izzo, 2013; Shanahan, 2016). People with invisible, intermittent, or chronic conditions may have gaps in their employment records or face difficult trade-offs between disclosure and stigma from advisors and employers (e.g., Jones and Brown, 2013). Given this social context, many of us who fall into underrepresented groups in STEM are also in the minority among our demographic peers *because* we have had access to scientific training. Neil deGrasse Tyson has provided an exemplary discussion of perceived conflicts between interest in science and responsibilities to the African-American community (interviewed in Andrist, 2013).

Scientists who fall into multiple underrepresented categories must navigate the challenges of multiple social forces. Each may compete for time we would rather be spending on our work; in combination, they may have greater-than-additive impacts (Armstrong and Jovanovic, 2015). Interventions that focus on homogenized populations may compel those of us with intersectional identities to choose one specific facet to receive institutional support. However, our multiple, linked cognitive loads often cannot be reduced in such a way, and we can take less for granted in our daily lives because of the ways these facets intersect. If faced with sufficient challenges, we may not be able to fully capitalize on opportunities that our colleagues and the scientific community bring to us, even when we are well-prepared and deeply interested. Learning about these structural factors and demonstrating curiosity about individuals' challenges both creates useful support on a human level and makes us better colleagues and advisors (Killpack and Melón, 2016).

Because quantitative methods can exclude diverse experiences, additional methods are needed to comprehensively identify and address issues related to diversity and inclusion in science. Most natural scientists lack training in qualitative methods, so collaboration with social scientists who do is critical in advancing understanding. Qualitative research also allows study designs that humanize and create partnerships with underrepresented individuals, rather than viewing us as abstracted research samples or as scientists getting "distracted" from lab or field studies. For example, discussions among a highly heterogeneous cohort of underrepresented scientists and trainees at the 2014 Northeast Scientific Training Programs Retreat have provided valuable, wide-ranging insights on supporting diversity and inclusion in science (Campbell et al., 2014). A prominent theme was a need for greater interdisciplinarity—defined in this case as using social justice, communications, and the arts to guide and disseminate scientific research.

This study raises the possibility of linking science and the humanities in service to diversity and inclusion. The scientific mindset encourages us to look to the data to discover the *most likely* path to a graduate degree or a tenured position in biology, and the *most likely* way that certain individuals may leave that path. A humanistic mindset looks to individualized experiences to discover *all*

possible paths to success, providing a map of roads less traveled. Where the scientifically rational "likelihood perspective" could risk activating stereotype threat, a humanistic "possibility perspective" may be a useful counter (Schinske et al., 2016). Storytelling can therefore balance science's homogenizing and depersonalizing tendencies. A natural science perspective does not address practical questions, such as what a graduate student with intersectional identities should do if they experience a *specific instance* of bias or harm (e.g., racial harassment) from a colleague within an institution they perceive as biased in other ways (e.g., sexist or ableist). Here, reading narratives from or having conversations with scientists who have had similar experiences can make the difference between choosing to leave academia and using ingenuity to find or advocate for a healthier work environment. Stories provide alternative means of understanding possible options, help build trust and deepen relationships, and become tools for healing and sense-making (Gold, 2008; Harter and Bochner, 2009). Even brief reading/writing assignments in introductory biology classrooms highlighting the diversity of scientists' identities and practices can shift students' perceptions about scientists in ways that are linked to higher performance and interest in science (Schinske et al., 2016). Those of us who are in a position to do so should consider sharing our stories of navigating major career challenges, formally or informally.

Natural scientists spend our educations learning to identify where things like pipelines break down, while our counterparts in the humanities often spend their training considering where metaphors do so. A critical place where the leaky pipeline metaphor breaks down with reference to diversity and inclusion lies in what that pipeline carries. Human diversity is defined by its discrete and overlapping heterogeneity, while water flows, mixes, and homogenizes. The *overuse* of scientific thinking in this context risks treating students, postdocs, adjuncts, and those on the tenure track—our (previous) selves—as interchangeable droplets following universal rules, subject to an engineered solution requiring little conversation. Interrogating this metaphor is not merely intellectual play: I have highlighted how quantitative research can homogenize scientist identities, narrow the range of perceived need, and miss possible solutions. Although those working in the humanities do not hypothesize the way that biologists do, their ways of knowing can generate insights on where science may unintentionally become part of the challenges we try to address. I leave it as an exercise to the reader to consider how our questions about the leaky pipeline might change if we thought of students and academic scientists as "fish" rather than "water." To practice my own recommendation, I will write a follow-up essay sharing some of my own experiences as a fish who has navigated between pipeline and outside "stream" multiple times to highlight the most important lessons I have learned.

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PlantingScience Program Experience Benefits Students

PlantingScience continues to grow! This past fall marked our largest PlantingScience session ever, with more than 70 teachers and over 3000 students participating.

Thanks to all of our scientist mentors, new and experienced, who volunteer an hour of their time per week to inspire the next generation of plant scientists by mentoring students' plant science investigations online.

As part of the NSF-funded Digging Deeper project, we have been conducting an efficacy study of PlantingScience's Power of Sunlight Investigation Theme. Preliminary results are showing statistically significant achievement gains regarding major plant biology concepts for students of teachers who participated in the Digging Deeper/PlantingScience programs. Students' attitudes about scientists also improve as a result of participation. I'll be sharing more news about the program's efficacy as we begin publishing the research results in the coming months.

Participating students recognize and appreciate both the plant biology and the soft skills they learn by conducting their own science investigations and collaborating with scientist mentors. Sharon Harris, a PlantingScience AP biology teacher shares:

"All of my AP students from last year said the PlantingScience activity was the single most important academic achievement for them (in all their courses, not just the sciences)! They spoke of gaining confidence, loving the independence of designing their own experiments, and finding inner strength when their experiments proved frustrating. Thank you for what you provide to these young scientists!"

Pre-service teachers are also benefitting from the PlantingScience program, with a partnership at Wright State University where undergraduate education majors participate as students in the program, making connections with scientist mentors and experiencing the process of science and the pedagogical techniques of inquiry learning themselves. You can see a star-project winning team from this collaboration at https://plantingscience.org/projects/wsukenyonwosfall2017project5.

By Catrina Adams, Education Director

BSA Science Education News and Notes serves as an 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.

Congratulations to all of our Fall 2017 Star Project teams. Each session we choose 10-15 projects to feature in our Star Project gallery. These projects represent projects that have excelled in one of several categories. Check out our Star Project Gallery (https://plantingscience.org/starprojectgallery) to see what makes these projects exemplary (Figure 1).

Figure 1. *Team "Parasite Prognosticators," one of 15 Star Project winners for the Fall 2017 PlantingScience session, conduct an investigation comparing the effects of store-bought and home remedies on brown soft scale insects living on Dieffenbachia leaves. See more from the team at https://plantingscience.org/projects/hthsrochefall2017project8/info.*

The PlantingScience received this fantastic e-mail showing the impact the program and its mentors had on one particular student!

Several years ago I had a very unmotivated student. Seriously, nothing got him excited about learning—not going to the creek, not labs, not cool environmental videos. Anyway, it was time to begin PlantingScience. This year we were doing the genetics project. Well, my unmotivated student suddenly became excited about something. He was communicating with his mentor scientist on several topics with genetics of plants. This kid who tried his best to sleep through his day was now pretending to take notes or work on assignments on his computer while talking to his mentor scientist. The mentor scientist made such a difference for this kid. Other teachers told me he was no longer sleeping in their classes.

It must be added that this student was one that was considered "at risk," meaning at risk of not graduating. He went on to Kennesaw State and got very involved with the environmental program there. Kennesaw's program has grown so much in the past years. It grows food to feed the students in the cafeteria, and students do a lot of work in a several greenhouses. My student got so much from his experience with having a scientist mentor. I really think it changed his path, and possibly his life.

Mentors are so valuable. Having an expert who takes the time to encourage students is something that really helps the students and makes the students confident to take the responsibility of designing and following through with an experiment. The scientist mentors have been wonderful. Many are young and relate well with the students or experienced and patient with the students, all offering a positive influence that really is a special thing for students. It is really one of the very best things about this wonderful project.

QUBES Faculty Mentoring Network (FMN) "Plants by the Numbers" Kicks Off this Spring

Fifteen faculty members have joined the first QUBES/BSA Faculty Mentoring Network "Plants by the Numbers: Growing Quantitative Literacy Using Botany" (https://qubeshub.org/groups/bsa2018). These faculty are interested in adopting plant-focused modules that address quantitative reasoning skills in their undergraduate life science courses. This spring they will work together as they customize and implement newly designed education modules on a range of botanical topics drawn from the PlantED digital library (https://planted.botany.org/). Every other week they meet in facilitated virtual sessions to collaborate with and support others in the network and receive mentoring.

The PlantED Digital library is a great place to submit your educational materials at https://econboted.econbot.org/index.php?P=EcoEdDL_SubmissionInstructions for peer-review, and to access peer-reviewed materials to use in your courses. Teaching notes from the Plants by the Numbers faculty participants will be added to selected resources in PlantED at the end of the FMN experience.

Check Out "Beyond the Bean Seed": A Plant Exploration YouTube Channel

BSA member Melanie Link-Perez (Miami University, Ohio) shares a host of ways to bring plants into your classroom in her new YouTube channel: https://www.youtube.com/channel/UCWujRCTgYlQkEZQPrWtq4fw/featured.

Her aim is to help others meet the challenge issued in Link-Perez and Schussler (2013, *Plant Science Bulletin*) to explore the diverse, exciting, and intricate world of plants that lies "beyond the bean seed." She is also soliciting requests for new resources on the Discussion page of the channel and is planning to produce episodes on demand. Support her efforts by sharing her channel!

Image Quiz Software Available for Visual Learning of Plant Identification

BSA member Bruce Kirchoff (University of North Carolina) has been developing effective software for active visual learning (Kirchoff et al., 2014; Burrows et al., 2014). The Image Quiz software he has developed is free and

open-source. The plant identification quizzes are available to download at: *https://github.com/Jasig/ImageQuiz/releases.*

VL-PI.1.2.zip is the PC version and VL-PI.dmg is the Mac version of the software. The two remaining files include source code packaged for PC/Mac.

It is also possible to add your own images to the basic software to create custom versions for your own classes. The software is versatile and can be adapted to a number of different learning domains. Versions of the software that help students learn algae and vascular plant life cycles and plant morphology terminology have also been developed, and we'll share links to those resources in future issues of the *Plant Science Bulletin*.

For questions about the software, you can contact Dr. Kirchoff at kirchoff@uncg.edu.

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FROM THE *PSB* ARCHIVES

60 years ago: The BSA Committee to Study the Role of Botany in American Education, which received funding from NSF to recommend how and why botany should be integrated into high school and university courses, published their report. Much of what they suggest is quite familiar. Below is an excerpt.

"The Role of Botany in College Education of All Undergraduates:
We believe that some study of plants should be included in the college work of all undergraduates in order:

1. To make clear the role of plants in the nature cycles, in the maintenance of soil fertility, in erosion control, etc.
2. To emphasize the dependence of human life upon plants
3. To develop understanding of certain general principles: inheritance, evolution, interrelationships of living organisms, etc., for the illustration of which plants are especially suitable.
4. To appreciate the development of practical applications of science from research in the basic, "pure" sciences. Basic research in botany has led for many years to practical applications in agriculture, forestry. etc.
5. To clarify the inter-relationship of structure and function in living plants, since plants are susceptible of easy and revealing experimentation."

- Report of Botanical Society of America Committee to Study the Role of Botany in American Education *PSB* 4(3): 1-3

50 years ago: An In Memoriam for Edmund W. Sinnott was published. "On January 6, 1968, Edmund W. Sinnott, Sterling Professor of Botany Emeritus, Yale University, died at the age of 79. The death of this eminent scientist and scholar is a severe loss not only to the botanical world but to the academic community and to the broad spectrum of biological sciences which his distinguished career encompassed and so greatly enriched."

- Wilson, Katherine S. "Edmund Ware Sinnott (1888-1968)" *PSB* 14(1): 6-7

Roundup of Student Opportunities

Isn't it hard to believe that we are already in a new year? Many of us may have created a list of New Year's resolutions, and since we are already a few months into 2018, it's the perfect time to re-evaluate and/or fulfill some of those goals. If you happened to make any career-focused resolutions, we're betting that there was at least one pertaining to writing and/or improving your research. In fact, you may be trying to figure out what you can do to help you reach your educational, research, and career goals. Fear not, because we have compiled a list of opportunities that you might be interested in. Although some of the deadlines may have already passed, they might be opportunities that you will want to keep in mind for 2019!

Below, we have four categories for easy browsing that include the following: Grants and Awards, Broader Impacts, Short Courses and Workshops, and Job Hunting.

Grants and Awards

Grants and awards can help fund your research; provide assistance for travel related to training, fieldwork, or conferences; and even contribute to your cost-of-living and tuition expenses (e.g., fellowships). Additionally, applying for grants and awards is a great opportunity to hash-out a research plan as well as fine-tune your writing skills by articulating said research plan. Lastly, don't forget to check with your department and university to become familiar with internal grants for which you can apply!

By James McDaniel *and* **Chelsea Pretz**,
BSA Student Representatives

BSA Graduate Student Research Awards	
$500	Botanical Society of America
Research Funds Deadline: March 15	Aim: To support and promote graduate student research in the botanical sciences. Includes the J.S. Karling Award.
More info:	www.botany.org/Awards
BSA Undergraduate Student Research Awards	
$200	Botanical Society of America
Research Funds Deadline: March 15	Aim: To support and promote undergraduate research in the botanical sciences.
More info:	www.botany.org/Awards
BSA Student Travel Awards	
Variable, up to $500	Botanical Society of America
Conference Travel Deadline: April 10	Several awards support student travel to the annual BOTANY conference: - Cheadle Student Travel Awards - BSA Section Awards
More info:	www.botany.org/Awards
NSF Graduate Research Fellowship Program	
$34K/year + tuition	National Science Foundation
Stipend & Tuition Deadline: October	Aim: To support outstanding graduate students in NSF-supported disciplines who are pursuing research-based Master's and Doctoral degrees at accredited United States institutions.
More info:	www.nsfgrfp.org
Torrey Botanical Society Fellowships and Awards	
up to $2,500	Torrey Botanical Society
Research Funds & Travel Deadline: January 15	Aim: To support research/education of student society members (fund field work, recognize research in conservation of local flora/ecosystems, or fund course attendance at a biological field station). There are awards for undergraduate and graduate students.
More info:	www.torreybotanical.org
Prairie Biotic Research Small Grants	
up to $1500	Prairie Biotic Research, Inc.
Research Funds Deadline: December 20	Aim: To support the study of any species in U.S. prairies and savannas.
More info:	www.prairiebioticresearch.org

Botany In Action Fellowship	
$5000	Phipps Conservatory and Botanical Gardens
Research Funds Deadline: January 12	Aim: To develop new, science-based plant knowledge and chronicle traditional knowledge of plants. BIA promotes interactive scientific education about the importance of plants, biodiversity, and sustainable landscapes.
More info:	https://phipps.conservatory.org/green-innovation/for-the-world/botany-in-action/call-for-proposals
The Lewis and Clark Fund for Field Research	
up to $5000	American Philosophical Society
Research Funds Deadline: February 1	Aim: To encourage exploratory field studies for the collection of specimens and data as well as provide the imaginative stimulus that accompanies direct observation.
More info:	www.amphilsoc.org/grants/lewisandclark
ASPT Graduate Student Research Grants	
up to $1000	American Society of Plant Taxonomists
Research Funds Deadline: March 5	Aim: To support both master's and doctoral students conducting fieldwork, herbarium travel, and/or laboratory research in any area of plant systematics.
More info:	www.aspt.net/award
Richard Evans Schultes Research Award	
up to $2500	The Society for Economic Botany
Research Funds Deadline: March 15	Aim: To help defray the costs of fieldwork on a topic related to economic botany for students who are members of the Society for Economic Botany.
More info:	www.econbot.org
Sigma Xi Grants-in-Aid of Research	
up to $1000	Sigma Xi
Research Funds Deadline: March 15 and October 1	By encouraging close working relationships between students and mentors, this program promotes scientific excellence and achievement through hands-on learning.
More info:	www.sigmaxi.org/programs/grants-in-aid
Systematics Research Fund	
up to £1500	The Systematics Association & The Linnean Society
Research Funds Deadline: February 15	Besides research focused on systematics, projects of a more general or educational nature will also be considered, provided that they include a strong systematics component.
More info:	www.systass.org/awards

The Exploration Fund Grant	
up to $5000	The Exploration Fund Grant
Research Funds Deadline: mid-November	Aim: To provide grants in support of exploration and field research for those who are just beginning their research careers.
More info:	www.explorers.org/expeditions/funding/expedition_grants
CIC Smithsonian Institution Fellowship	
$32,700 for one year	CIC & the Smithsonian Institution
Stipend Deadline: December 1	Aim: To support research in residence at Smithsonian Institution facilities. All fields of study that are actively pursued by the museums and research organizations of the Smithsonian Institution are eligible.
More info:	www.cic.net/students/smithsonian-fellowship
Ford Foundation Fellowship Programs	
$24K-$45K, for 1-3 years	Ford Foundation
Stipend Deadline: Mid-December	Three fellowship types are offered: Predoctoral, Dissertation, and Postdoctoral. The Ford Foundation seeks to increase the diversity of the nation's college and university faculties.
More info:	http://sites.nationalacademies.org/pga/fordfellowships/index.htm
Early Career Grant	
up to $10,000	National Geographic Foundation
Research Funds Deadline: April 4	Aim: To support research, conservation, and exploration-related projects consistent with National Geographic's existing grant programs. In addition, this program provides increased funding opportunities for fieldwork in 18 Northeast and Southeast Asian countries.
More info:	https://www.nationalgeographic.org/grants/what-we-fund/
The Mohamed Bin Zayed Species Conservation Fund	
up to $25,000	The Mohamed Bin Zayed Species Conservation Fund
Research Funds Deadlines: February 28, June 30, and October 31	This fund is a new and significant philanthropic endowment established to directly support the cause of species conservation. It is open to applications for funding support from conservationists based in all parts of the world dealing with plant and animal species.
More info:	http://www.speciesconservation.org/

Fulbright U.S. Student Program	
Varies	U.S. Department of State
Travel (abroad) Deadline: October	Offers a variety of grants for one year of study or research abroad to over 100 countries. Applicants must have proficiency in the written and spoken language of the host country.
More info:	https://us.fulbrightonline.org/
P.E.O. Scholar Award	
up to $15,000	P.E.O. Scholar Awards Laureate Chapter
Scholarship Deadline: November 20	Female applicant must be within two years of completing her doctoral-level degree and she must have one full academic year of work remaining at the time the award payment is made in August or September.
More info:	https://www.peointernational.org/psa-eligibility-requirements
AAUW American Fellowships	
Varies	American Association of University Women
Scholarship Deadline: November 15	Aim: To support women scholars who are completing dissertations, planning research leave from accredited institutions, or preparing research for publication.
More info:	https://www.aauw.org/what-we-do/educational-funding-and-awards/american-fellowships/

Broader Impact Opportunities

These opportunities are not just for NSF grants! Sharing your passion for plant science with a wide range of audiences will help develop speaking skills as well as help you re-connect with why you decided to go to graduate school in the first place.

The Arnold Arboretum Awards for Student Research	
$2000-$10,000	The Arnold Arboretum
Research Funds Deadline: February 1	Multiple awards and/or fellowships are offered for undergraduate and graduate students with topics that focus on Asian tropical forest biology and comparative biology of woody plants (including Chinese-American exchanges). Be sure to check the website for full information on each award.
More info:	www.arboretum.harvard.edu/research/fellowships/

Garden Club of America Scholarships	
$2500-$8000	Garden Club of America
Research or Training Funds	Many awards are offered to support botanical research, with foci ranging from public garden history/use, field botany, medicinal botany, and horticulture. Be sure to check the website for full information on each award.
Deadline: January-February	
More info:	www.gcamerica.org/scholarships
PLANTS Grant	
Varies	National Science Foundation and Botanical Society of America
Conference Travel	The PLANTS program will pay the expenses of up to 12 undergraduate students to participate in the BOTANY 2018 meetings (Rochester, Minnesota from July 21-25, 2018) as well as provide mentoring from both peer and senior mentors in the plant sciences.
Deadline: March 1	
More info:	http://botany.org/Awards/F_PLANTS.php
SMART Program	
$25K-$38K/year + tuition	American Society for Engineering Education
Stipend & Tuition	Aim: To increase the number of scientists and engineers in the DoD. The program is particularly interested in supporting individuals that demonstrate an aptitude and interest in conducting theoretical and applied research.
Deadline: December	
More info:	http://smartscholarship.org/

PlantingScience	
What it is:	A learning community where scientists provide online mentorship to student teams as they design and think through their own inquiry projects.
What you can do:	Interact with grade school to college-level students online as they work on plant-focused learning modules in the classroom.
More info:	www.plantingscience.org/

Science Olympiad	
What it is:	Competitions are like academic track meets consisting of a series of 23 team events in each division (middle school or high school). Each year, a portion of the events are rotated to reflect the ever-changing nature of genetics, earth science, chemistry, anatomy, physics, geology, mechanical engineering, and technology.
What you can do:	Mentor local students in person on a variety of science and engineering oriented topics and skills as well as help organize and run competitions.
More info:	www.soinc.org/
Local Arboretums, Parks, Museums, and Herbaria	
What it is:	These institutions often depend on volunteers to donate their time and expertise to help people of all ages enjoy their collections and grounds. They may already have programs in place that allow you to lead tours or interact with visitors at special events so that you can share your interests and passion.
What you can do:	Lead tours as well as help organize and run events
More info:	Look up local parks/arboretums/museums/herbaria online or inquire at visitors' centers.

Short Courses and Workshops

These are a great way to learn new research skills, which can also be added to your CV or resume. Here are a few of the many options available to graduate students for part of a semester or summer.

Advanced Field Botany	
University of Idaho June or July	This two-week course is open to upper division undergraduates and early career graduate students. In the course, you'll gain valuable experience and botanical knowledge in the field. You'll also get acquainted with the flora of Idaho in the Inland Northwest. Interested students should look for an announcement in the spring.
More info:	www.webpages.uidaho.edu/dtank/AFB/Advanced_Field_Botany.html

Tropical Botany Summer Course	
University of Florida June or July	This course highlights the biology and systematics of tropical plants, specifically the extensive holdings of tropical vascular plants at Fairchild Tropical Garden, The Kampong of the National Tropical Botanical Garden, and the Montgomery Botanical Center. Field trips will also be offered to the Everglades, the Florida Keys, and other adjacent natural areas. Be on the lookout for an announcement during the winter months.
More info:	www.flmnh.ufl.edu/herbarium/news/tropicalbotany.htm
OTS Courses in Tropical Field Biology	
Organization for Tropical Studies Variable dates	Courses through the Organization for Tropical Studies (OTS) are a well-renowned way to spend a summer or semester in the field, learning about the biology of tropical ecosystems in Costa Rica and South Africa. Course offerings include Tropical Plant Systematics, but check their website for the full list of offerings.
More info:	www.ots.ac.cr
Molecular Evolution Workshop	
Marine Biological Library at Wood's Hole July 19 to July 29	This 10-day course features a series of lectures, discussions, and bioinformatics exercises. Included are sessions on phylogenetic analyses, population genetics analyses, databases and sequence matching, molecular evolution, and comparative genomics. Applications for participation are due in April.
More info:	molevol.mbl.edu/index.php/Main_Page
Bodega Bay Applied Phylogenetics Workshop	
UC Davis and the Bodega Marine Laboratory To Be Announced	This week-long course will cover topics in statistical phylogenetics and give students the opportunity to complete a project during the course. The schedule will likely include sessions on Bayesian inference, divergence-time estimation, MCMC diagnosis and model selection, biogeography, continuous and discrete trait evolution, species tree inference, and rates of lineage diversification.
More info:	www.treethinkers.org
The R Basics Workshop	
Missouri Botanical Garden To Be Announced	This workshop is one way to get exposure and experience working with R, a powerful statistical software package. Scientists from the Center for Conservation and Sustainable Development in St. Louis will teach June 5-7, 2018. Look out for formal announcements in December or January and watch their website.
More info:	www.rbasicsworkshop.weebly.com

edX: Data Analysis for the Life Sciences	
online	edX, a free online course provider, offers a 7-part course on data analysis for the life sciences (PH525.1-7). These courses are a self-paced way to learn R for statistical analysis, starting with basic R use to dealing with genomic datasets. These courses combine video lectures, practical exercises, and a discussion board monitored by course developers.
Variable Times	
More info:	search "PH525" on www.edx.org

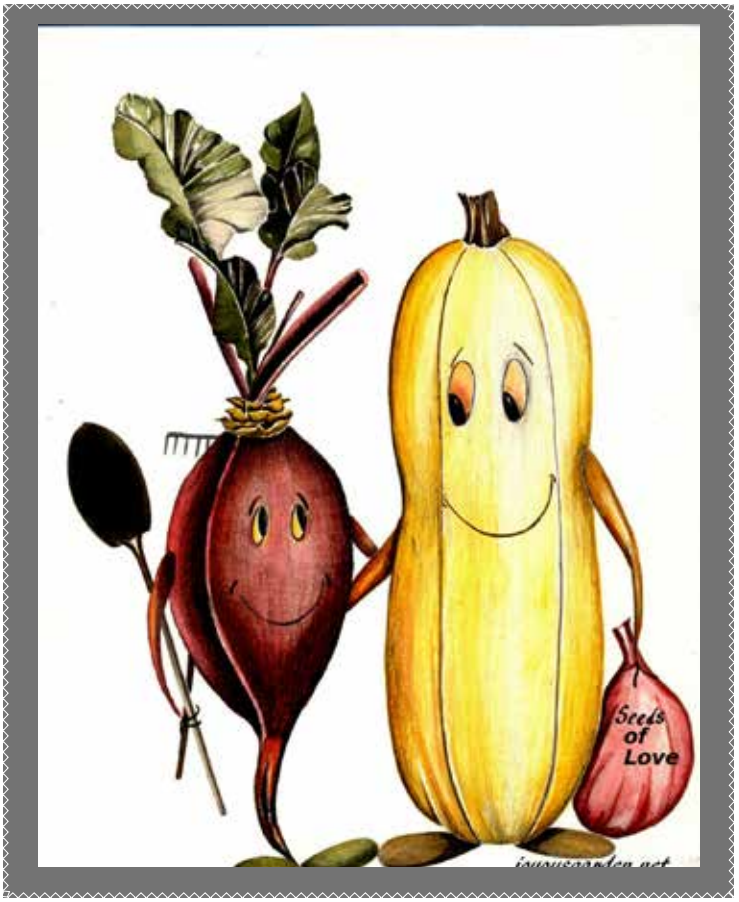
What's Next: Looking for a Job in Botany

Before you complete your degree, or if you are looking to switch jobs, it is important to consider your next step—whether it be finding a PI and lab to work in for continuing your education, finding a postdoctoral research opportunity, or finding a job that suits your goals and skills. Finding out about jobs often happens through personal contacts, but there are great online resources as well.

Masters/PhD/Post-Doctoral Opportunities	
These types of jobs are easily searchable on the "EvolDir" website under "PostDocs" and "GradStudentPositions." Click the icon, and listings will pop up in a list from the newest to the oldest. This site shows positions from across the biological sciences, but it is a great option for plant evolutionary biologists.	
EvolDir	http://life.biology.mcmaster.ca/~brian/evoldir.html
Academic Teaching Positions	
Check the BSA website, click on the "Careers/Jobs" tab, and you can select the "Post-doctoral, Fellowship, and Career Opportunities" link to see a current list of a variety of job postings. The BSA website is a great resource for one-stop shopping for careers and other opportunities in a variety of botanical sciences. Another good resource for finding jobs (including postdoctoral opportunities) can be found through AAAS, at the Science Careers site.	
Botanical Society of America	jobs.botany.org
AAAS Science Careers	jobs.sciencecareers.org/jobs/botany-plant-science
Government Positions and Non-Academic Jobs	
Searches for government jobs can begin at usajobs.gov and federaljobsearch.com. A good resource for non-academic jobs is the Conservation Job Board; this site allows you to search within various fields by state and is updated regularly. Networking sites like LinkedIn and ResearchGate will help you connect with and organize your professional contacts, so be sure to keep your profile pages updated and polished!	
Government Positions	www.usajobs.gov
	https://www.federaljobsearch.com/
Conservation Job Board	www.conservationjobboard.com/category/botany-jobs

Use your University!
Many academic institutions have offices that focus on helping alumni succeed after graduation. Check with your department or institution for resources on job announcements, workshops focused on personal development (such as CV/resume writing or getting a teaching certificate), and networking opportunities.

As you take on another year of research, make sure to spend time working on the skills that are necessary for becoming a researcher. These "soft" skills are learning to engage with the public, successfully obtaining funds, and writing. A large part of student training is learning how to write well and concisely. This isn't a skill that can be learned overnight, and it requires hours of practice and editing. This task can seem daunting to a biology student since there are often other things that can take us away from writing. Something to keep in mind is that clear thinking doesn't create clear writing; however, learning to write and spending time thinking about your research will give you the ability to think clearly. [Paraphrased from Josh Schimel's *Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded.*] In the long run, if you invest substantial time in your writing early on, skills associated with thinking clearly will trickle into clearer communication.



Joyous Garden

ANNOUNCEMENTS

Heather Hales Cacanindin Named Botanical Society of America Executive Director

St. Louis, MO—The Botanical Society of America's Board of Directors is pleased to announce that Heather Hales Cacanindin, former BSA Director of Membership and Marketing, has been named as the Society's new Executive Director, effective March 19, 2018. Cacanindin, who served as Interim Executive Director since October 2017, has played a key role in the Society since 2007. Prior to joining the BSA, Cacanindin served as Program Manager for the United Soybean Board, a farmer-led nonprofit that invested a budget of over $60 million.

Following an extensive search, BSA's Board selected Cacanindin from an impressive field of candidates based on her excellent management skills, extensive knowledge of scientific societies and association management, as well as her deep commitment to the members of the BSA and to fulfilling the Society's mission.

"I have spent my entire career in association work mostly because I enjoy working in a mission-driven type of environment, and after ten years at the Botanical Society of America, I have a deep understanding of the organization, its culture, our staff and our members' needs," Cacanindin said. "This is a dynamic time for our organization as we build new partnerships, transition our financial business model, and seek ways to draw more attention to the critical work of our members and to plant science research. I look forward to working with our members and volunteer leadership as we re-imagine how we attract, mentor, engage, and deploy a diverse new generation of botanical scientists and how we can best support our members in all career stages."

Cacanindin's previous experience as a Membership and Marketing Director included evaluation and improvement of the society membership experience and related messaging and marketing for three international associations (BSA, as well as the Society for the Study of Evolution and the Society for Economic Botany); creating and analyzing multiple member surveys that drove strategic planning processes; managing relationships with a diverse group of sponsors, donors, librarians, and contractors, and reconciling and providing financial oversight

for budgets, income and expenses; and providing strategic direction and oversight of the successful government-funded diversity and mentoring program, PLANTS.

BSA President Loren Rieseberg commented, "We are thrilled that Heather was willing to take over as Executive Director of the BSA and are confident that she is the right person to successfully implement the strategic goals of the organization."

Cacanindin holds a B.A. in History and French from St. Louis University, and an M.A. in History from the University of Wisconsin, Madison, as well as a Graduate Certificate in Nonprofit Management from Washington University in St. Louis, and a Certificate in Financial Management from the American Society of Association Executives (ASAE). She is a member of ASAE and the St. Louis Society of Association Executives and has served on the board of the nonprofit Center for Women in Transition.

Cacanindin succeeds William Dahl, who retired in October 2017 after serving 15 years as the BSA's first executive director.

BSA Research Journals Successfully Move to Wiley Platform

Authors and readers of the* American Journal of Botany *and* Applications in Plant Sciences *see updated look, better author tools

The recent partnership between the Botanical Society of America (BSA) and John Wiley & Sons, Inc., to publish and promote the BSA's two research publications, the *American Journal of Botany* (*AJB*) and *Applications in Plant Sciences* (*APPS*), kicked off successfully in January. This partnership provides support for the BSA's publications that will allow the Society to better serve the journals' authors and readers—and ultimately to better serve the mission of promoting botany.

"We bring to the table our people, our scientific and editorial expertise, and our passion; Wiley brings a wealth of publishing and technological expertise and services," said *AJB* editor-in-chief Pamela Diggle and *APPS* editor-in-chief Theresa Culley, in a recent jointly written editorial that appeared in both journals. "We will work together to expand our reach, enhance our online presence, and support our authors, reviewers, and editors, while keeping the journals accessible and affordable."

The challenges of a rapidly changing publishing landscape prompted BSA leadership to deliberate on how to best adapt its journals to better meet the needs of authors and BSA members. A committee was formed over two years ago to analyze the benefits and costs of self-publishing versus partnering with an outside publisher. After careful consideration and much discussion, Wiley was chosen as BSA's publishing partner based on its record of

successful partnerships with similar scholarly and professional societies and its reputation as a strong publisher of academic journals.

What will this partnership mean for you, as a reader and author? Much of what our authors, reviewers, and readers already experience at both journals will remain the same. The Society retains control over content and all editorial processes. Costs (subscription and Open Access fees) have been negotiated to remain affordable, and authors, reviewers, and editors will continue to interact with their BSA editorial staff (Amy McPherson, Richard Hund, Beth Parada, Sophia Balcomb, and Benjamin Merritt). Copyediting will, as always, be handled through the BSA's careful and knowledgeable team. The *Plant Science Bulletin* will continue to be self-published by the BSA.

The editorial team encourages you to explore the new homes of the *American Journal of Botany* and *Applications in Plant Sciences* at https://onlinelibrary.wiley.com/journal/15372197 and https://onlinelibrary.wiley.com/journal/21680450, respectively.

Animated Short "TreeTender" released online

The University of Florida and Florida Museum of Natural History have released "Tree-Tender," an engaging and visually stunning animated film that examines the interrelationships among living things and the importance of protecting biodiversity. The goal of the film is to engage the general public and increase understanding of complex scientific topics. BSA members Pam and Doug Soltis, as well as Robert Guralnick, served as the Science Team behind the film. The film and additional educational resources are freely available at https://www.treetender.org/. "TreeTender" is a Digital Worlds Production.

BOOK REVIEWS

DEVELOPMENT AND STRUCTURE

IAWA List of Microscopic Bark Features

Veronica Angyalossy, Marcelo R. Pace, Ray F. Evert, Carmen R. Marcati, Alexei A. Oskolski, Teresa Terrazas, Ekaterina Kotina, et al.
2016.
DOI: 10.1163/22941932-20160151
http://booksandjournals.brillonline.com/content/journals/10.1163/22941932-20160151. 99 pages
IAWA Journal, International Association of Wood Anatomists, Leiden

International Association of Wood Anatomists (IAWA) is an international forum that has made a tremendous contribution in the field of wood anatomy since 1931. The publications brought by the association are held high for their quality. For instance, IAWA list of microscopic features for hardwood identification and softwood identification was a ready reckoner for wood researchers (Wheeler et al., 1989; Richter et al., 2004). The present publication deals with one of the lesser-focused aspects of wood anatomy: the bark. There is no skepticism that the present book forms an authoritative list for bark microscopic characters.

Different from the conventional books, this book is a sort of report brought out by the committee established by IAWA, following the Brazilian initiative of IAWA bark committee. The team members of 16 experts from 10 different countries have come together for this work. Henceforth, in terms of the language as well as content, it is made universally readable in simple English. There is a brief acknowledgement of previous works as well as the areas that need future research. The detailed preface can make the beginner to cherish the uniqueness of the book.

Bark features can be a great tool in the identification of wood as that of the anatomical features. However, the committee acknowledges the shortcomings—the editors themselves made a list of these limitations—in the preface, which makes the reader more informed about the content of the book. The colorful pictures come in handy in identification. Illustrations and explanations for all 173 anatomical characters have been meticulously detailed. The authors do give an introductory description of each character as well as comments based on their experience to help out the researchers. Among with the illustrations, the transverse section on the outgrowths of the bark such as prickles were fabulous.

One of the major difficulties in the bark anatomy is getting a very good histological section, since the bark is composed of hard, lignifed cells, as well as soft, unlignifed cells. The committee has also addressed this issue by incorporating an appendix, which specifies certain methods along with their references for benefits of the readers. Some of the researchers (such as Kotina et al., 2017) are carrying out full-fledged research on the bark anatomy.

There is the huge economical potential of bark for pharmaceutical and other industries, which may justify the need for this special publication. Despite good planning and execution, the short communication by Lev-Yadun (2017) points out a feature that was missed in this publication. In this regard, readers may also need to have a look at it. In all regards, I would recommend this book as a primary framework for anyone interested in plant anatomy as well as a good start for the beginners in wood anatomy. The open access nature of this publication will delight many readers.

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–S. Suresh Ramanan, M.Sc. (Forestry), College of Forestry, Kerala Agricultural University, Kerala, India

ECOLOGICAL

Plant Ecology in the Middle East

Hegazy, A., and J. Lovett-Doust
2016. ISBN-13: 978-0-19-966081-0
Hardcover, US$55.00. 339 + xxix pages
Oxford University Press, New York

This work emphasizes deserts of the Middle East, a region broadly considered to include South Sudan to Azerbaijan and Libya to the Caspian Sea. These deserts studied in detail are chiefly in Egypt, Saudi Arabia, and Libya. The book is, in fact, a handbook of desert ecology. Of the eleven chapters, five deal almost exclusively with deserts.

This emphasis is not surprising, of course, considering the extent of deserts in the region. Although the Saharan and Arabian deserts are best known, there are severe albeit lesser-known deserts in Iran and other places. The term "Syrian desert" is consistently used in the book, although it's an arid region probably better considered as a steppe.

As noted, eleven chapters comprise the book. Most of these provide detailed information on a broad range of topics dealing with plant ecology, from continental drift to seed biology. Global climate change and continents in motion (Chapter 3) would be a good introduction of these topics to a general audience and could be reduced in length. Other chapters, with similar depth and extent of treatment, include adaptations for aridity, seed biology, chemical ecology, and "Sex in a hot dry place."

This group of chapters is followed by a review of agriculture, again with detail including the Fertile Crescent and other widely known facts that add breadth to the book but with much that is not essential. The penultimate chapter is timely and details human impacts and efforts at conservation.

I have lived and worked in numerous countries of North Africa, the Levant, and Iraq, so I was eager to determine how plant ecology for these countries fared in this treatment. Sudan (including South Sudan) was well covered though with diminished information on the northern half of the country. While smaller in size but with as much or greater diversity, Syria is allocated only about a page. Lebanon has the highest mountains in the region and a great diversity of plant communities yet is limited to about half a page. These examples and others indicate the bias toward Saharan countries. Coverage of non-desert communities in greater depth would be desirable.

The authors have apparently missed some recent floristic treatments of several countries. Examples include the first edition of Tohmé and Tohmé's flora of Lebanon (2017), the exhaustive flora of Qatar (Bary, 2012), and a flora of the United Arab Emirates (Karim and Fawzy, 2007).

A well-researched book—carefully edited with helpful graphs and images (including a collection of sharp, clear color images)—with an overall excellent bibliography, this should be on the bookshelf of anyone with an interest desert ecology. It will also be of value to students of biodiversity, especially since the regions covered in the book include some of the earliest examples of intensive agriculture and its impact on the environment.

The authors' stated goal "is to provide a solid baseline and stimulate further research". Mission accomplished—though one would like to see more non-desert ecology included.

LITERATURE CITED

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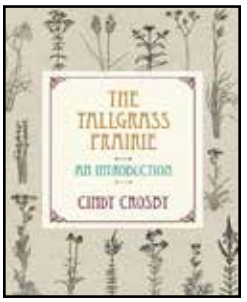
–Lytton John Musselman, Department of Biological Sciences, Old Dominion University, Norfolk, Virginia 23529-0266

The Tallgrass Prairie: An Introduction

Cindy Crosby
2017. ISBN-13: 978-0810135475
Paperback, US $19.95.
144 pp.
Northwestern University Press, Evanston, IL



Native grassland habitats are among the areas most in need of conservation throughout North America. In Illinois, where the author Cindy Crosby works and resides, 3000 acres of tallgrass prairie remain from what was once 22 million acres. In her new book, *The Tallgrass Prairie: An Introduction*, we learn that this decline in natural grassland habitat can be traced to blacksmith John Deere's 1837 invention of a plow—one that could efficiently cut through the densely rooted prairie sod—that facilitated the largescale conversion of these fertile soils into cropland. For this reason, a principal theme of *The Tallgrass Prairie* is the urgent need to protect, restore, and care for what remains of these prairies. As the reader is conveyed to the tallgrass prairies through stories of its history, biology and culture, we are grounded by connections to the relevance of this information for the conservation of these habitats.

Crosby is a writer, teacher, interpreter, as well as a steward supervisor at the Schulenberg Prairie, and a steward at Nachusa Grasslands in Illinois. Her expertise in communicating to a broad audience is displayed by her deft ability to simultaneously address an audience of readers both new and experienced with tallgrass prairies.

The book opens by describing the characteristics that define a prairie, starting with some of its signature grasses and forbs. We are taught that the Great Plains has different kinds of prairies. From west to east, the distribution of shortgrass, mixed grass, and tallgrass prairies reflects a gradient of increasing precipitation cast by the rain shadow of the Rocky Mountains. We also learn that there is a diversity of types of tallgrass prairies, the classification of which is largely based on the soils on which they are found. Each of these types of tallgrass prairie has unique communities of plants worth seeking.

The second chapter of the book presents a brief overview of the history of the American prairies. We are given glimpses of what it must have been like to encounter seas of grass in their pristine state. As the overview moves to the present, this history unfortunately necessitates the reader to become familiar with the concepts of remnants, restoration, and reconstruction as they pertain to the tallgrass prairies.

"Why should I care about the tallgrass prairies?" is the title of the third chapter. The author presents ways to look at these habitats from different perspectives, including: for enjoyment, ecological value, research subject, and spiritual nourishment. This chapter encourages the reader to consider why our natural habitats are important to us. This basic question is an active area of discussion, but what is widely appreciated today is that there are many dimensions of value to natural

habitats and the author encourages the recognition of those dimensions.

Throughout the book, Crosby consistently accompanies stories of natural history, told in an easy colloquial style, with a means for the curious reader to delve further into those stories. In particular, each organism mentioned is typically followed by a species name in parentheses that permits a quick search for images and more information. The identification of organisms, mostly plants, is not an afterthought, as the author has dedicated a chapter to her passion for binomial nomenclature and having others learn it. Crosby argues rather strongly for the importance of standardized names, and her personal anecdotes drive home how common names change between places and over time. For example, in 1960s central Indiana, "mangos" referred to what we now usually call "green peppers." The chapter on nomenclature closes with the author teaching the reader tricks to remember scientific names, much like people might learn birdcalls.

Other chapters include coverage of topics ranging from ethnobotany, prairie management (e.g., prescribed burns, weeding), prairie seed ecology and harvesting, and prairie animals. As in the rest of the book, Crosby pairs descriptions of what the reader might expect to see or do on a trip to the tallgrass prairies with key biological concepts, all the while maintaining a strong sense of how these things are important to conservation.

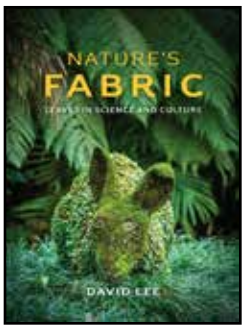
In the last third of the book, the reader is taught practical knowledge on how to experience the tallgrass prairies. Crosby takes the role of guide, mentor, and friend to those who have not had the fortune to spend much time outdoors. She suggests wearing pants and long sleeves so the "blades" of prairie cordgrass (*Spartina pectinata*) do not give you the feeling of countless paper cuts. Crosby also reminds us to listen silently, and to take deep breaths to become aware of smells as part of becoming personally connected with the tallgrass prairies.

The final chapter covers the topic of building a native prairie garden in one's own backyard. Drought tolerance and suitable flowers for native pollinators are among the benefits of this kind of garden. The book has a glossary of terms, which are bolded in the main text, and a nicely curated list of suggested readings and contacts for an inspired reader to continue their prairie journey. *The Tallgrass Prairie: An Introduction* is a well-written and passionate introduction to the tallgrass prairie intended for all enthusiastic readers.

–Tan Bao, Department of Biological Sciences, University of Alberta, Edmonton, Canada. tan.bao@ualberta.ca

Nature's Fabric: Leaves in Science and Culture

David Lee
2017. ISBN-13: 978-0-226-18059-5
Hardcover, US $35.00. 512 pp.
The University of Chicago Press, Chicago, Illinois, USA



Leaves are everywhere. They adorn the crowns of trees, crackle under our feet in the fall, and bring life to our homes and gardens. Besides providing beauty to our environment, leaves play an important role in the production of food, shelter, and oxygen for most organisms. However, due to their omnipresence, leaves can often be overlooked and underappreciated. Dr. David Lee, an emeritus professor and leaf aficionado, has long been an advocate of these extraordinary "green machines." His newest

book, Nature's Fabric, takes readers through the science, culture, and history surrounding leaves, in hopes of enhancing their interest in nature and the humble leaf.

The book is organized into 15 chapters that range from leaves in history and culture, to leaf economics, and the science behind the creation, evolution, and function of leaves. The chapters seem to seamlessly transition from one topic to another, weaving together fascinating stories and facts about leaves that will undoubtedly leave the reader more aware and appreciative of the leaves that they encounter daily.

Lee eases the reader into the book with stories of the green men and Garden of Paradise, two topics that many people have likely encountered at least once in their lives. Next, Lee details the rise of the leaf, starting with the creation of the Earth and detailing the first living cells and multicellular organisms, early land plants, and leaf evolution over time. The third chapter explores the history of plant physiology research, including the discovery of radioisotopes, chloroplasts, plasticity, and adaptation. The fourth chapter expands on adaptation through discussion on how the climate influences leaf function, phenology, and connections with the water, carbon, and nitrogen cycles.

Lee should be praised for his ability to eloquently synthesize and apply information so readers with different perspectives can appreciate the knowledge that he is trying to instill. This is best expressed in Chapter Two when he discusses the creation of Earth, and takes into consideration creationism, scientific, and other cultural perspectives of how Earth was created. He also expresses this skill in Chapter Five when he explains the functions of a leaf using economics. In short, leaves run like factories. They have construction costs and need to think about longevity, efficiency, and profitability just as a factory would.

Chapter Six gives readers some insight into leaf models (e.g., *Arabidopsis*), mutants, and math (e.g., relation of the Fibonacci series to leaf and flower formation). Chapter Seven continues some of the focus on math with a discussion of leaf and tree architecture, including the development of quantitative plant architectural models. In this chapter, Lee also includes some references to how architects and artists, such as Leonardo da Vinci, were inspired by plants.

"Bioinspirational" plants remain a trend in Chapters Eight through Eleven, which focus on leaf shapes, surfaces, veins, and colors. For example, some readers may not know that Velcro was influenced by cockleburs, or that plants have influenced pesticide products, water repellents, and even 3D glasses. The diversity of leaf shapes and surfaces that help leaves with defense, water collection, and other functions, are the same traits that have inspired scientists, engineers, artists, and many others for a long time.

Chapters Twelve and Thirteen fixate on plants as food and shelter for other life forms. Leaves are a key source of nutrients for many animals. Because of this herbivory, plants have evolved defense mechanisms (e.g., trichomes, chemical compounds, thick cuticles, and colors that indicate unpalatable texture or taste) to try to avert herbivores. Lee also delves into plant communication and intelligence, a topic that is still gaining ground in the scientific community. The discussion on leaves as shelter in Chapter Thirteen takes the reader into a tiny wonderland of bromeliad tank gardens that shelter frogs and other plants; plant domatia that provide refuge for small ants, spiders, and mites; and leaf roosts that shelter bats. This

image of plants as caretakers of the wildlife quickly turns in Chapter Fourteen when Lee discusses carnivorous plants and their role in understanding plant movement via similar methods as animals.

The final chapter of *Nature's Fabric* focuses on the importance of nature for our well-being. Lee includes some personal stories in this chapter, and reflects on the value of nature as a form of rehabilitation and stress control. He recalls E.O. Wilson's biophilia hypothesis, and ponders whether some cultures are more deeply connected to other organisms than other cultures. In modern-day America, we often surround ourselves with nature "fakery" to try to simulate the feelings we get from going outdoors without having to go outdoors. Lee contends that we all need to drop the technology and get back to nature to improve our well-being and appreciation for our environment.

There are many positive things to say about this book. Nearly every turn of the page is filled with vibrant images that immerse the reader in the stories within each chapter. Lee also provides appendices that are filled with invaluable information for the general reader. Appendix A provides leaf terminology, and a lot of great photos to aid in plant identification. Appendix B teaches the reader how to dry and preserve leaves for crafts. Appendix C provides a list of K-12 science projects that will help students learn more about leaves. At the end, Lee dedicates just under 100 pages to notes and citations from the chapters for those wanting to learn more about the figures, history, and research contained in each chapter.

In the preface, Lee indicates that his purpose in writing this book was to help nonscientists enhance their appreciation of leaves, and improve their connection with nature. He certainly has accomplished this and more. *Nature's Fabric* not only makes an excellent addition to the libraries of nonscientists, but should also be read by natural historians, professional botanists, curators, researchers, teachers, and students.

– A.N. Schulz, Department of Biological Sciences, Arkansas State University, Jonesboro, Arkansas, USA

ECONOMIC BOTANY

Forest Management and Planning

Pete Bettinger, Kevin Boston, Jacek P. Siry and Donald L. Grebner
2017. ISBN-13: 978-0-12-809476-1
Hardcover, US $105.00. 343 + xi pages
Academic Press (imprint of Elsevier)

The subject of forest management has not changed since its wide acceptance in the 1900s. However, the objective of forest management has drastically shifted from production forestry to protection forestry, incorporating the aspects of wildlife management, soil and water conservation, carbon sequestration, etc. This book with 16 chapters has been well conceptualized and brings in the latest development of forest management such as forest certification, linear programming, and remote sensing without belittling the classical concepts. Summary and questions at the end of each chapter will be exhilarating to readers, especially students. With elaborate content, coverage on each of the topic in a precise manner reveals the trust and teamwork the authors had between them.

The first chapter has slammed the hardcore of the forest management, i.e., the management

plan. The authors have to be appreciated for hitting the hardest concept in the beginning with relatively large examples from various part of the globe. The technical terms and details in the second chapter are usually explained elaborately in forest mensuration books, yet the authors' maintained brevity in the content for their objective is to deal with the valuation of benefits from the forest. Appropriate examples for explaining the economical concept does distinguish the book from other management books. The subsequent chapter broke the continuity of the subject content; still, it elaborated on the accomplishment of remote sensing and GIS (geographic information system) in forest management. Furthermore, the book keeps on elaborating some concepts that are not currently trendy, such as volume table and yield table. Even though these concepts are very important, the authors have well-planned weightage that has to be devoted, for growth and yielding modelling has completely replaced the former.

As all of the entire forest management is about achieving the objective of the owner, a chapter has specifically dealt with the priority list that a forester or a silviculturist should focus. Apart from the conventional yield optimization techniques, the authors have included the latest tools such as decision tree analysis, dynamic programming, and mathematical modelling for yield optimization. This part of the book will be very new even for the professional forester and academia around the globe. Furthermore, chapters following it offer real-time lessons and solutions for the present-day forest management problems, which developing countries such as India should take up and exclude some very outdated classical techniques. As a forester, I appreciate the authors including the latest developments in forest management in their book. In the mean time, they should have written these chapters more elaborately, for these concepts are very new to many foresters.

Sustainability has been incorporated and stressed globally. This concept in relevance to American context has been explained, but it would be really interesting if the authors did compare/contrast the sustainability concept across different countries/regions (e.g., in line with the former, the concept of "Normal Forest," which aims at maximum production within given limits). Chapter 11, which has been given a gloomy title, deals with the concept of yield regulation. Still, it has covered the classical concept of Von Mantel's formula in glorious simplicity with better real-time examples, where many of the forest management books fail to do so. Once again, the latest development in the field forest management is explained in the book in an elaborate manner. Chapter 12 is not easy for beginners in the subject but is a mandate for professionals. The forest supply chain management concept, with many flowcharts, does take readers to the next levels. The authors have maintained their brevity and given only a glimpse in supply chain management and planning, which suffices for the time being.

Forest certification and carbon trading are the new avenue for researchers and academia to balance the economic and ecological views of production forestry. Each concept with relevant examples and data indicates the dedication and commitment involved. Each book does leave an impression, even multiple impressions, on the readers. The topics such as linear programming, heuristic planning, and forest management planning software are really new to foresters of the developing world. Yet the authors made their level best in explaining the content. The book emerges as a new door in explaining the latest vista of forest management, which can aid policy

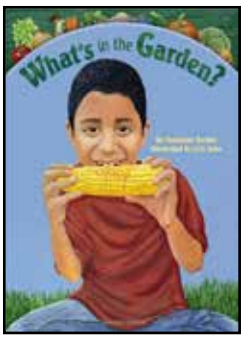
makers, students, and researchers. A book of this sort is recommended for forestry students, park managers, or rangers, for it can widen the perspective of management of forests both natural and man made, thereby paving a better way toward sustainability.

--By S. Suresh Ramanan (M.Sc., Forestry) and T. K. Kunhamu (Professor and Head, Department of Silviculture and Agroforestry), College of Forestry, Kerala Agricultural University, Kerala, India

EDUCATION

What's in the Garden

By Marianne Berkes, Illustrated by Cris Arbo
2013. ISBN-13 978-1-58469-189-1
Hardcover, US $16.95. 32 pp.
Dawn Publications.



What's in the Garden is a children's book about vegetables and fruits that may be found in a backyard garden and would be most suited for children 3-8 years old. It would be a perfect addition to any school or home library. The book is made up of poems about common garden fruits and vegetables, includes full-page illustrations and a fun recipe using the fruit or vegetable. The pictures often feature children baking, picking, or eating the vegetable.

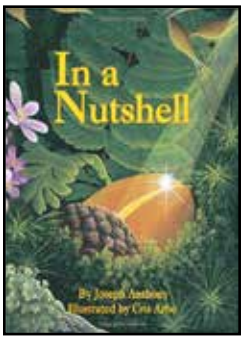
The poems allow the child to interact with the book, or an adult reading to him or her, by answering the questions posed by the poem. Each page is filled with a full-color drawing of the plant growing in the garden. The illustrations are biologically accurate including details of the parts of the plant and inclusion of pollinators or beneficial insects. At the back of the book, there is a section describing the difference between fruits and vegetables, and good ideas about how to get involved in growing plants and using the products.

I could see *What's in the Garden* being a favorite at a nature center, school, or preschool or at home. It would be a great tool to instill the love of plants and gardening in the next generation of botanists.

-Rebecca Bowen

In a Nutshell

Joseph Anthony, Illustrated by Cris Arbo
1999. ISBN-13 978-1883220983
Hardcover, US $4.99. 32 pp.
Dawn Publications.



In a Nutshell is a children's book, suitable for ages 3-10, that tells the life story of an oak tree. An acorn that falls to the ground, grows into a young tree, and endures hardships of cold, fire and the changes of time. It grows up, eventually dies and replenishes the soil for future trees and life. It is a nice "circle-of-life" story that includes death and decay as an inevitable (but not scary or sad) part of life.

The illustrations are beautiful, full-page, full-color drawings of the different stages of the tree's life, which also includes humans. The illustrations capture the botanical accuracy and a snapshot in human history, from colonial to modern day.

My one critique of the book is that the term "forest" was used throughout, but many of the illustrations did not show a forest. By the time the tree dies, the area is a suburban neighborhood, not a forest. However, the sentiment is still valid. *In a Nutshell* would be

a good addition to a nature center, home, or school library. Reading this book with a child and then going outside and seeing acorns and trees would be a good way to connect children to nature, putting the pieces together for themselves.

-Rebecca Bowen

HISTORY

Tropical Plant Collections: Legacies from the past? Essential tools for the future?

By Ib Friis and Henrik Balslev (eds)
2017.
Hardcover, 300 DKK. 320 pp.
The Royal Danish Academy of Sciences and Letters.

This volume, published in 2017, contains 24 papers as the proceedings from an international symposium held at The Royal Danish Academy of Sciences and Letters in Copenhagen, May of 2015. It was edited by Ib Friis and Henrik Balslev and divided in five themes with an introductory chapter.

Tropical Plant Collections presents an excellent historical summary of centuries of botanical enterprises carried out by explorers at the service of European empires sent to their colonies to document the wonders found in those distant lands. The first chapters of Herbaria in the North and South take the reader from the 15th century's mostly medicinal use of plants, to curiosity cabinets, and onwards to private, state, and national collections. Thousands of herbarium specimens were transported back to Europe and became the foundation of our current botanical knowledge carefully stowed away in personal bounded books at first, latter becoming loose herbaria sheets as known today. European herbaria flourished and became the centers of plant descriptions. A little known Italian Jesuit priest, Luigi Sodiro, would travel to Western South America to teach at the school of botany in Quito in the 1870s. However, collaborators in the colonies were mostly locally based expatriates. The burst of exuberance and exploration during the era of Enlightenment and the naming of every plant species glorify Linnaeus, de Candolle, and the likes. Seeds and living plants from the four corners of the earth made it back across the oceans on long tedious voyages and eventually became attractions at nascent botanical gardens.

The second part of the North and South collaboration focuses mainly on post-colonial times. The ~2885 herbaria worldwide contain an amazing 376 million specimens! While Europe enriched their museums both with collections from their colonies, it is only in the mid-1800s that herbaria came into prominence in North America. The concentration of large collections in the top 33 herbaria in North America is noticeable, and a large piece of the pie (about 40%, p. 83) is from the tropics. Collections from sub-Saharan Africa dating from the 1670s were deposited in European herbaria, since no academic institutions with herbaria existed in that region until 1870. It is surprising to find out that 11 sub-Saharan countries (out of 49) still do not have a herbarium (officially registered in *Index Herbariorum*)! After a long colonial history, the relatively small herbaria at Limbe and the National Herbarium of Cameroon (which apparently derives from Portugues "Rio dos Cameroes,' river of prawns) are now contributors to the Flora of Cameroon. In contrast, South African botanical institutions collectively house large herbarium collections and advanced from floras into the modern era of molecular studies. The botanical history in India goes back to references in Sanskrit,

but it is the establishment of the *Botanical Survey of India* in 1890 that is the keystone to all aspects of present day botany. The creation of the Naturalis Biodiversity Center in Leiden reminds us of the current struggle botanical institutions and museums are facing, with small herbaria closing or being amalgamated into others willing to save these precious samples each with so much history on each label and twig. The era of digitization of specimens like GBIF, Tropicos, and IPNI have made a world of difference, especially for scientists with reduced travel budgets or other institutional priorities.

The chapters on North-South collaborations once again point out the long botany disparity since colonial times until just a few decades ago in the 1970s. Four collaborations from Thailand, North Africa, Ecuador, and Brazil are highlighted as very collaborative in nature rather than just one-way North-South. The Flora of Thailand exemplifies the increased participation of Thai botanists towards completion of their own flora, using modern standards through international collaborations. It will, however, take a century to complete this country flora since its inception in 1969 (graph on p. 183). Norwegian collaborations in various African countries have evolved into an equal partnership with exchange of knowledge both ways benefiting researchers and the studies of biodiversity. The graduate courses in botany at Brazil's Instituto Nacional de Pesquisas da Amazônia (INPA) empowered students by completing masters or doctoral degrees. I personally benefited from the adventurous trip of Holm-Nielsen and Jeppesen to Ecuador in 1968 that resulted in a fruitful mutualistic Danish-Ecuadorian collaboration. I obtained my PhD in Denmark and have made my career at the Missouri Botanical Garden in the last 25 years, continuing with strong connections and projects in my home country. I can only emphasize the positive results of this program leading to an all-Ecuadorian scientific staff managing the herbarium since 2002 and teaching a new generation of botanists at the Catholic University in Quito.

Tropical plant collections and big data are represented in chapters on the modern availability of enormous amounts of data and how to tackle simple to large scientific questions using those data. Plant migration, effects of climate change, functional traits, phylogenetics, and historical biogeography are all integrated toward a better understanding of plant diversity patterns aiming at a sustainable conservation planning. The trend in publications using herbarium data has grown exponentially, as shown on p. 229. However, our knowledge of the natural world is still surprisingly limited. One starts to dream about the wealth of information we currently have stored in various botanical databases and potential uses and applications (see, for example, Ulloa Ulloa et al. [*Science* 358: 1616, 2017], the first list of almost 125,000 species of vascular plants for the Americas).

Modern DNA techniques like barcoding are urgent to authenticate herbal products and the importance of interdisciplinary efforts and complementary expertise in modern drug discoveries. The old concept of 'dead' herbarium collections is revived as next-generation sequencing becomes a new tool of using these collections toward complete genomic sequences with a gentle although slightly destructive approach. This fascinating volume ends with a perspective on the role of botanical gardens as engaging institutions to educate the public on plant diversity towards a better, greener world. The map of botanical gardens globally (p. 289) reflects, however, the strong inequality of botanical institutions and resources worldwide.

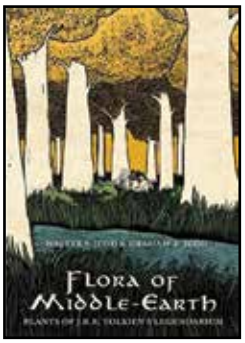
This delightful volume is richly illustrated with historical and modern images of plant specimens, botanical institutions, maps, graphics, sailors, and botanists. I loved seeing Benjamin Øllgaard, one of my botany teachers, on the cover; quite curious is the piece of stem of *Clusia rosea*, which looks like a mummified hand (p. 21). The official portrait of H. van Rheede in tight armor made me wonder if he wore that during field work. Last, the traditional red iron spiral staircase of the old giant, Kew herbarium (p. 30), in contrast with the budding QCA herbarium (p. 203) bridges current botanical knowledge and gives me a personal satisfaction of having embraced the legacies from the past and using tools for the future!

–By Carmen Ulloa Ulloa, St. Louis, Missouri

SYSTEMATICS

Flora of Middle-Earth: Plants of J.R.R. Tolkien's Legendarium

Walter S. Judd and Graham A. Judd
2017. ISBN-13: 978-0-19027631-7
Hardcover, US $34.95. 406 pp.
Oxford University Press, New York, NY



Middle-earth is known to many as the fictional setting for some of our most beloved adventures of J.R.R. Tolkien's greatly celebrated works (i.e., *The Hobbit, The Lord of the Rings,* and *The Silmarillion*). The *Flora of Middle-Earth: Plants of J.R.R. Tolkien's Legendarium* draws from this Legendarium to give life to its plants in a way that I can only imagine Tolkien himself would have been altogether captivated by. This well-executed and creative collaboration between father and son is a treat to the minds of Tolkien devotees and botanical enthusiasts alike.

Its authors, Walter S. Judd and Graham A. Judd, are uniquely suited to this task, as they are not only avid readers of Tolkien's works, but they are well established in their specialized disciplines. Walter Judd has spent a distinguished career studying plant systematics and evolution; thus, his comprehensive understanding of the world of botany gives him a clear advantage when it comes to researched and educated guesses about the identity of plants in Tolkien's Legendarium, even when it is not altogether obvious. Graham Judd holds an MFA degree in Printmaking and works as an artist, illustrator, and educator. He handles the task of illustrating the flora with great care to honor Tolkien by choosing a style befitting the Legendarium. Early in the book, the authors bring attention to a vital piece of information that readers of popular books by Tolkien may not fully appreciate. Namely, "Middle-earth" should not be interpreted as a fictional place, but instead, the Old World of our beloved and very real, Planet Earth. They emphasize that Tolkien did not intend for his writing to serve as a means to escape; to the contrary, he envisioned his works to cultivate curiosity and connectedness to the natural world. Knowing this, as well as bringing our awareness to Tolkien's love for plants, sets the stage to take an in-depth look at the plants that exist in the realm of his writing, both real and imagined.

The first chapter is an introduction outlining the importance of plants to Tolkien's Legendarium. Chapter Two provides descriptions of the plant communities that make up Middle-earth. In this chapter, we learn that the world created by Tolkien is likely botanically similar to today's Europe,

temperate North America, and Northern China. This understanding provides a foundation for the authors to explore the possible identities of the plants of Tolkien's texts.

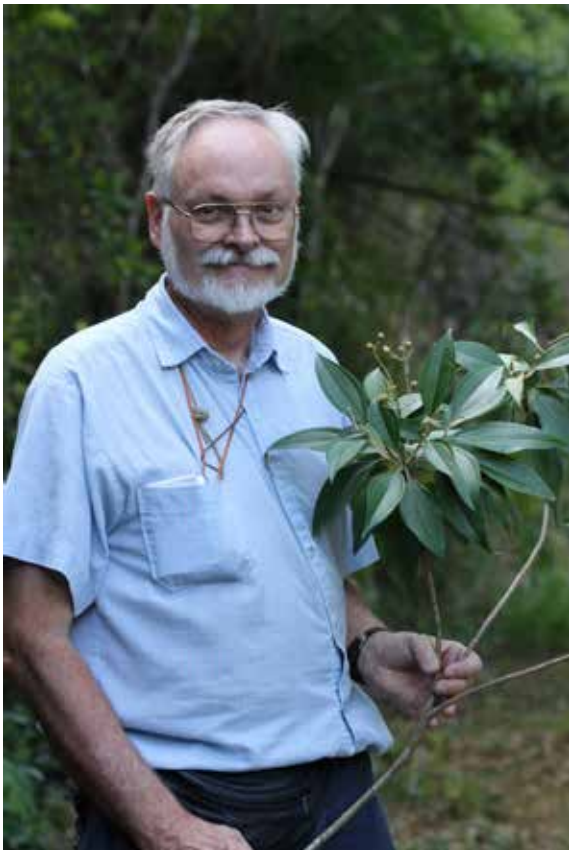
Chapters Three and Four offer an overview of the tree of life and an introduction to plant morphology. The latter includes a primer for understanding terminology and content typically included in plant species descriptions. The fourth chapter is particularly important for any reader who has not studied plants and will be worthwhile for some readers to prepare them for the pages ahead. Chapter Five introduces the crucial botanical identification tool: the dichotomous key. The identity of any important plant from Middle-earth should be discernible by using the two keys constructed by the authors. One is a key to the flowering herbs of Middle-earth and the other for every other type of plant included in the text. Telperion and Laurelin are two important fictional trees of Tolkien's writings. The authors use Chapter Six to thoughtfully explore the mythological and religious significance of these two trees.

Chapter Seven is the main body of the book. It includes each important plant in Tolkien's Legendarium with a few explained omissions and a few groupings of plants that have a lesser importance. To better accommodate all readers, the flora is arranged in alphabetical order by common name. Each treatment includes the common name, scientific name, and the plant family to which it belongs. Next, the authors offer extensive explorations of each taxon. First, the authors include a short quote from one of Tolkien's works referencing the plant. This quote precedes a detailed explanation as to how the plant is significant to Tolkien's Legendarium. Fascinating observations infuse this section of the treatment, such as insights into how the authors identified species that Tolkien was most likely referring to. For example, as a part of the account of Clovers (*Trifolium* spp.), interactions noted between the plants and the different types of bees that were visiting them become significant indicators of the plant's more specific identity. Another thought-provoking insertion is the morsel of trivia stating that grasses are the most commonly referenced plant in Tolkien's Legendarium. The treatments also include a detailed examination of the etymology, geographical distribution, economic uses, and a scientific description of the plant. A botanical illustration accompanies most entries, many of which include insets depicting scenes from the Legendarium.

Chapter Eight is a note from the book's Illustrator, Graham Judd. He is responsible for all of the roughly 160 masterfully designed figures that bring the many plants of Middle-earth to life in an imaginative and scientifically descriptive way. His printmaking experience has successfully informed his ability to maintain the look of traditional relief wood carving and printing techniques, even though he explains that he used digital tools as his medium for this project.

This book provides a creative melding, elucidation, and analysis of the imagined Middle-earth combined with the botanical understanding of our Earth. It would be a welcome addition to the bookshelves of any Tolkien fan as well as any botanist, and an unexpected delight for a person who falls into both of those categories! If anyone is hungry for more, the authors provide ample suggestions for further study, including many references to publications they reviewed during the process of writing this impressive tome.

–Maggie Sporck-Koehler, Department of Botany, University of Hawaii, Manoa, Hawaii, USA; sporck@hawaii.edu



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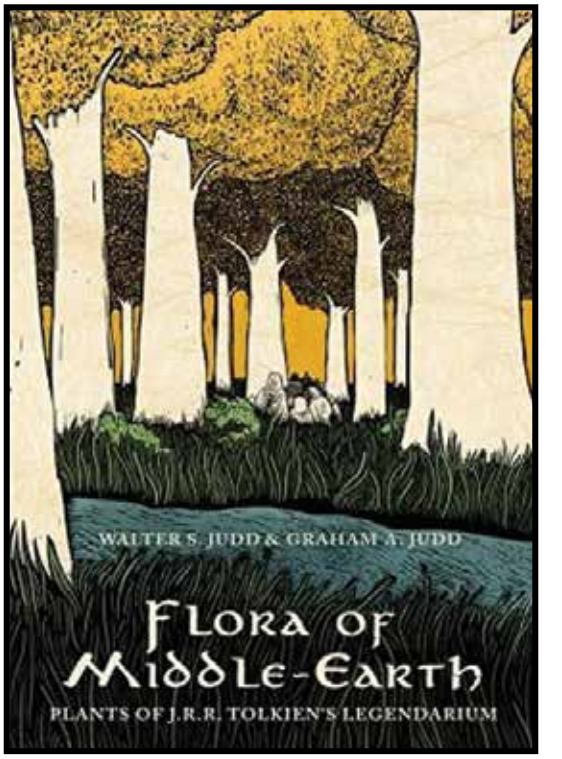


Come and Meet

Walter Judd,
Plenary Speaker
and
Graham Judd

at Botany 2018

Sunday, July 22, 7:30 pm

with a book signing immediately afterward

Flora of Florida, Volume IV

Richard P. Wunderlin, Bruce F. Hansen, and Alan R. Franck
2017. ISBN 978-0-8130-6248-8
Hardcover, US$69.95. 384 pp.
University Press of Florida

Florida, with over 4300 species of native and naturalized vascular plants, is the third most floristically diverse state in the U.S. This series, which will include ten volumes, aims to be the "go-to" reference for the state. The first volume (published in 2000) covers ferns, lycophytes, and gymnosperms. The volume reviewed here covers 31 Eudicot families, mainly Rosids and Caryophyllids.

Like the other volumes I reviewed in 2016, this volume has a short Introduction detailing how the book is laid out. This section is seemingly identical to that of the previous volumes. The systematic arrangement of the families follows Angiosperm Phylogeny Group III (APG III), with "slight modifications." This volume includes the following orders: Myrtales, Crossosomatales, Picramniales, Sapindales, Malvales, Brassicales, Santalales, and Caryophyllales. However, some families of these orders are excluded from the volume (e.g., Cactaceae, Portulacaceae). No reason for this omission is provided. My main gripe with the taxonomy is the authors' circumscription of the Brassicaceae. The closely related families Brassicaceae, Capparaceae, and Cleomaceae are all included in a broadly defined Brassicaceae. Only two (puzzling) sentences give a rationale for this: "Recent molecular and morphological data reveal that the Capparaceae as traditionally circumscribed is paraphyletic with the Brassicaceae and embedded within it (sic). This has resulted in some workers recognizing three monophyletic lineages as families: Capparaceae, Cleomaceae, and Brassicaceae s.s." The authors cite the introduction of the Capparaceae in *Flora of North America,* vol. 7 (2010), written by Gordon C. Tucker, as justification for this. However, Tucker notes, "Chloroplast sequences strongly support the monophyly of each of the three lineages Brassicaceae, Capparaceae, and Cleomaceae, with strong support for a sister relationship of Cleomaceae to Brassicaceae. Rather than merging the three families into one, all-inclusive Brassicaceae (in the sense of Angiosperm Phylogeny Group 1998, 2003), it might be more acceptable to recognize the three clades as separate, amply distinct families." I am very confused that the authors state that the families should be kept together as one, citing a source that argues otherwise. Then their second sentence seems to agree with the rationale put forth by the source they cite! APG III (and its recent update) keeps these three families distinct, which makes the most sense. The families are easily recognized and merging them should only confuse users of the volume.

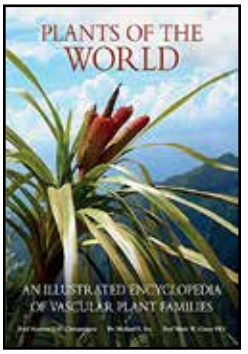
As with previous volumes, each family has a full description and a brief synopsis of its size and distribution worldwide. A key to the genera found in the state follows, with each genus treatment then arranged alphabetically afterwards. The species within each genus (if more than one) are treated alphabetically as well. As before, one thing that gets a little burdensome is the (sometimes long) list of synonyms for a taxon (e.g., *Chenopodium album*). Descriptions of taxa are thorough and useful, just like in previous volumes. It is nice to see consistency across the volumes, even if both good and bad features are consistent!

The keys themselves seem to work and do not have any ambiguous terms or confusing wording. Like in Volumes II and III, the families are arranged by order (but this is not indicated anywhere in the book), which makes it hard to find a particular family if one simply flips pages. The Contents page at the beginning of each volume lists in order the families contained within, but again, if you don't know that families have undergone drastic rearrangements in the past decades, you might have a hard time finding the family you need. Unfortunately, the header for each page remains the same: the left-hand page header simply says, "Flora of Florida" and each right-hand page header says "Dicotyledons, *range of families in the volume*." Changing these headers to reflect which family is covered on a particular page would make flipping through the volume much quicker. A Literature Cited section, as well as indices to common and scientific names, ends each volume.

The book itself is still of good quality with lightweight but not cheap-feeling paper. The covers are durable but not heavy. It would be difficult to bring all ten planned volumes in the field, but it would not be too burdensome to bring two to three if you are specifically going to look for a particular family and want the reference along with you.

-John G. Zaborsky, Botany Department, University of Wisconsin – Madison, Madison, Wisconsin, USA; jzaborsky@wisc.edu

Plants of the World: An Illustrated Encyclopedia of Vascular Plants



Maarten J. M. Christenhusz, Michael F. Fay, and Mark W. Chase.
2017. ISBN-13 978-0226522920.
Hardcover, US $95. 792 + viii pp.
Royal Botanical Gardens, Kew and University of Chicago Press.

Move over Mabberley! *Plants of the World* is a magisterial treatment of the 451 plant families of the world and like Mabberley's *Plant Book* will become a classic and an invaluable reference for botanists—though not as portable.

Plants of the World is crammed with detail delicious to a botanist yet accessible to any user. Considerable thought and planning went into designing the layout. Introductory sections deal with evolution, plants and human culture, nomenclature, phylogeny, fossil plants, families, common names, genera, phytogeography, and economic botany. Each of these sections is compact and cogent, taking half a page up to two pages and provide an excellent introduction to vascular plants.

The bulk of the 7.2-lb (3.3-kg) tome is plant families arranged according to the scheme of the Angiosperm Phylogeny Group (APG). Families are listed under their respective orders in the APG system. Not all taxonomists will agree with the placement or dissection of families. One example is several fern families broken into subfamilies rather than being recognized as individual families.

There is a cladogram with the orders of vascular plants. To make these relationships more meaningful for the general user, orders

have been placed on an image of a tree. At the introduction of each order, there is a reduced image of the tree with a red dot showing the order's relative location in the branches of the tree. How meaningful this is for the general user is questionable.

Each family includes a description of morphology (in detail), phylogeny and evolution including the age of the family, a comprehensive list of all the genera with the number of species in each, uses, and etymology of the family name. Also included is a tiny world map with distribution in red, for plants with restricted ranges almost too small to see. Extensive references, not cited directly in the text, are given for each family. A comprehensive illustrated glossary adds to the utility of the book.

Like the entire book, these sections are clearly written and carefully edited. I found some of the phylogeny sections with too much history of the family's phylogenetic studies, likely of interest only to specialists in that group.

Scattered randomly through the book are informative excursuses on botanists (including Cronquist, Takhtajan, Bessey, Thorne, de Candolle, Jussieu, Engler and Prantl).

The sections on uses are worth the price of the book alone. I learned so much ethnobotany from these. For example, Asteraceae is often noted as being a large family with relatively small ethnobotanical interest. The authors devote about five full pages to the uses of plants in the Asteraceae, bringing together information I have not found elsewhere. The extensive research of the authors in the tropics is evident in the detailed original observations of plant uses in those parts of the world.

More than 2500 full-color, well-reproduced images adorn the book, offering pictures of families that few botanists will ever see such as the Ecdeiocoleaceae or the Stegnospermataceae. Unfortunately, the quality of images varies considerably. Some easily accessible plants have poor-quality images including *Laportea canadensis, Monotropa uniflora, Ocimum basilicum, Toxicodendron rydbergii,* and *Hedera helix*. There are more examples.

The authors, like most botanists, are fascinated by carnivory, and many families have a separate discussion on this phenomenon. The well-known groups like pitcher plants, sundews, and bladderworts are thoroughly covered. This volume goes beyond these to discuss different and unfamiliar forms of carnivory. One example is the seeds of the common shepherd's purse, *Capsella bursa-pastoris* (Brassicaceae), which have mucilage with chemicals that attract nematodes and microorganisms and then release proteases that break down these organisms, yielding amino acids absorbed by the seeds. Another example is species of *Philcoxia* (Plantaginaceae) that catch and digest nematodes. Students are often interested in carnivorous plants, and this book will be a good resource for them.

In an encyclopedic treatment like this, there are sure to be oversights, omissions, and errors. I found very few. These include neglecting the invasive nature of *Phragmites australis*; the image of *Verbena honariensis* is placed in the wrong family. The fruits of *Hydnora* (Aristolochiaceae) are not foul-smelling; it is the flowers that smell like decaying meat. (The fruits of *Hydnora*, on the other hand, are relatively odorless and delicious to eat.)

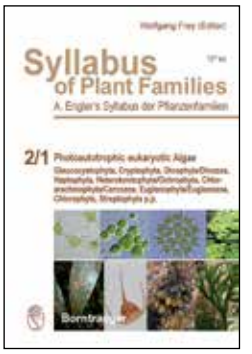
These oversights and errors do not detract from the overarching beauty and value of the book in bringing together fascinating facts. Here are some I enjoyed: The longest species name is *Ornithogalum adseptentrionesvergentulum*

(Amaryllidaceae). The largest herbaceous plant is the giant banana, *Musa ingens* (Musaceae). More plants (over 10,000) were named by A. P. de Candolle than any other botanist. *Moringa oleifera* (Moringaceae) leaves have higher levels of calcium than milk, more vitamin C than oranges, and more iron than spinach. And there are so many more interesting gems uniformly presented throughout the book.

Who will use this book? The design is different from any plant dictionary or encyclopedia I have seen. It has many features of a textbook with its detailed information on every plant family on the planet. Large families like Fabaceae and Asteraceae have helpful diagrams of floral parts labeled with the technical terms used in those families. It could be used as a textbook in a taxonomy course but would require a separate backpack because of its size. Professional botanists will find it an indispensable reference for family characteristics and phytogeography. Ethnobotanists will find information not available elsewhere.

This is an essential work that belongs on the bookshelf of every botanist. The cost is remarkably reasonable for a book with copious images and almost 800 pages.

–Lytton John Musselman, Department of Biological Sciences, Old Dominion University, Norfolk, Virginia 23529-0266



Syllabus of Plant Families: A. Engler's Syllabus der Pflanzenfamilien, 13th ed. 2/1 Photoautotrophic Eukaryotic Algae: Glaucocystophyta, Cryptophyta, Dinophyta/Dinozoa, Haptophyta, Heterokontophyta/Ochrophyta, Chlorarachniophyta/Cercozoa, Euglenophyta/Euglenozoa, Chlorophyta, Streptophyta p. p.

W. Frey, editor
2015. ISBN-13: 978-3-443-01083-6
Hardcover, 89 € (US$110). 324 pp.
Borntraeger Verlagsbuchhandlung, Stuttgart, Germany

Botany, you may be relieved to know, is not dead. True, many scientific journals and university departments have abandoned the term in favor of more modern-sounding substitutes, while AJB and its Canadian counterpart resist such impulses, confident that their standing is enhanced rather than tarnished by association with the discipline's deep history. The organisms that were traditionally studied by botanists are, of course, far too diverse to characterize with any single unifying concept, let alone a phylogenetic one. But many of us see the value in considering—and teaching—these divergent and convergent organisms alongside each other, not in spite of what we know of their phylogenies, but because of it. And if we don't introduce the next generation of researchers to all those interesting fringe groups, who will?

In this regard, Borntraeger Scientific Publishers appears to be stepping up to the plate. Under the editorship of W. Frey, they have resurrected the classic Syllabus of Plant Families, a systematic survey of all "plant" groups that was published in 12 previous

editions from the nineteenth through the mid-twentieth century. Unsurprisingly, the many authors who contribute to the present edition apply contemporary biosystematic principles to the groups they cover, based on the latest phylogenetic data. At the higher levels of organization, however, the series quite selectively includes only those major lineages that were traditionally included in the province of botany: not only plants and eukaryotic algae, but also cyanobacteria, fungi, slime molds, and stramenopile pseudofungi. That in itself need not be problematic, but a contemporary botanist will expect to see a reasonable principle of organization that effectively highlights structural/functional trends against the broad backdrop of phylogeny.

The present volume in the series is a modern treatment of the major groups of eukaryotic algae, excluding the reds, with descriptions of their component taxa down to family and principal genera. At so many levels, classification has undergone major upheaval in the molecular age, with many of the phenotypic themes that underlay previous taxonomic schemes now shown to correspond poorly with gene-based phylogenies. Individual chapters include many high-quality color images and some electron micrographs of characteristic taxa, as well as a number of informative drawings and diagrams. Not only in biosystematics are forward steps taken. The "cyanelle" of the Cercozoan Paulinella is finally recognized as a primary plastid, independent in origin from that of the Archaeplastida, although the author stops short of formally treating Paulinella in a new algal group. The familiar Volvox is, for once, never referred to as a "colony," in long-overdue recognition that this organism meets all basic criteria of multicellularity.

The chapters are authored by 13 different specialists who provide treatments of specific groups: W. Hofbauer (Glaucocystophyta, Eustigmatophyceae); H. Kawai & T. Nakayama (Cryptophyta, Haptophyta, Dinophyta, some Heterokontophyta, Chlorarachniophyta, Euglenophyta); E. J. Cox (Coscinodiscophyceae, Mediophyceae, Fragillariophyceae, Bacillariophyceae); B. de Reviers, F. Rousseau & T. Silberfeld (Phaeophyceae); J. Neustupa (Chlorophyta, some Streptophyta, Trentepohliales); F. Leliaert, J. López-Bautista & O. de Clerck (most Ulvophyceae); F. Leliaert (Palmophyllales); I. Blindow & M. Schudack (Charophyceae). In assembling an authoritative team of experts from linguistically diverse nations, it is to be expected that the English prose of many authors, good as it may be, will inevitably contain imperfections. Unfortunately, this volume appears to have been produced without the assistance of a scientific copy editor proficient in the language, resulting in the publication of a considerable number of errors in spelling and grammar. In most cases, they represent little more than distractions, but they do take some of the polish off the otherwise high production standards.

Within each chapter, authors organize groups discussed in a biosystematic framework, as expected. At the level of chapter order, and volume organization, however, the intentions and vision of the series/volume editor are far less clear. The present volume covers all the eukaryotic algae, except for the Rhodophytes, which are treated in a separate volume. Why? Perhaps due to practical considerations, related to page limitations or author deadlines, but no explanation is given in the introduction. Of the remaining groups in the Archaeplastida, the Glaucophytes are treated at the beginning of the book, but the

Chlorophyta and Streptophyta are not covered until last, after all the other eukaryote groups. And there, they are treated in a section titled Organization type: "Green Algae" that also includes the unrelated Chlorarachniophytes and Euglenophytes. Here, a brief introduction summarizes the different origins of the plastids in each case, but doesn't get around to saying exactly what the unifying principle is. It could only be plastid pigmentation, because there is nothing these groups have in common structurally that could possibly represent a common "organization type." But then one wonders why there is no corresponding category set up for the major clades that have red alga–derived plastids and pigments. Since the series is all about systems, the reader will want to understand the layout, particularly where it diverges from phylogenetic schemes. Perhaps the editor is merely following the organization of the last edition (not seen by me), published in the 1950s. But that ought to be explained somewhere, and justified in a contemporary context.

We find the plastid-containing stramenopiles (Heterokontophytes) treated in the present volume, while their heterotrophic lineages (Oomycetes, Labyrinthulids) are covered in a separate volume with the true fungal "water molds" and the slime molds. That seems justifiable, since those heterotrophic groups are most likely to be considered and taught within the context of mycology. But the volume that treats those molds also includes the cyanobacteria (ultimate source of all plastids), which would be much more appropriately placed in the present work among the eukaryotic algae. In short, while one might make a case for any number of different schemes, we never quite grasp the logic of how the series or this volume is organized. It would be helpful to have in the preface or inside cover an overview cladogram of the major "supergroups" of eukaryotes, with indications of those clades treated in specific volumes. The individual chapters make many of these connections, but no encompassing perspective is presented for the series or for this volume. So if you're hoping that the reappearance of Engler's Syllabus will help revitalize the inclusive traditions of classical botany, you may be disappointed by the lack of a clear rationale for the trans-phylogenetic juxtapositions that it adopts. That said, there is unquestionably a great deal of value to found in the individual chapters of this book, which are, after all, its essence.

–William B. Sanders, Florida Gulf Coast University

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Plant Science Bulletin Featured Image

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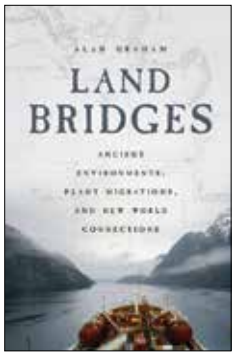

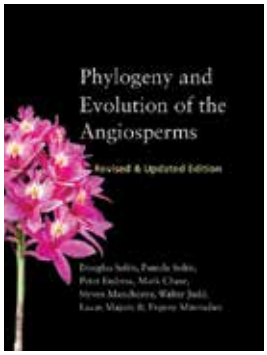

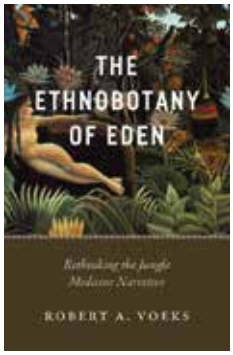

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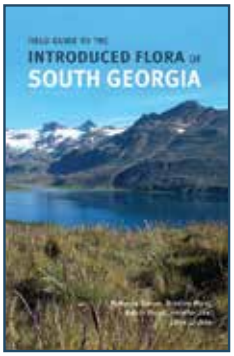

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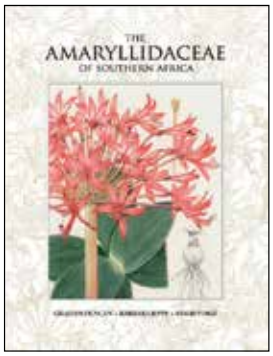

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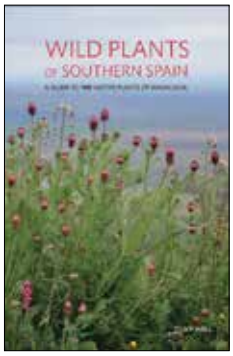

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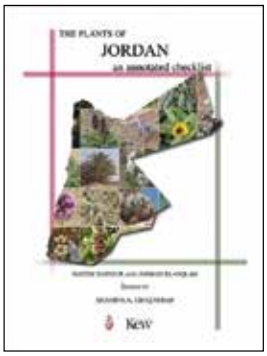

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