

The Plant Press



Smithsonian
National Museum of Natural History

New Series - Vol. 21 - No. 2

April-June 2018

Botany Profile

Using Big Data to Ask Big Questions: Why Are There So Many (Damn) Daisies?

By Robert Edwards

For those who have had Saturday afternoons in the field happily keying out wildflowers rudely stymied by yet another Damn Yellow Comp, the question “why are there so many daisies?!” may have sprung to mind (possibly not quite so politely). An answer: that the environment plays a primary role in driving the generation and distribution of plant diversity and community composition, will have occurred to many, and is hardly a novel concept. Yet due to a lack of data at sufficiently broad scales our ability to identify continent-wide patterns and fundamental relationships between ecology and diversity has until recently been limited to mostly descriptive work or studies of small numbers of taxa. Within the last decade however, advancing computer power and storage, coupled with museum digitization initiatives, has begun to open up huge repositories of data to research that can be used to start tackling questions on a grander scale.

Almost one in ten flowering plants on the North American continent is from the daisy family (Compositae) with unusually high diversity in southwestern United States and northern Mexico; however, the exact origins of this diversity remain unclear. It has been proposed that a cooling and drying trend since the mid-Eocene has allowed smaller herbaceous plants to thrive at the expense of woodier species, with more recent shuffling and mosaicism of communities during glacial ups-and-downs over the last 25,000 years exposing a highly heterogeneous land-

scape with plenty of previously unoccupied niches. The Compositae are particularly adept at colonizing a vast array of niches, including those generally considered environmentally challenging and apparently inhospitable to many other plant groups, and during this time underwent several large and relatively rapid radiations. As such they make a perfect group for using Big Data to test whether extremes in particular environmental factors may be responsible for driving species diversity at large scales. My colleagues and I have chosen 14 tribes within the Compositae with predominantly North American distributions to study, allowing us to compare and contrast patterns across lineages.

The greatest challenge facing the harnessing of large and agglomerated data-sets is assessing and dealing with (often poor) data quality. The time consumed cleaning data is almost always underestimated, and while there are as-is statistical analysis packages that aim to tie many common tasks together in a relatively accessible way (see various R packages – a programming language for statistical computing and graphics), these never cover all contingencies, with different issues unique to every dataset and question.

For our work we engineered a data acquisition, cleaning, and analysis pipeline using a variety of computer programs, including R, Excel (still one of the most useful tools for screening, merging, and wrangling data),

OpenRefine, ArcMap, and Biodiverse. Collection records were collated from the three largest publically available databases for North American biological specimen data—GBIF, iDigBio, and BISON. While much is shared between these repositories they are not entirely overlapping and the quality of data can vary markedly between them. In fact, the decision to use all three despite high redundancy allowed us to: a) scrape all possible data available at the time; and b) cross-reference between supposedly duplicate data from all three servers to identify issues or errors. Curation of the data behind-the-scenes can be rather opaque and this approach allowed us to identify and compare different taxonomies between databases (or even within a database) including outing an overzealous GBIF synonymization algorithm that was merging related taxa with the same generic first letter, species name, and author initial (eg. *Helianthus atrorubens* L. with *Hebeclinium atrorubens* Lemaire).

An initial data-dump of close to 2 million records was reduced by three quarters before analysis. Many removed records were straight duplicates; however, a surprising number were para-duplicates – records with small inconsequential differences such as differently rounded geo-coordinates, present or absent collector initials, etc. The remaining records were scrubbed for weeds, garden-grown collections, gross

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Travel

Gabriel Arellano traveled to Puerto Rico (1/11 – 2/14) to assess the damage of Hurricane Maria at the El Verde Research Station in El Yunque National Forest.

Marcos Caraballo travelled to Mexico (2/12 – 2/28) to attend an IUCN meeting on *Agave*, to visit the MEXU herbarium, and to collect samples of mistletoes; and to the Cayman Islands (3/14 – 3/19) to collect samples of mistletoes and other parasitic plants.

Stuart Davies traveled to Panama (2/20 – 3/3) to attend the annual fellowship symposium at the Smithsonian Tropical Research Institute with **Lauren Krizel** and **David Kenfack**, and to meet with Mi Ambiente to discuss a new plot in Camino de Cruces National Park in Panama; and to Singapore (3/10 – 3/31) to teach a forest ecology course at the Asian School of the Environment – Nanyang Technological University (ASE-NTU), co-organize a workshop on forest ecology, and meet colleagues at ASE-NTU to promote Smithsonian-NTU partnership.

Laurence Dorr traveled to Sarasota, Florida (3/13 – 3/16) to present an invited lecture, “Variations on a theme: Andy

Warhol and Hibiscus,” at the Marie Selby Botanic Garden, and to meet with the scientific staff and conduct herbarium research.

Ashley Egan traveled to Provo, Utah (3/15 – 3/30) to visit Utah herbaria for the Flora of North America treatment.

David Kenfack traveled to Kenya (3/3 – 3/27) to initiate the re-census of the Mpala ForestGEO plot.

W. John Kress traveled to London, England (1/28 – 2/1) to present an invited lecture on the Earth BioGenome Project at the Wellcome Trust Workshop on Biodiversity Genomics; to New York, New York (2/16 – 2/18) to attend the national meeting of the American Psychoanalytic Association to participate in a panel discussion entitled, “Our Plant/Ourselves”; and to San Jose, Costa Rica (3/5 – 3/12) to participate in the annual meeting of the Assembly of Delegates of the Organization for Tropical Studies (OTS) as the Smithsonian representative and the OTS Board of Directors meeting as Chair.

Gary Krupnick traveled to Edgewater, Maryland (3/14 – 3/16) to participate in a retreat of the Working Land and Seascapes program of the Smithsonian Conservation Commons at the Smithsonian Environmental Research Center.

Marcelo Pace traveled to Costa Rica (2/3 – 2/10) to collect plants at the La Selva Reserve.

Melinda Peters traveled to Raleigh, North Carolina (1/25 – 1/26) to pick up a specimen of coco-de-mer (*Lodoicea maldivica*) that was on display at the North Carolina Botanical Garden; and to Fremont, North Carolina (1/26 – 1/27) to train and deliver specimens to staff mounter **Annie Johnson**.

Peter Schafran traveled to Myrtle Beach, South Carolina (3/28 – 3/31) to present a paper and a poster co-authored with **Elizabeth Zimmer** and **Carl Taylor** titled, “Unexpected genetic diversity in

polyploid *Isoetes* revealed with PacBio DNA sequencing” and “The *Isoetes flacida* complex in the southeastern United States: unrecognized species diversity in southern Georgia and northern Florida” at the Association of Southeastern Biologists annual meeting.

Laurence Skog traveled to Sarasota, Florida (1/22 – 1/25) to continue his research on Gesneriaceae for Flora Mesoamericana at the Marie Selby Botanical Gardens.

Robert Soreng traveled to Colombia (2/3 – 3/8) to teach a 4-day class on grass identification at the Universidad Pedagógica y Tecnológica de Colombia in Tunja with Steven Sylvester from Royal Botanic Gardens Kew, visit COL, FMB, HUA, JAUM, MEDEL herbaria in preparation for a revision of the genus *Poa* for the country, and visit three paramo vegetation sites, finally joining a Royal Botanic Gardens Kew/Instituto de Investigación de Recursos Biológicos Alexander von Humboldt expedition to collect grasses in the paramos above Chiscas, Boyaca, with the expedition and grass course being sponsored by the Newton Fund.

Warren Wagner traveled to Chicago, Illinois (3/18 – 3/21) to participate as a collaborator in a meeting of the NSF Dimensions of Biodiversity grant to the Chicago Botanic Garden on plant family Onagraceae; to Irvine, California (3/23 – 3/29) to participate in an NSF-funded team meeting on the endemic Hawaiian plant lineage *Schiedea* at the University of California at Irvine; and to Kauai, Hawaii (3/29 – 4/18) to attend the National Tropical Botanical Garden board meeting and to collaborate on a research project on the flora of the Marquesas Islands.

Kenneth Wurdack traveled to St. Louis, Missouri (3/15 – 3/19) to conduct herbarium research at the Missouri Botanical Garden.



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Chair of Botany

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Visitors

Xu Su, Qinghai University, China; Triticeae (Poaceae) (12/31/16-3/1/18).

Yuan Xu, South China Botanic Garden, China; *Androsace* (Primulaceae) (4/1/17-3/31/18).

Caroline Andrino, Universidade de São Paulo, Brazil; *Paepalanthus* (Eriocaulaceae) (12/5/17-1/5/18).

Steven Sylvester, Royal Botanic Gardens Kew, United Kingdom; Poaceae (12/11/17 - 1/10/18).

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What's Going On

As much as I enjoy writing, I know I would never make it as a newspaper columnist. I have trouble meeting deadlines. I wait for inspiration or for a clever hook. Then the words flow relatively easily through a dozen or more drafts. If neither inspiration nor metaphorical fishing tackle save me, then I struggle. I have written a fair number of these columns, some confessional and others sermon-like. A few I knowingly structured as telegraphed messages: I laid out what I planned to do as chair to make a select few employees understand what I wanted to accomplish. I have discarded almost as many drafts of this column as I have completed. I have an extensive folder of scrunched up and discarded word processing documents, the electronic equivalent of paper balls tossed toward the trash can.

The activities of the department are something that I have not devoted much time to describing in these columns. For this, I am perhaps remiss. We have been busy the last few years and we have devoted enormous resources (planning, staff time, and money) to improving the U.S. National Herbarium. I hope the results are beginning to be visible. To begin with, there has been a physical overhaul of the herbarium. We converted our four compactor-bays from electrical to mechanical assist controls. We have gone from endless malfunctions to almost none, and some of us are getting more exercise in the bargain. We have added over 200 new herbarium cabinets, many of them replacements for older substandard wooden cabinets and yet others constructed to address the needs of special collections such as our bulky bamboos. These new cases permit some expansion but more importantly allow decompression of sections of the herbarium where specimens now are too tightly packed. Our goal is to remove and replace all of the substandard cabinetry in the herbarium. We also have mostly decluttered our common space although we still have far too much Botany material stored in the attic. (Yes, there is an attic in the Natural History building).

With generous financial support from the Smithsonian's Digitization Program Office (DPO), Office of the Chief Information Officer (OCIO), and from the Sant Director of the National Museum of Natural History (NMNH) we have digitized more than 1.5 million herbarium specimens, including not only capturing images but also transcribing label data. We have accomplished this while continuing to operate the herbarium as normal. In other words, we have been able to do this without closing sections of the collection. It is difficult to convey to those who only visit us electronically the enormous behind-the-scenes preparation involved in our digitization project, but it exists and one of the less obvious benefits of digitation is that we are improving the physical curation of the entire collection.

We have always thought of our digitization project

as more than physical curation or herbarium management and we are beginning to see the potential for applying machine learning to large digital datasets to answer more compelling evolutionary questions. To this end, we were pleased to receive support from both OCIO and the Institution's Scholarly Studies program to recruit a two-year post-doctoral student who begins this September and who will tackle some very interesting questions about the distribution of morphological characters and plant family discrimination. It is also, as best we can tell, the first joint OCIO-NMNH postdoctoral fellowship.

With all our moving and shaking it only seemed logical to initiate a series of interrelated projects to update our filing systems to reflect current ideas about phylogenetic relationships. The Pteridophytes were reorganized when they were prepared for digitization, and are now organized according to the recently published Pteridophyte Phylogeny Group (PPG I, 2016) scheme. We have begun to reorganize the Angiosperms according to the most recent Angiosperm Phylogeny Group (APG IV, 2016) scheme. This is a little more challenging: the Angiosperm collection is much larger than the Pteridophyte one and it is on three separate floors of the herbarium rather than one. There will be a lot of shifting. A related and ongoing project to curate the grass herbarium, reorganizing its filing scheme and replacing and standardizing the folders, has helped make a huge dent in the reorganization of the Angiosperms. This past week we also received support to reorganize our Bryophyte collection, which we will store as loose packets of specimens in boxes in cases rather than as packets glued or pinned to sheets. This will facilitate and make more efficient the handling and curation of these materials.

We have consciously tried to become more responsive to external requests by implementing a new internal tracking system. Interestingly, not only can we now determine how long it takes to satisfy an external request, but we also are beginning to have data on the nature of our external requests. We still receive large numbers of loan and destructive sampling requests, but we have also noticed a significant number of digitization requests. These last will certainly disappear when we have the entire collection digitized, but we had not previously appreciated their volume.

What are some of the continuing challenges? We are still struggling to figure out the optimal system or systems for managing a fully digitized collection. Staff and visitors have been very cooperative. Unfortunately, for those of us who began in the non-digital era it is still difficult to accept we cannot rearrange a collection on the fly but need to submit specimens to others to update name changes or reimage. Another major

Chair

With

A

View

L.J.
Dorr



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Departures

Melinda Peters, a staff member of the Core Collections Management team, will be leaving the National Museum of Natural History to take a position at the U.S. National Arboretum as the volunteer manager for the Friends of the National Arboretum. Peters joined the Department of Botany in 2013. Peters filled many roles during her short tenure here. She took over the volunteer mounting program and greatly expanded it. There are now 22 volunteers mounting plants on a regular schedule and 20 intermittent volunteers. Over the 5-year period, her volunteers mounted over 90,000 specimens. She was a mentor to several interns and conducted plant mounting courses for interns across the museum each summer. Peters was involved as a Botany representative with exhibit planning and with policy initiatives affecting the department. She became a scientific scuba diver and was part of a collecting expedition in Hawaii. She constantly managed and reduced the backlog of specimens for mounting and exchange. Her efforts made a significant contribution to the role the herbarium plays for the department.

Laura Tancredi, a staff member of the Information Management team, will be leaving the National Museum of Natural History to take a position at the National Museum of American History as a museum specialist in the Exhibitions and Collections Management Office. Tancredi began at Natural History in 2012 and joined the Department of Botany in 2016. Within a short period of time, she learned and embraced the upkeep and management of the digitized collection data, and created documentation of the Botany data entry workflow, policies and standards. Tancredi was also in charge of all Smithsonian Transcription Center botany projects, and hosted a number of interns under a "Digitization Strategies" internship.

New Faces

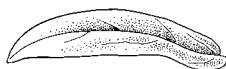
Marcos A. Caraballo-Ortiz joined the Smithsonian Botany Department in January as a Peter Buck Postdoctoral Fellow under the supervision of **Jun Wen** and **Pedro Acevedo**. His research is focused on exploring the phylogenetic relationships and organelle structure of lorantha-



Marcos Caraballo-Ortiz

ceous mistletoes in the Neotropics. Caraballo-Ortiz obtained his Master's degree at the University of Puerto Rico-Río Piedras on pollination ecology, and his doctoral degree at The Pennsylvania State University on the taxonomy, phylotranscriptomics, and ecology of Caribbean mistletoes. His research also includes taxonomy, botanical explorations, natural history, propagation, and ecology of Neotropical plants, especially from the Caribbean Islands.

This past Fall and Winter, **Caroline Kittle** worked as a data intern with the administrative offices of ForestGEO at the Natural History Museum. She primarily collected life history information for species present in two of the network's 65 forest research plots, which together represent every forest type worldwide. Her work contributed to the refinement of new ForestGEO website. Kittle is continuing her journey with ForestGEO as a member of the 2018 re-census crew for the plot at the Smithsonian Conservation Biology Institute in Front Royal, Virginia.



Recipients of the 2018 Travel Awards

The Department of Botany recently awarded five recipients with 2018 travel awards. Three awards were funded through the Jose Cuatrecasas Fund, one from the Harold Robinson Fund, and one from the Ruth & Lyman Smith Fund. The dates of their visits are subject to change.

Cuatrecasas Fund

Juan Fernando Carrión Rodríguez from Universidade Estadual de Feira de Santana, Brazil, for his project, "Phylogeny and biogeography of *Bernardia* (Euphorbiaceae), with a synopsis of the South American species." His proposed dates are May/June 2018.

Israel Lopes da Cunha Neto from University of São Paulo, Brazil, for his project, "Nyctaginaceae: Diversity and evolution of the vascular system." His proposed dates are August/September 2018.

Cassiano Aimberê Dorneles Welker from Universidade Federal de Uberlândia, Brazil, for her project, "Taxonomic revision and phylogeny of *Eriochrysis* P. Beauv. and *Schizachyrium* Nees (Poaceae – Andropogoneae)." Her proposed dates are January/February 2019.

Robinson Fund

Vivian Oliveira Amorim from Universidade Estadual de Feira de Santana, Brazil, for her project, "Phylogeny of an endemic clade (Eupatorieae, Asteraceae) from Espinhaço Range, Brazil." Her proposed dates are September 2018.

Ruth & Lyman Smith Fund

Susy Juanita Castillo Ramón from Universidad Nacional Mayor de San Marcos, Peru, for her project, "Updating taxonomy, phylogeny and biogeography of *Gentianella* from Peru." Her proposed dates are October 2018.

Awards & Grants

Research Associates **Joseph H. Kirkbride, Jr.** and **John Wiersema** and co-authors Piero Delprete (Institut de Recherche pour le Développement) and Alan Franck (University of South Florida) have been awarded the 2017 Richard and Minnie Windler Award for Systematics from the Southern Appalachian Botanical



Spermacoce latifolia. A. Plants growing in Jumping Gully Conservation Area, Pasco County, Florida. B. Detail of distal nodes with flower in anthesis. (photos by Alan Franck; image from *Castanea*)

Society. They received the award for their published article “A new weed in Florida, *Spermacoce latifolia*, and the distinction between *S. alata* and *S. latifolia* (Spermacoceae, Rubiaceae)” in the journal *Castanea* (82: 114-131; 2017).

Graduate student **Peter Schafran** received funding from the Washington Biologists’ Field Club to collect members of the *Isoetes riparia* complex from the upper Potomac and Delmarva Peninsula.

Visitors

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Jonathan Flickinger, Fairchild Tropical Botanic Garden; Caribbean Myrtaceae (1/3 - 1/5).

Victoria Crisci, Colegio Nacional Rafael Hernandez, Argentina; Internship (1/4).

Matthew Cicanese, National Geographic Explorer; Collections visit (1/9).

Elizabeth O’Brien, Villanova University; Guyana Shield plant diversity (1/9 - 1/15).

Dave Gammon and 8 students, Elon University; Plant conservation and herbarium tour (1/11).

Genise Somner, Universidade Federal Rural do Rio de Janeiro, Brazil; *Paullinia* (Sapindaceae) (1/12 - 2/11).

Ronaldo Vinicius da Silva, Universidade Federal de Viçosa, Brazil; Bambusoideae (Poaceae) (1/13 - 2/13).

Qing-Jun Li, Yunnan University, Kunming, China; Zingiberaceae (1/15 - 1/19).

Gustavo Ramos, Universidade Estadual de Feira de Santana, Brazil; *Aldina* (Fabaceae) (1/19 - 2/19).

Jie Yu, Southwest University, China; Plant DNA Barcoding (1/22/18 - 1/4/19).

Phil Banks and 39 conference attendees, Weed Science Society of America; Herbarium tour (1/29).

Susan Pell, U.S. Botanic Garden, and **Emily Warschefsky**, Fairchild Tropical Botanic Garden; *Mangifera* (Anacardiaceae) (2/13).

Emily Smith, Randolph College; Sydney Parkinson and the Endeavour Voyage (2/23).

Lauren Pile, U.S. Forest Service; *Pinus* (Pinaceae) (3/1).

Sterling Keeley, University of Hawaii, Manoa; Compositae (3/6 - 3/11).

Joy Winbourne, Brown University; Plant DNA Barcoding (3/6 - 3/7).

Sandra Knapp, Natural History Museum, London, United Kingdom; Solanaceae (3/16 - 3/18).

Raymund Chan, Independent researcher, Singapore; Compositae (3/26 - 3/31).

Justin Williams, University of Colorado Boulder; Hawaiian *Haplostachys*, *Stenogyne*, and *Phyllostegia* (Lamiaceae) (3/26 - 3/28).

Linda Hollenberg (1953-2018)

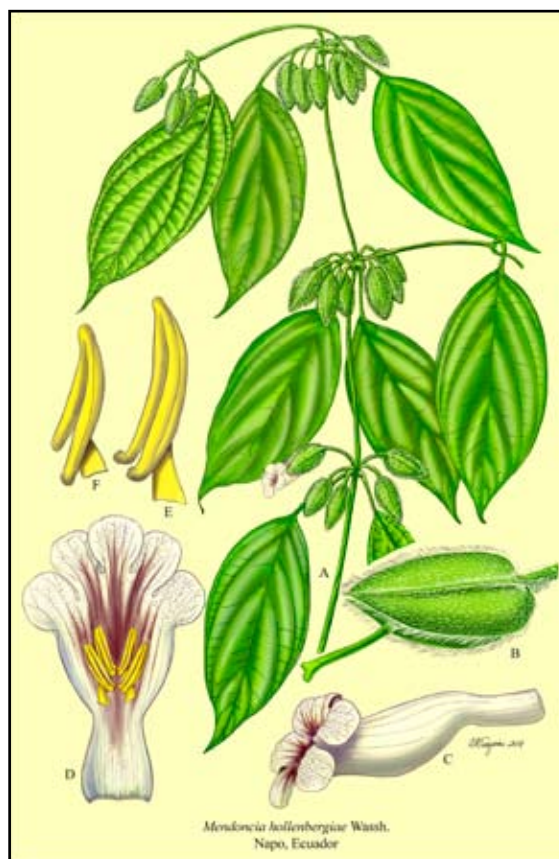
As this issue of *The Plant Press* was going to press, we were saddened to learn that **Linda Ann Hollenberg** passed away on 21 April 2018 in Silver Spring, Maryland. Hollenberg was born on 6 May 1953 in the District of Columbia. She joined the Smithsonian’s Department of Botany in 1979 as a Museum Specialist. Hollenberg had been responsible for a number of critical core functions within the Department, including overseeing all Botany collections at the Museum Support Center, collections space in the herbarium, administrative, budget preparation, fund allocation, collections conservation issues, and special projects. She retired from the Smithsonian in 2014.

Hollenberg was an integral part of the Society for the Preservation of Natural History Collections (SPNHC) council since 2005, first as a co-chair on the Education and Train-

ing Committee before becoming chair of the Archive Committee. She served as Archivist for SPNHC for 11 years. She was also active in several local native plant societies and volunteered as an usher for lectures sponsored by the Smithsonian Resident Associates and for performances at Arena Stage and Shakespeare Theatre.

Hollenberg is survived by her spouse Addison Wynn.

In 2015, Emeritus Research Botanist Dieter Wasshausen honored Linda Hollenberg by naming a new plant species *Mendoncia hollenbergiae* Wassh. This species in the Acanthaceae was first collected from the lowland riverside vegetation of the Yasuni National Park, Ecuador.



Tangerini Illustrations Featured in Three Exhibitions

Botanical illustrations by **Alice Tangerini** are currently on view in three different exhibitions. Tangerini shows her mixed media (graphite and watercolor on drafting film) of *Camellia sasanqua* in an exhibition of botanical and landscape art, “The Spirit in Bloom 2018,” at the Washington National Cathedral in Washington, DC. The show, sponsored by the All Hallows Guild, opened on 15 April 2018. Artworks on display are by artists of the Cathedral Community and the Botanical Arts Society of the National Capital Region (BASNCR), of which Tangerini is a member. A number of staff members from Smithsonian’s Botany Department were present at the opening reception. The exhibit closes 18 May 2018.

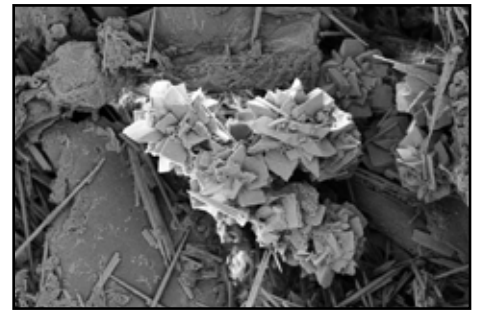
Tangerini’s pen and ink illustrations of *Pentagramma glanduloviscida* and *Hibiscadelphus stellatus* are included in the exhibit, “Botanical Art Worldwide: America’s Flora,” a juried exhibition of artworks of native plants, staged in the Conservatory Gallery of the U.S. Botanic Garden (USBG) opening 4 May 2018. A collaboration of the American Society of

Botanical Artists (ASBA) and USBG, the exhibition includes 46 original contemporary botanical artworks, juried from a field of over 200 entries. On 18 May, the Worldwide Day of Botanical Art, USBG will host three programs for visitors; a lecture, *Botanical Art Worldwide: 6 Continents, 25 Countries, 1 Worldwide Project*; a public program, *Meet the Artists: Botanical Art Worldwide: America’s Flora*; and a reserved program, *Behind-the-Scenes: Botanical Art Worldwide: America’s Flora*. The exhibit will remain on view at USBG through October 2018, and then travel through the end of 2019. The exhibit website can be viewed at <https://www.usbg.gov/botanical-art-worldwide-americas-flora>.

Tangerini’s illustration of *Vernonia echinoides* received a “Highly Commended” award in the 2018 Margaret Flockton Award contest held yearly at the Royal Botanic Gardens, Sydney, Australia. The Margaret Flockton Award commemorates the contribution Margaret Flockton made to Australian scientific botanical illustration. This contest invites illustrators from around the world to submit scientifically accurate drawings that accompany the published taxonomic description of the plant, and are highly detailed black and white drawings primarily undertaken in pen and ink, pencil, or digitally rendered. The Maple Brown Family and the Founda-

tion & Friends of the Botanic Gardens sponsor this annual, international award for excellence in scientific botanical illustration. Illustrations are on display at the Royal Botanic Garden Sydney from 21 April to 6 May 2018, and travel to The Australian Botanic Garden Mount Annan (May–July 2018) and to The Blue Mountains Botanic Garden Mount Tomah (August–September 2018). The exhibit website is <https://www.rbgsyd.nsw.gov.au/science/botanical-illustration/the-margaret-flockton-award-2017>.

***Vernonia echinoides* by Alice Tangerini received a “Highly Commended” award in the 2018 Margaret Flockton Award contest at the Royal Botanic Gardens, Sydney.**



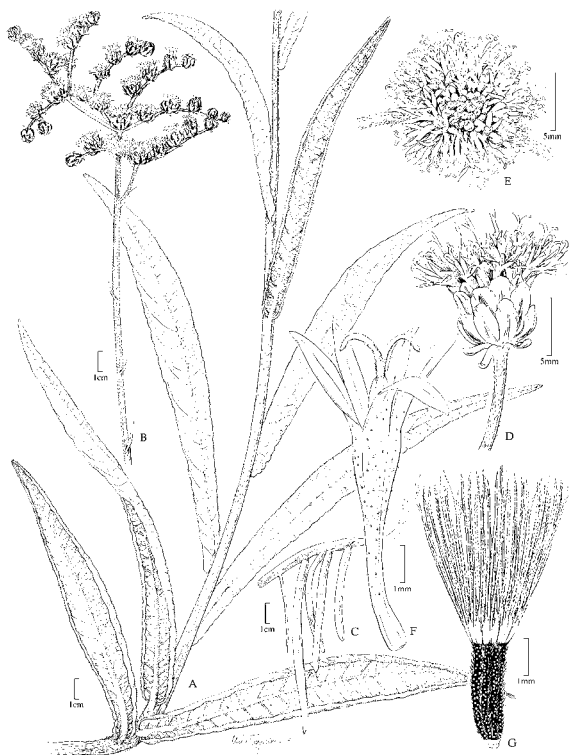
Druse phytoliths (center) surrounded by needle-like calcium oxalate raphides extracted from basal petiole tissue taken from the Chinese taro, *Alocasia cuculata*. (photo by Juan Pablo Hurtado Padilla)

Forensic Botany: Delicious or Deadly

Each Thursday evening between 25 January through 22 February, **Gabriel Johnson, Elizabeth Zimmer, Melinda Peters, Erika Gardner, Shruti Dube, Peter Schafran**, Steven Canty (Smithsonian Center for Marine Conservation), Colleen Popson, Benjamin Taylor, Juan Pablo Hurtado Padilla, Nichole Webster (NMNH Department of Education & Outreach) and Lee Coykendall (U.S. Botanic Garden) taught an introductory Botany class to 26 local high school students. The course was called “Forensic Botany: Delicious or Deadly.” The first class opened with Gardner leading a tour of the herbarium. The second class included a lesson about the nature of collections-based research.

On the third week, the students took a field trip to the U.S. Botanic Garden to key-out the various Araceae in the Palm House and to determine which species were edible in the Hawaii House. The students learned how to make plant collections, and they pressed herbarium specimens of six different edible aroids. They were taught how to mount their specimens and prepare a herbarium label.

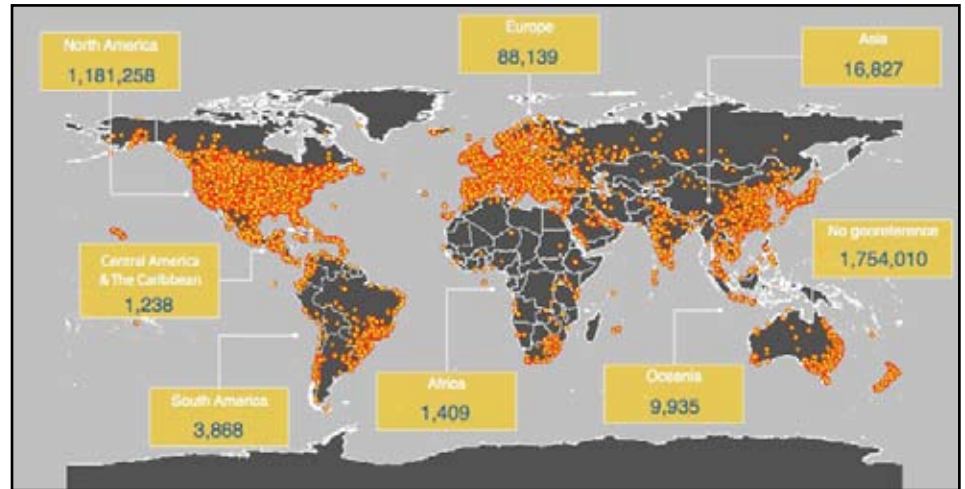
The students also dissected leaves and corms to learn plant anatomy and to test for anthocyanins and proteinase activity. They learned how to observe raphide and druse phytoliths under polarized light microscopy as well as observe them on a pre-prepared stub on the Quanta SEM scope. For the final class, each student prepared a DNA extraction of one of the six edible aroids and observed the DNA in gel electrophoresis.



Native Tree Ranges and Exotic Plant Expansions are Tracked Using LeafSnap

By Carlos Garcia-Robledo

In a recent paper in *BioScience* (<http://dx.doi.org/10.1093/biosci/biy019>), botanists **W. John Kress** and **Ida Lopez** (Smithsonian Institution), Carlos Garcia-Robledo (University of Connecticut), Katharine Wilson (Smith College), computer scientists David Jacobs (University of Maryland), João Soares, and Peter Belhumeur (Columbia University) joined efforts to identify range alterations of native trees and the expansion of exotic plants across the United States using data provided by citizen scientists. Plant identifications and their geolocations were submitted by users of the mobile iPhone app *Leafsnap*. This app is designed for the automatic identification of 220 tree species from the Northeastern United States.



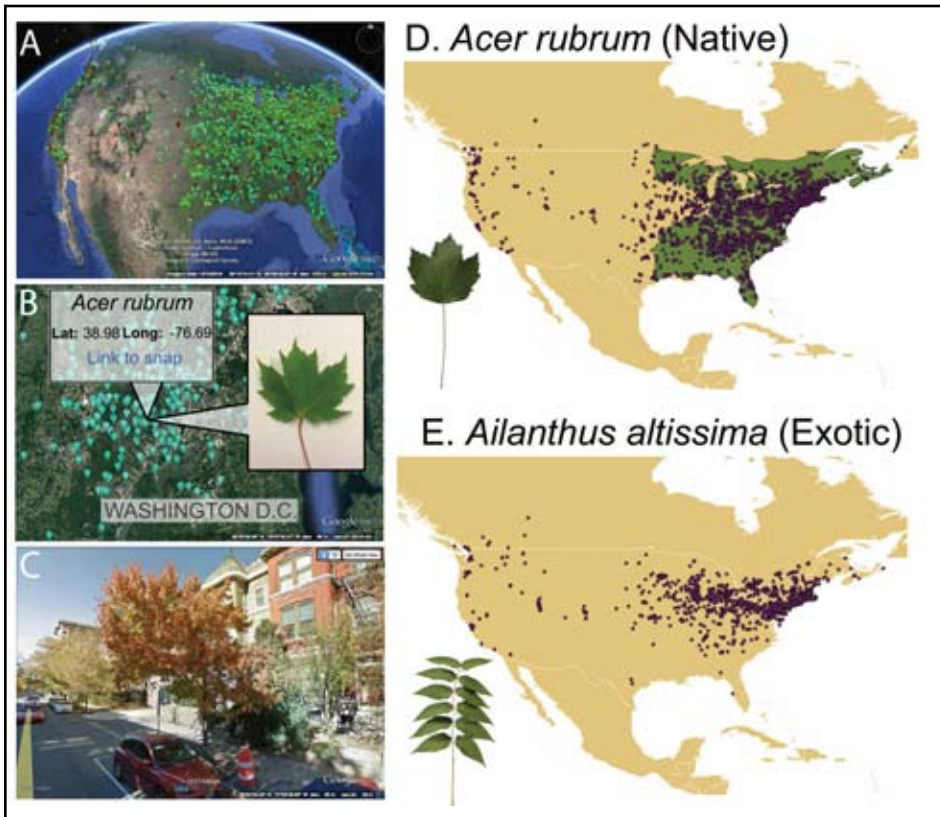
Location of users of *LeafSnap* who are identifying trees around the world. Three years after the release of this app, users on 5 continents and in 181 countries recorded over 3,056,684 leaf images.

LeafSnap was released to the public in 2011. In the first 3 years of release, the app has been downloaded more than 1.5 million times by users on five continents. Users from 181 countries have recorded over 3,056,684 leaf images (see map above). The high levels of accuracy of *Leafsnap* identifications were confirmed

by expert botanists at the U.S. National Herbarium at the Smithsonian Institution. These records were used to map the geographical distribution of native and exotic species at a scale previously unachievable without this technology and without the aid of citizen scientists. Some tree species demonstrated northerly migrations, southerly migrations, or changed little from their estimated distributions in the 1950s (see figures to the left).

LeafSnap data also can be imported to Google Maps. Images recorded by citizen scientists at each location can be visualized by clicking on each data point (see images to the left). When users collected data close to roads, it is possible to zoom in on the tree where the image was recorded.

These results suggest that this tool carried on the phones of millions may potentially collect invaluable data that can be used to monitor the effects of climate change and exotic species on tree distributions at broad geographic scales. Moreover, the widespread use of digital photography and image sharing platforms will allow biologists to collaborate with citizen scientists to acquire the appropriate images for these field guides. The authors of the article predict that the construction of a unified core recognition technology will enable the creation of dozens of “LeafSnaps” for a wide range of plants, animals, fungi, and maybe even microorganisms. In the future, a single “LifeSnap” tool may allow citizen scientists to identify and record the presence of species across all domains of life.



LeafSnap data can be imported to Google Maps to visualize in some cases the tree where distribution and identification data were collected (A-C). Using these records, the researchers tracked the distribution of native and exotic trees all over North America. Both *Acer rubrum* and *Ailanthus altissima* are shown as examples (D-E).

Ancient Grape Lineage Discovered

By Kayleigh Walters

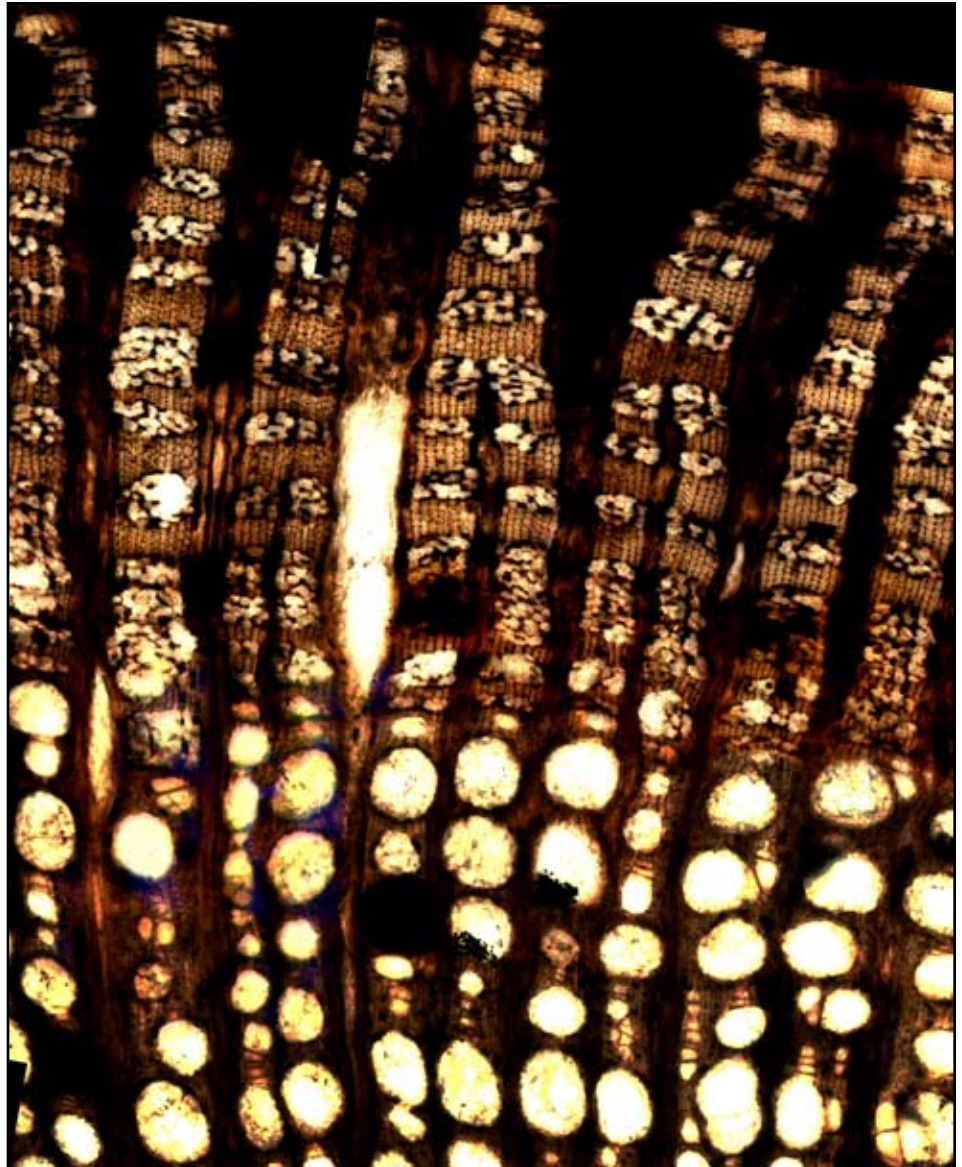
When **Marcelo Pace** and **Stan Yankowski** gave a tour of the National Museum of Natural History's wood collection to Andrew Rozefelds, no one anticipated that it would lead to the publication of two new papers (including a recent paper in the *Journal of Systematics and Evolution* <<http://dx.doi.org/10.1111/jse.12300>>) and the discovery of a new, ancient vine lineage.

While visiting from Australia on a Queensland Government Smithsonian Fellowship, Rozefelds began talking to Pace about an interesting wood specimen he had brought from the Queensland Museum. The thinly sliced fossilized wood sample was a vine (liana) with extremely well preserved wood and bark, which had been sitting unidentified for over 20 years. Pace, an expert in vine anatomy, examined the slide under a microscope and was able to make out cell tissue and structures. In fact, the vine was so clearly preserved that he could study it like a modern vine – one that looked very familiar. Here was a *Vitaceae*, a vine in the grape family similar to those which currently produce wine grapes, from 29-32 million years ago. These scientists had uncovered evidence of the first grape vine in the Southern Hemisphere.

Pace and Rozefelds named the new fossil *Austrovideira*, with *Austro* alluding to southern and *videira* the Portuguese word for vine, as many of the more traditional Latin and Greek words for this family had already been used by other

Top: External appearance of the permineralized stem of the fossil *Austrovideira dettmannae*. Note tessellate bark with vertically oriented fissures, similar to modern grape vines.

Bottom: General view of the perfectly preserved wood and bark anatomy of the fossil *Austrovideira dettmannae*. Liana anatomy is evident by the wide and narrow vessels combined (vessel dimorphism) and wide rays. Stratified phloem with alternating bands of fibers and dilating rays are typical of the *Vitis* clade.





Modern riverbank grape vine (*Vitis riparia*) native to northeastern USA displays a very similar anatomy to the ancient fossil, with vessel dimorphism, wide rays and stratified phloem.

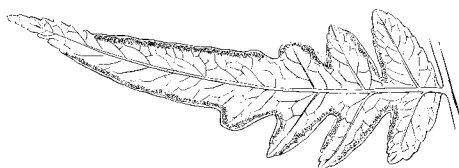
botanists and fossil plant researchers.

This discovery teaches us more about the ancient Australian environment. By comparing the *Austrovideira* to related modern plants, we know the vine likely had broad leaves, and other fossils at the site tell us it was part of a complex seasonal rainforest environment. These remnants of the past allow scientists to paint a more detailed picture of the environmental history of Queensland and the northeastern Australian site where it was found. Today, this area is dominated by dry, drought resistant vegetation - sharply different from the rainforest of 30 million years ago. Due to this discovery, we have one more piece of evidence that provides far-reaching insights into how environments have changed on our planet over time.

Austrovideira demonstrates the potential for discovery sitting in vast museum collections. When the fossilized vine was initially discovered, it was stored away and not fully identified—a potential scientific discovery waiting for a researcher.

“Sometimes you can discover just as much in the collections as you can in the field,” Pace said. “You need to look at those plants that nobody could identify; they’re probably special. Many times, they are new species.”

In museum collections as large as the Smithsonian and Queensland’s, who knows how many more discoveries are waiting to be found?



30 Years of the Biological Diversity of the Guiana Shield Program

The Biological Diversity of the Guiana Shield Program (BDG) recently celebrated its 30th anniversary. This dynamic program seeks to document, study, and preserve the biological diversity of the Guiana Shield. The Shield is a natural area occupying the northeast corner of South America and has a rich and poorly explored biodiversity. Understanding diversity in the area is complicated by the fact that it encompasses six political units

(Guyana, Suriname, French Guiana, and parts of Colombia, Venezuela, and Brazil) and five languages. The Shield includes a wide variety of habitats including the unique “Lost World” tepuis and towering greenheart forests as well as savannas, lowland and montane forests, and coastal mangrove areas each of which has a complex interaction of plants and animals.

BDG has worked to explore this rich diversity and to make the information available and useful to the public and a variety of agencies. Although based in the Department of Botany at the National Museum of Natural History, the program has interacted with scientists in almost all of the Natural History biodiversity

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Kaieteur Falls, Guyana. (photo by Carol L. Kelloff)

Guiana Shield

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departments as well as the National Zoo, Smithsonian Tropical Research Institute, and the Smithsonian Conservation Biology Institute.

To accomplish its goals, BDG has a worldwide network of collaborators. In fact, the program has worked with over 850 people in research, education, training, and outreach. These efforts have resulted in tens of thousands of new collections that have been used to address a variety of questions from the basic “What is it?” and “Where does it live/grow?” to synthetic ones, such as “What is it related to?”, “What are the levels of endemism?”, “Are there adaptive radiations?”, “Where are the highest areas of species richness and endemism?”, “Where should future expeditions go?”, and others.

Over the life of the program BDG has collected, databased, barcoded, and geo-referenced over 60,000 new plant collections. In addition, BDG has databased and barcoded over 121,000 specimens already housed in the U.S. National Herbarium totaling over 152,000 plant collections in the database. All collection data will become available via the online Botany Specimen Catalog at <<https://collections.nmnh.si.edu/search/botany/>> in early 2019.

Other databases in the museum for



Erin Tripp exploring near an unnamed black water falls, Kamakusa expedition 2012. (photo by Kenneth J. Wurdack)

the Shield area include 6,290 specimens (3893 skins, 1939 skeletons, 821 tissue in fluids, 5 eggs, 2 nests), ca. 9,000 spiders, 8,235 Lepidoptera, 75,000 ants, 23,000 aquatic insects, 450 termites, odonates, and cockroaches, ca. 3,388 amphibians and reptiles, and ca. 1,300 mammals. Over 1,100 papers have been published using the specimens and data, including theoretical papers on species richness and methods of estimating diversity as well as various checklists.

Training and education have involved the local people as well as traditional academic activities. Over the years, BDG has sponsored Amerindian training and parataxonomy courses, had numerous students, postdocs, and have frequently hosted visitors. In 2011, BDG collaborated on an exhibit in NMNH titled *More than Meets the Eye*. Other recent outreach efforts available on the BDG website include a method using Google Earth to display information from expeditions and a Google Earth tour on the biodiversity of the Guiana Shield. However, BDG's major way of interacting with colleagues and the public is the website <<http://botany.si.edu/bdg/>>, which contains all the specimen information, publications, and outreach efforts.

Core funding for the program has allowed BDG to compete successfully for funding from a variety of organizations. Over the years, the program has raised millions of dollars for projects including funds from the Royal Bank of Canada and USAID to build a biodiversity center in Guyana. Other successful grants and contracts have come from the National Geographic Society, International Development Bank, World Bank, and United Nations Development Program.

The BDG staff is proud of their accomplishments. However, they believe that every program should have a beginning and an end. Therefore, they have made the difficult decision to “wind down” so



***Brocchinia* (Bromeliaceae) savanna, Kamakusa expedition 2012. (photo by Kenneth J. Wurdack)**



***Burmanna bicolor* Mart.**
(Burmanniaceae) from the 2012
Kamakusa Tipui expedition, Guyana.
(photo by Kenneth J. Wurdack)

that they have time to accomplish their final goals. Over the next few years BDG has two overarching goals: 1) To publish 3-4 papers that provide a synthesis of biodiversity patterns on the Shield and 2-3 monographs that cover the remaining collector volumes as well as collections of papers related to the Shield; and 2) To complete processing of the remaining specimens and other biodiversity documentation (e.g., images), and to make sure all BDG data are in EMu and available on-line. In summary, the BDG staff seeks to make public all information and ideas, and to leave no backlog of specimens and archives for others to deal with. BDG has labeled this effort, “No Plant Left Behind”.

How Did Renaissance People Dye Easter Eggs?

By Kayleigh Walters

Springtime brings Easter and the joy of dyed eggs. Even though Easter was on April 1 this year, our interest in the botanical history of egg dyeing is still piqued. In an age before packets of color tablets were available from grocery stores, or drops of food dye was mixed with vinegar, people

colored Easter eggs with dyes made from plants. While there are a wide variety of historically important dye crops, three plant dyes were likely available from an early date to both rich and poor people: turmeric, purple cabbage, and onion skins.

Historic documents from Europe place Easter egg coloring as early as the 13th century. By the Renaissance period (the 14th to 17th centuries), there are records of Polish, English, Russian, and German people dyeing Easter eggs. How did these historic people dye their eggs? Likely, through a combination of three plants which could have formed the basis of a color wheel of dyes:

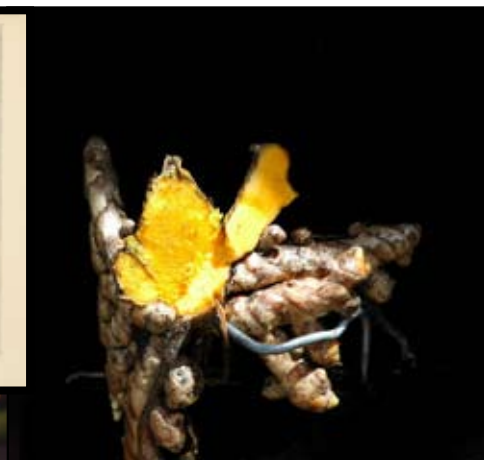
Turmeric (*Curcuma longa*) – Yellow

Turmeric, which has been used for centuries, is an herb from India and South-east Asia, which found its way to Europe via the Silk Road. Its ginger-like vividly yellow root can be dried and ground into a powder, which likely stained the hands of many cooks. People of that time may have dyed their eggs yellow by soaking them in a turmeric bath or painting them with turmeric paste.

Purple Cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) – Blue

Cabbage, likely domesticated in the pre-history of Europe, would have been

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Clockwise from top left:

- **Painted Easter eggs** from the District of Neresnice-on-the Terešva (Slavic and East European Collections, The New York Public Library. 1926. “a-h) Id”. Retrieved from <http://digitalcollections.nypl.org/items/510d47e2-a4d7-a3d9-e040-e00a18064a99>)
- **Turmeric (*Curcuma longa*)** rhizome from the Botany Research Greenhouses
- **Red Cabbage** (retrieved from Wikimedia Commons)
- **Onion (*Allium* sp.)** (photo by R.A. Howard)

Easter Eggs

Continued from page 11

plentiful in Renaissance households. In order to dye eggs (counterintuitively) blue, eggs may have been soaked in the water left over from boiling purple cabbage.

Onion Skins (*Allium cepa*) – Red

Onions, for being common, are one of the earliest domesticated vegetables. In addition to being a cold hardy abundant crop which would have stored well during the refrigerator-less Renaissance, yellow onion skins were boiled in a pot with eggs to produce varying shades of red.

Traditions can have deep roots – even those as whimsical and brightly colored as a basket of Easter eggs. When looking through the ethnobotanical collections of the U.S. National Herbarium, we can see pressed and dried plant specimens collected from the wild alongside cultivated specimens that we adapted for our own use.

Thanks to Jennifer Heise's deep dive into the history of egg dyeing in her article, "Eggs dyed with period dyestuffs" <<http://www.gallowglass.org/jadwiga/SCA/eggs/eggdyes.html>>.

Unusual Properties within the Grass Genus *Diplachne*

Adapted from Pensoft Publishers

The grass genus *Diplachne* only includes two species, but it does not fall short when it comes to remarkable fea-

tures. It was precisely this affinity to the unusual displayed by the nearly worldwide genus that inspired Neil Snow (Pittsburg State University), his co-authors **Paul Peterson** and **Konstantin Romaschenko** (National Museum of Natural History) and Bryan Simon (Queensland Herbarium) to delve deeper in a dedicated monograph published in the open access journal *PhytoKeys*.

Occurring widely on all continents except Antarctica, *Diplachne fusca*, one of the two known species, is by far not just another grass species, with two of its four subspecies displaying high salt tolerance.

Even more intriguing is the discovery by a German research team that found that some populations from southern Asia harbor a nitrogen-fixing bacterial species, which when described was new to science.

"The combination of nitrogen-fixing bacteria and high levels of salinity tolerance is unknown in others grasses, at least that I am aware of", explains Snow.

"The high tolerance for growing in saline soils suggests the plants may have untapped potential for the reclamation of salinized agricultural soils, which is more and more problematic for some producers."

In significant contrast, the second species, *Diplachne gigantea*, is restricted to small pockets in Africa. Having been collected only a few times and not since the early 1980s, the enigmatic plant is an emergent species, meaning its roots are in the water but upper portions typically extend well above the surface.

"I spent two long and hot days in a boat in the Okavango Delta in Botswana

in 1996 looking for this elusive plant, but regrettably without success," comments Snow on his attempt to encounter *Diplachne gigantea* in its natural surroundings. "Given the widespread potential habitat in the Okavango, it seems odd the species is collected so infrequently, but it may well be that it is quite rare."

Snow's colleagues at the Smithsonian Institution, Peterson and Romaschenko, included a molecular phylogenetic analysis of 21 individuals of *Diplachne*, which indicated that while the genus is monophyletic, some accessions of the four subspecies of *D. fusca* are in fact polyphyletic.

Chair with a View

Continued from page 3

challenge for us is figuring out how to increase our capacity to mount, or prepare, herbarium specimens. We have one full-time employee, numerous volunteers, and various contractors. However, with several hundred thousand unmounted specimens in our backlog we need to become cleverer in how we increase our capacity.

I am very pleased with how committed our staff, volunteers, and contractors have been in helping us to accomplish so much in the past three years. My hope is that these physical improvements help lead to the formation of even more exciting intellectual ideas about plants and their evolution.

Botany Profile

Continued from page 1

georeferencing errors, and guestimated georeferences (the White House is home to upwards of 200 species of Compositae alone if raw GBIF data is to be believed as it is a commonly used centroid for records with no better locality information than "the district"). The removal of synonyms both between and within databases also took a lot of manual inspection and reference-hunting.

A final list of close to 500,000 records for over 3,000 species was curated. Values for 187 soil, geochemistry, topography, and climate variables were extracted for each point, with correlation analyses reducing the final set to be considered down to 50. A metaphylogeny was constructed using a Genbank and an Open Tree of Life backbone, with unplaced taxa grafted on according to expert opinion.



Typical growth form of *Diplachne fusca* subsp. *fascicularis*. (photo from *PhytoKeys*)



The diversity of soils and climate gradients associated with the southwest US and northern Mexico provide a mosaic of habitats for adaptable plant groups. Here a *Gereae canescens* (Heliantheae tribe) overlooks the geochemically and topographically varied rim of Death Valley, Nevada. (photo by R. Edwards)

Armed with this data we can finally address the questions: Where are centers of diversity for North American Compositae? Are these similar across lineages? What environmental variables are correlated with increased or decreased diversity, and how do these differ across lineages? Does diversity appear to have a predictable response to certain variables through space? Are particular variables associated with more diverse clades?

As expected, we find high diversity and endemism across tribes in the Californian floristic province and extending down through northwestern and central Mexico. Interestingly (but probably not surprisingly) rarefaction curves (a technique used to assess species richness from the results of sampling) show that tribes tend to be under-sampled towards the margins of their distributions, suggesting that collectors head for areas with the greatest species diversity and neglect sampling scattered fringe species more exhaustively. Also, intuitively, we find that areas of high diversity across all tribes are associated with increased soil quartz content, as well as temperature and rainfall variables typical of the hot/dry seasonal habitats they favor. More intriguingly, each tribe also presents environmental variables that are

uniquely correlated with diversity, such as soil pH in the tribe Heliantheae, slope of the terrain in the tribe Bahieae, and soil water content in the tribe Chaenactideae.

Using another statistical technique,

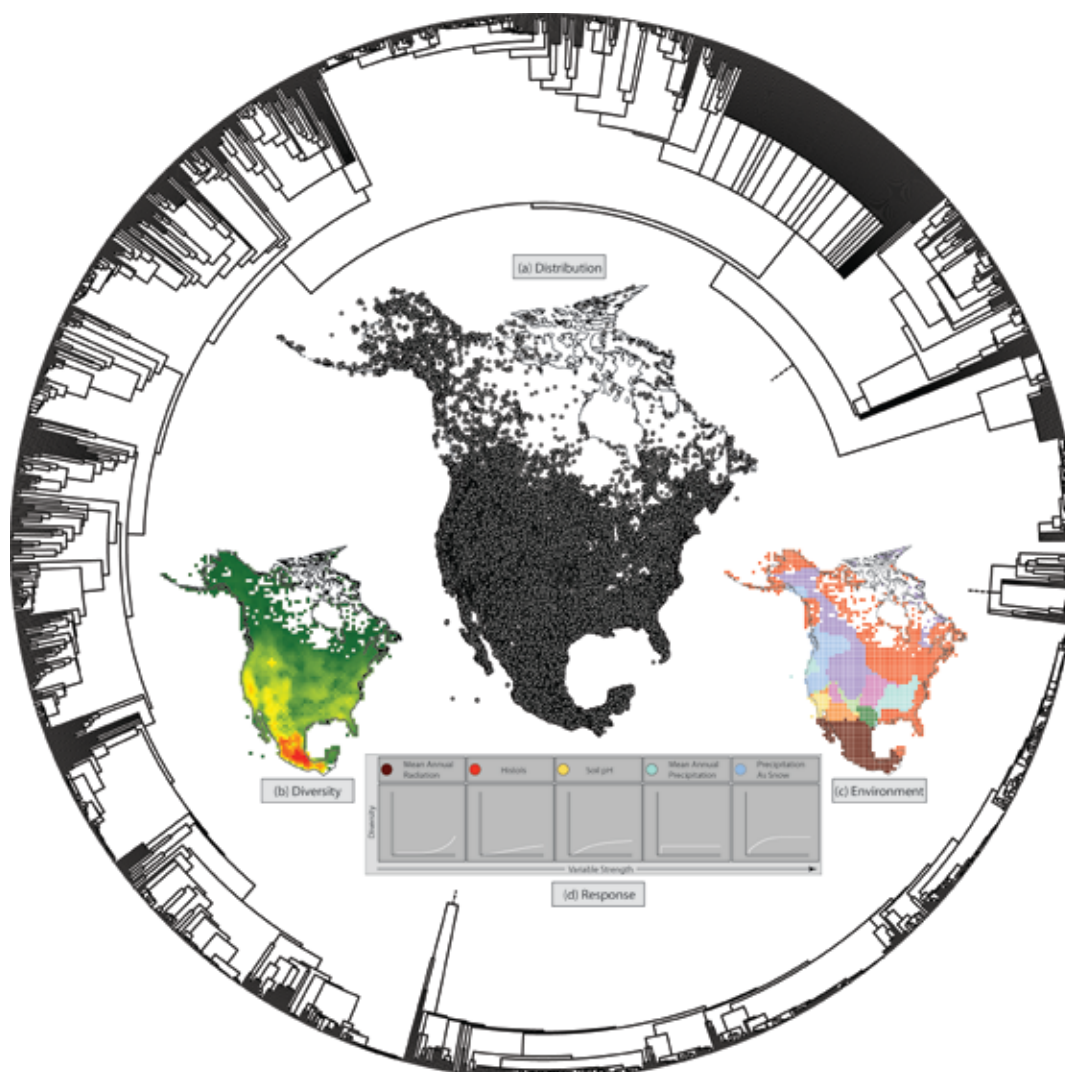
Generalized Dissimilarity Models, we can ask how diversity responds as values for these variables increase or decrease: diversity peaks in Heliantheae at a pH of a little above 7, rapidly diminishes above a certain slope pitch in Bahieae, and tails off in Chaenactideae as soil saturation increases. These results, replicated across tribes and for each of our environmental variables, give us an insight into the characteristics of the niches being exploited by different groups. Work to place this in a phylogenetic context – tracing environmental tolerances on to a phylogeny and determining which are correlated with increases or decreases in speciation rates – is ongoing.

While the Compositae have long been associated with harsh dry sandy environments, there do appear to be signals of adaptation to different discrete sets of variable extremes within these areas, allowing multiple independent and sometimes overlapping radiations. Clearly morphological and physiological characteristics of the group (including the frustratingly similar and generalist nature of many a damn yellow one) are well suited to exploiting a wide range of niches, and the next step will be to integrate phenotypic data into evolutionary models to tease out which characteristics allow species to

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Monoptilon bellidiforme (Astereae tribe) showing a preference for highly quartzitic soil and challenging extremes in climate in Death Valley, Nevada. (photo by R. Edwards)



Integrating multiple lines of Big Data to answer large-scale questions about the role of the environment in species diversification: Locality records for North American radiations of Compositae (Asteraceae) (a) are used to calculate diversity metrics, (b) and are combined with soil, geochemistry, climate, and topological data, (c) to determine regionally significant environmental variables that correlate with this diversity. How diversity changes across gradients in variable strength can also be modeled, and (d) placed in a phylogenetic context. Figure by R. Edwards from Funk (in press) and used with permission of the author.

Botany Profile

Continued from page 13

adapt to particular environments. Similarly, replication of these methods across other diverse groups via more Big Data are needed to draw broader conclusions as to the drivers of diversity at the level of communities and species assemblages. Not that knowing any of this makes me feel less inclined to throw my field-guide at the next impossible-to-key-out daisy I encounter, but it does make me feel like my frustration is somehow an acknowledgement of the impressive resilience and adaptability of this group of plants.

The “us” behind this project is a working group tasked with characterizing extreme environments in North America

and the role that these play in driving plant diversification: Robert Edwards (US); Vicki Funk (US); Elisabeth Bui (CSIRO); Marty Goldhaber (USGS); Joe Miller (NSF); Jennifer Cartwright (USGS); Chase Mason (UCF); Jim Thompson (UWV/USGS); Pam Soltis (UF); Brian Anacker (CU/City of Boulder); Ian Pearse (USGS); and Travis Nauman (USGS). It is funded by the USGS Powell Center for Analysis and Synthesis.

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Art by Alice Tangerini

***Hymenoxys ambigens* (S.F. Blake) Bierner var. *neomexicana* W.L. Wagner**

Reported from southeastern Arizona and southwestern New Mexico, *Hymenoxys ambigens* is comprised of three local varieties. Variety *neomexicana* is known from the rocky slopes of the Animas and Peloncillo Mountains of New Mexico, and is ranked as imperiled (T2, NatureServe status). In the cover story in this issue of The Plant Press, Robert Edwards finds that soil pH is a strong environmental variable that is uniquely correlated with diversity in the tribe Heliantheae. Tangerini illustrated this variety for Warren Wagner in his treatment of the species in *Brittonia* (51: 79–86; 1999).



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