

The Plant Press



Smithsonian
National Museum of Natural History

Special Symposium Issue continues on page 13

New Series - Vol. 21 - No. 3

July-September 2018

Botany Profile

Turn Back Time: Plant Fossils Find a Way

By Kayleigh Walters and Gary A. Krupnick

This year's Smithsonian Botanical Symposium explored the deep time of botany with the theme, "Plants in the Past: Fossils and the Future." Seven speakers presented a whirlwind of information over the course of a day, focusing heavily on the benefit brought by developing technologies to the field of paleobotany. The symposium, held on 18 May 2018, convened at the Warner Bros Theater at the National Museum of American History, a change in scenery from past symposia as Natural History's Baird Auditorium undergoes renovations.

Before the symposium began, the Joseph F. Cullman 3rd Library of Natural History opened its doors to attendees for special tours of the library's paleobotany books. The Library put on display a wide selection of publications that highlight fossil plants, from Boccone's *Recherches* (1674), through the editions of Scheuchzer's *Herbarium diluvianum* (1709, 1723), to Brongniart's works in the 19th century, and more. Attendees learned the tale of Johann Beringer, a professor in 1725 who was made a fool when two of his colleagues planted fake fossils for him to find and research. Fortunately, this was the only fakery of the day.

The symposium began with opening remarks by Kirk Johnson, Sant Director of the National Museum of Natural History and Laurence Dorr, Chair of the Department of Botany. Johnson was pleased with the theme of the symposium this year, as the symposium coincides with the development of the Natural History Museum's Deep Time exhibition, a

major overhaul of the National Fossil Hall, which is scheduled to open to the public in June 2019.

Before the speakers' talks began, Kenneth Wurdack presented the José Cuatrecasas Medal for Excellence in Tropical Botany to Alan Graham, a paleobotanist from the Missouri Botanical Garden.

Graham recalled his time as a post-doctoral fellow at Harvard University and his "first social responsibility" in hosting a dinner for José Cuatrecasas and his wife. He was honored to be able to do that then, and now 56 years later, thrilled to be receiving an award in Cuatrecasas' name.

Sir Peter Crane opened the symposium with a talk on the origin of flowering plants called "The Enigmatic 'Mesozoic Seed Ferns.'" He introduced the complexity of studying the topic by discussing how the field of paleobotany has changed in recent decades. In the 1970s, paleobotany was a field that was literally frozen in stone due to a lack of high-quality fossils and tools to study them. Sir Peter demonstrated how far the field has come when he showed a digital reconstruction of a fossilized flower "bloom" for the crowd. Technology such as this allows scientists to study internal structures of fossilized plants.

Having demonstrated the advantages conferred by recent advances in technology and their impact on paleobotanical research, Sir Peter launched into his

updated theory on seed ferns. He presented a new understanding of the origin of angiosperms based on his research of fossils collected from the Early Cretaceous in Mongolia. He explained that the origin of the outer integument and the carpel are two key questions for understanding the origin of angiosperms.

He argued that the curvature responsible for the second integument in angiosperms has

deep evolutionary roots. He explained that the origins of this curvature could be seen in diverse seed plants of the Mesozoic, such as *Caytonia*, corystosperms, and similar plants. Curvature results from the curvature of a seed-bearing axis that sometimes also bears modified bracts. Sir Peter explained that in pre-angiosperm seed plants, this curvature might be associated with a flotation based pollination mechanism involving saccate pollen, which appears to be basic in all but the very earliest diverging seed plant lineages. He concluded that many of the seed-plant lineages we now treat as independent may be closely allied.

The next speaker was Andrew Leslie, who gave a talk on the evolution of cones called "Biotic Seed Dispersal, Growth Architecture, and the Evolution of Conifer Cone Diversity." He hypothesized what the first cones may have looked like, and why present cones look like the often spiky objects we are familiar with today. By examining the



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Pedro Acevedo traveled to São Paulo, Brazil (4/11 – 5/14) to teach a class on neotropical lianas at the University of São Paulo and to collect Sapindaceae and climbing plants in other families in Brazil.

Marcos Caraballo traveled to Philadelphia, Pennsylvania (5/9) to study specimens and types of mistletoes in Loranthaceae in the herbarium of the Philadelphia Academy of Sciences; to Cambridge, Massachusetts (6/14 – 6/15) to study specimens in the herbarium of Harvard University; to Chicago, Illinois (6/18 – 6/19) to study specimens in the herbarium of the Field Museum; to Carbondale, Illinois (6/21 – 6/22) to study specimens in the herbarium of the Southern Illinois University; and St. Louis, Missouri (6/25 – 6/29) to study specimens in the herbarium of the Missouri Botanical Garden.

Manuela Dal Forno traveled to Jamaica (4/9 – 4/20) to collect lichens, including important types collected by Olof Swartz, in the Blue Mountains of Jamaica; and to Graz, Austria (5/9 – 5/25) to work on lichen microbiome analyses and to learn techniques in culturing lichens.

Ashley Egan traveled to Spokane, Washington (4/30 – 5/10) to work on a collaborative project on *Phaeolus polystachios* (Fabaceae) at the University of Washington.

Vicki Funk traveled to Ecuador (3/28 – 4/28) for field work with Mauricio Bonifacino (MVFA) and Alina Freire-Fierro traveling up and down the spine of the Andes collecting composites from the snow line to the cloud forests; to Vienna, Austria (5/15 – 5/25) to attend the Global Genome Biodiversity Network (GGBN) meeting and to work in the herbarium of the Natural History Museum in Vienna (W); and to Honolulu, Hawaii (6/1 – 6/10) to work on a paper with Sterling Keeley, and to present an invited departmental seminar at the University of Hawaii.

Morgan Gostel traveled to Vienna, Austria (5/20 – 5/25) to attend the 2018 Global Genome Biodiversity Network conference to present on behalf of the Global Genome Initiative for Gardens (GGI-Gardens); and to Anaheim, California (6/3 – 6/8) to attend the annual meeting of the American Public Gardens Association where he organized and lead a symposium for GGI-Gardens.

Carol Kelloff and Mark Strong traveled to McBee, South Carolina (4/17 – 4/27) to collect genomic material for the Global Genome Initiative (GGI) in sand hill ecosystems of the Carolina Sandhills National Wildlife Refuge, Sugarloaf Mountain (Sandhills State Forest), and Hudsonia Flats (Cheraw State Forest), where some of the priority taxa for the Global Genome Biodiversity Network (GGBN) and GenBank were collected including three species of pitcher plants (*Sarracenia*), sandhills bean (*Phaseolus sinuatus*), white wicky (*Kamia cuneata*), zenobia (*Zenobia pulverulenta*), sandhills pyxie-moss (*Pyxidanthera brevifolia*), southern bogbutton (*Lachnocaulon beyrichianum*), and the pygmy spiderlily (*Hymenocallis pygmaea*).

W. John Kress traveled to Guadeloupe (5/21 – 5/29) to conduct fieldwork on *Heliconia*-hummingbird interactions as part of a long-term NSF-supported project; to Cambridge, Massachusetts (5/7 – 5/9) to give an invited talk, “Species interactions in the Anthropocene: Coevolution in a rapidly changing world,” at the Harvard Plant Biology Symposium – Natural History Collections in the Anthropocene; and to New York, New York (6/20 – 6/21) to participate as co-chair of the Earth BioGenome Project in a workshop and meeting held at the Flatiron Institute.

Sylvia Orli traveled to Bronx, New York (4/18 – 4/20) to attend the Axiell North American EMu User conference at the New York Botanical Garden.

Peter Schafran traveled to Texas (5/5 – 5/10) to collect *Isoetes* with researchers from Old Dominion University, Sam Houston State University, and the Texas Parks and Wildlife Department, which included the discovery of a new county record of *I. melanopoda* in Newton County; to Columbus, Ohio (6/1 – 6/4) to present a lightning talk, “Unraveling reticulate evolution of quillworts in eastern North America,” at the meeting of the Society of Systematic Biologists at the Ohio State University; and from Virginia to Louisiana (6/7 – 6/29) to collect longleaf pine (*Pinus palustris*) across its range.

John Wiersema traveled to Hokkaido, Japan (6/10 – 6/17) to attend the annual meeting of the International Seed Testing Association in Sapporo as Chair of their Nomenclature Committee and to collect and observe native populations of Japanese *Nymphaea* with Norio Tanaka of Tsukuba Botanical Garden, National Museum of Nature and Science, Tsukuba, Japan.

Kenneth Wurdack traveled to Bronx, New York (5/31 – 6/2) to conduct research in the herbarium at the New York Botanical Garden.



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Visitors

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

Jennifer Ackerfield, Colorado State University; Asteraceae (4/4-4/14).

Jennifer Huebert, International Archaeo-

logical Research Institute, Inc., Hawaii; Wood collection (4/9-4/11).

Blanca Leon, Universidad Nacional Mayor de San Marcos, Peru; Peruvian Melastomataceae and ferns (4/13).

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Among the Pioneers of Open Access in Botany, *PhytoKeys* is Celebrating its 100th Issue

-Adapted from Pensoft Publishers

Eight years, more than 500 articles and no less 13,000 pages since its launch, Pensoft's flagship botanical title *PhytoKeys*, celebrates its 100th issue. Among the open access pioneers in its field, the journal brings more than just numbers to the table when it comes to achievements and innovation. *PhytoKeys*' most notable milestones over the last 8 years are featured in the Editorial of its anniversary issue.

Following its main objective to speed up research in the field of botany, in its 100th issue the journal features a rare species, previously unknown to science – *Poa laegaardiana*, a new grass species found on sandy, volcanic soil in Ecuador, described by Smithsonian botanists **Paul Peterson** and **Robert Soreng** (read more about this species on page 9).

Launched less than a decade ago in 2010, *PhytoKeys* main



Poa laegaardiana, a rare species known only from the type collection in Provincia Bolivar, Ecuador, is featured in the 100th issue of the journal *PhytoKeys* (<https://dx.doi.org/10.3897/phytokeys.100.25387>).

Editor's Pick

objective was to accelerate research and free information exchange in fields such as taxonomy, phylogeny, biogeography and evolution of plants, implementing the latest technology and innovative workflows. As a result, *PhytoKeys* was the first botanical journal to introduce a XML-based publishing workflow, pre-publication registration of new taxa with the International Plant Name Index (IPNI), semantic markup and tagging of taxonomic treatments and taxonomic names, extensive data publishing modalities, and many more.

With a total of 466 new taxa published since its launch (including 1 tribe, 26 genera or subgenera, and 439 species or infraspecies) the journal can confidently claim to be succeeding in its original mission to speed up the publishing and documenting of plant diversity in a world loss is occurring at unprecedented rates.

While publishing new taxa in itself is a step forward for increasing our knowledge of plant diversity worldwide, *PhytoKeys* has always recognized the importance of developing innovative methods for dissemination and preservation of knowledge for future discoverability and re-use. This is why the journal's content is integrated with a significant number of global indexes and archives, such as PubMedCentral, CLOCKSS, Google Scholar, CAB Abstracts, DOAJ, Vifabio, BHL Citebank, to name a few.

"I got involved with *PhytoKeys* almost a decade ago because I believe in a world where information is shared openly and transparently for the benefit of all, especially information about the biodiversity of our planet. We work hard save what we care about, but can only care for the things we know about," shares Deputy Editor-in-Chief, Sandra Knapp, Natural History Museum London.

"The innovative open access platform that *PhytoKeys* has established means all botanists, everywhere, can know about plant diversity as it is discovered, levelling the playing field for future collaborative action to conserve it. Plants matter to the planet, and open access to knowledge about them like that provided on the *PhytoKeys* platform is one key to their - and our - future," says Knapp.

"When we established *PhytoKeys* our number one goal was to bring open access to the field of botany, while at the same time accelerating the ways in which knowledge about plant taxonomy is published and disseminated around the world," adds Editor-in-Chief, **John Kress**, Smithsonian Institution. "It has been our greatest pleasure to see the botanical community wholeheartedly accept these ideas and support us by choosing our journal as a venue for publishing their excellent research. I am sure that *PhytoKeys* will continue on this exciting and successful trajectory for years to come."

Staff Research & Activities

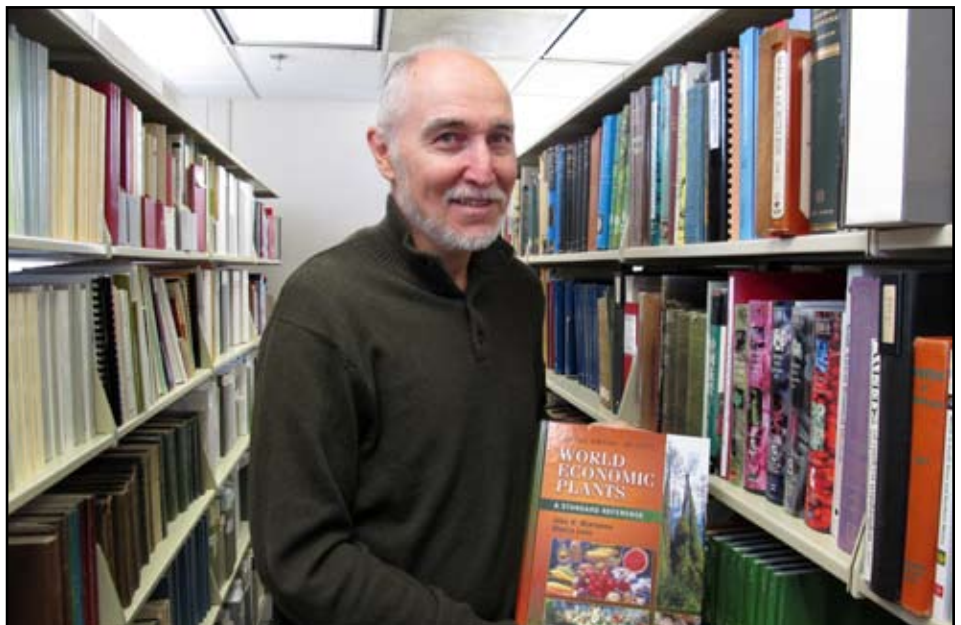
Manuela Dal Forno is now a Peter Buck Postdoctoral Fellow under advisor **Eric Schuettpeitz**. Her project title is “Starting from scratch: Using whole genome sequencing to understand lichenization in Basidiomycota.” Dal Forno received her Ph.D. in Environmental Sciences and Public Policy with an emphasis on lichen molecular systematics from George Mason University in May 2015. She is interested in understanding the evolutionary relationships and biodiversity of lichens, particularly tropical lineages of basidiolichens. During her Buck Fellowship, Manuela will sequence the genomes of both partners in the symbiosis *Cora-Rhizonema* to investigate patterns of gene loss and gain associated with the lichenization process; to assess presence of horizontal gene transfer; and to develop new genetic markers to understand the remarkable diversity within the *Dictyonema* clade (Basidiomycota, Agaricales).

Peter Schafran presented a poster “The *Isoëtes flaccida* (Isoëtaceae) complex in the southeastern United States,” on 18 May at the Smithsonian Botanical Symposium in Washington, DC. Schafran also presented a lecture on 5 June to the Botanical Society of Washington titled, “Botanizing in hostile territory: field work in Iraq and the Deep South.”

New Faces

Based in Lagos, Nigeria, **Temitayo Ogunbiyi** is a visual artist who creates work that considers and constructs contemporary channels of communication. She is currently working on a series that fuses hairstyles with botanical forms. This will be honed and developed further during her Smithsonian Artist Research Fellowship. Working with **Gary Krupnick** and **John Kress**, her research in the Department of Botany at the National Museum of Natural History will focus on medicinal plant species that thrive in the tropics. Her

Top: Manuela Dal Forno
Middle: Temitayo Ogunbiyi
Bottom: John H. Wiersema



findings will inform forthcoming works on paper and playground sculptures. She is also conducting research at the National Museum of African Art, the National Museum of American History, and the Smithsonian's American Art Museum. Ogunbiyi's work has been shown at the Pulitzer Foundation for the Arts, the Center for Contemporary Art Lagos (Nigeria), Tiwani Contemporary Gallery (London), Stephen Friedman Gallery (London), the Perm Museum of Contemporary Art (Perm, Russia), and Berlin Art Projects (Berlin). She recently took part in *Strange Attractors*, an artist book that was produced as part of the 10th Berlin Biennale. She earned her bachelor's degree from Princeton University in Art History, Visual Art, and African-American Studies and an M.A. in Curatorial Studies and Critical Art Theory from Columbia University.

Retiring from the U.S. Department of Agriculture's Agricultural Research Service in Beltsville, Maryland after more than 30 years, **John H. Wiersema** will be continuing his taxonomic and nomenclatural work at the National Museum of Natural History as a Research Associate in the Department of Botany, a position he has held since 2014. Previously he was a taxonomist for the USDA's national germplasm system's GRIN database. This position provided the opportunity to develop GRIN Taxonomy into an extensive and exhaustive taxonomic resource on economic plants important to global agriculture. Through this work Wiersema gained global standing as a specialist in plant nomenclature, and now has direct editorial involvement with both the botanical and cultivated plant codes of international nomenclature and the international journal *Taxon*. Wiersema is also well known as a specialist on the taxonomy of the water-lily family, especially the genus *Nymphaea*, is responsible for the discovery and description of several new species, and has participated in over 30 scientific publications on the group. He expects to pursue both of these interests here in the Botany Department.

Visitors

Continued from page 2

Sterling Keeley, University of Hawaii, Manoa; Compositae (4/23-4/27).

Patrick Herendeen, Chicago Botanic

Garden; International Association for Plant Taxonomy (4/24-4/27).

Karol Marhold, Slovak Academy of Sciences, Slovakia; *Cardamine* (Brassicaceae) (4/24-4/27).

Tom Lovejoy and 13 students, George Mason University; Plant conservation and herbarium tour (4/30).

Juan F. Carrión R., Universidade Estadual de Feira de Santana, Brazil; *Bernardia* (Euphorbiaceae) and allies (5/7-6/1).

William Trujillo, Universidad Militar Nueva Granada, Colombia; *Piper* (Piperaceae) (5/7-5/10).

Blake Fauskee, University of Minnesota Duluth; Pteridophytes internship (5/9-6/6).

Shirley Graham, Missouri Botanical Garden; Lythraceae (5/17).

Kelly Meiklejohn, North Carolina State University; Toxic plants (5/21-5/22).

Marco Pellegrini, Universidade de São Paulo, Brazil; Commelinales (5/29-6/27).

Hannah Ranft, Johns Hopkins University; Pteridophytes internship (5/29-8/3).

Deborah Ballem, Smith College; DNA barcoding internship (6/4-8/4).

Paulo Windisch, Universidade do Vale do Rio dos Sinos, Brazil; Brazilian ferns (6/15-6/18).

Nuri Benet Pierce, San Diego State University; *Chenopodium* (Chenopodiaceae) (6/18-6/19).

Suelen Vianna, Instituto Agronômico de Campinas, Brazil; *Acrocomia* (Arecaceae) (6/18-6/22).

Dutilh Julie, Universidade Estadual de Campinas, Brazil; Brazilian Amaryllidaceae, Hypoxidaceae, *Hagenbachia* (Asparagaceae) (6/19-6/22).

Jared Margulies, University of Sheffield, United Kingdom; Illegal wildlife trade (6/27-7/12).

Wonderful World of Plant Microtechnique

A tour of the Department of Botany's Plant Anatomy and Histology Lab was presented for National Museum of Natural History interns on June 20. This event was coordinated by the Academic Resources Center's Intern Team for Activities and Events. Participants had the opportunity to learn in detail how plant anatomy is useful in taxonomic research, and especially about the intricate methods that reveal anatomical structure and cellular organization in plants. Featured lessons included fixation, paraffin embedding, microtomy, whole mount clearing, critical point drying, and microscopy. The interns observed microslide preparations in brightfield, polarized light, and phase contrast, and research being conducted on the morphology of *Vitis* sp. (Vitaceae) seeds. The highlight of the tour was to section buds using a rotary microtome to produce exquisitely thin *paraffin ribbons*.



Summer interns at the National Museum of Natural History received a tour of the Plant Anatomy and Histology Laboratory.

Collections-based Science in the 21st Century

A recent open-access paper published in the *Journal of Systematics and Evolution* (a journal co-edited by Botany

Department member **Jun Wen**) discusses the importance of collections based research from the 1700s to 2100 (<https://onlinelibrary.wiley.com/doi/abs/10.1111/jse.12315>).

In the article, the author, Botany Curator **Vicki Funk**, discusses discoveries from collections-based science that have

changed the way we perceive ourselves, our environment, and our place in the universe.

The narrative begins with the 18th century, which saw the beginning of formal classification with Linnaeus proposing a system to classify all of life. Passing through the 19th century, the age of explo-



Some of the biological collections housed at the National Museum of Natural History. (photos courtesy of NMNH Photo Services; assembled by Alice Tangerini)

ration ushered in as naturalists undertook large-scale collecting expeditions leading to major scientific advances (the founding of Physical Geography, Meteorology, Ecology, Biogeography, and Evolution) and challenging long held beliefs about nature. Moving into the 20th century, Funk explains how collections were central to paradigm shifts, including theories of Continental Drift and Phylogenetic Systematics, and explains how Molecular Phylogenetics added testable hypotheses and computerized specimen records gave rise to the field of Biodiversity.

In more recent times, the first 15 years of the 21st century, Funk suggests that tree-thinking has pervaded the life sciences leading to the emergence of Evolutionary Medicine, Evolutionary Ecology, and new Food Safety methods. Finally, Funk looks into the future and how collections-based research is staged to produce even more advances: 1) open access to large amounts of specimen data & images; 2) linking of collections and climate data to phylogenies on a global scale; and 3) production of vast quantities of genomic data allowing researchers to address big evolutionary questions. Because of collections-based science, people see themselves not as the center of all things, but rather as part of a complex universe.

The paper concludes by stating that it is essential that we integrate new discoveries with knowledge from the past (e.g., collections) in order to understand this planet we all inhabit, and suggests that we must come together and plan for the future.

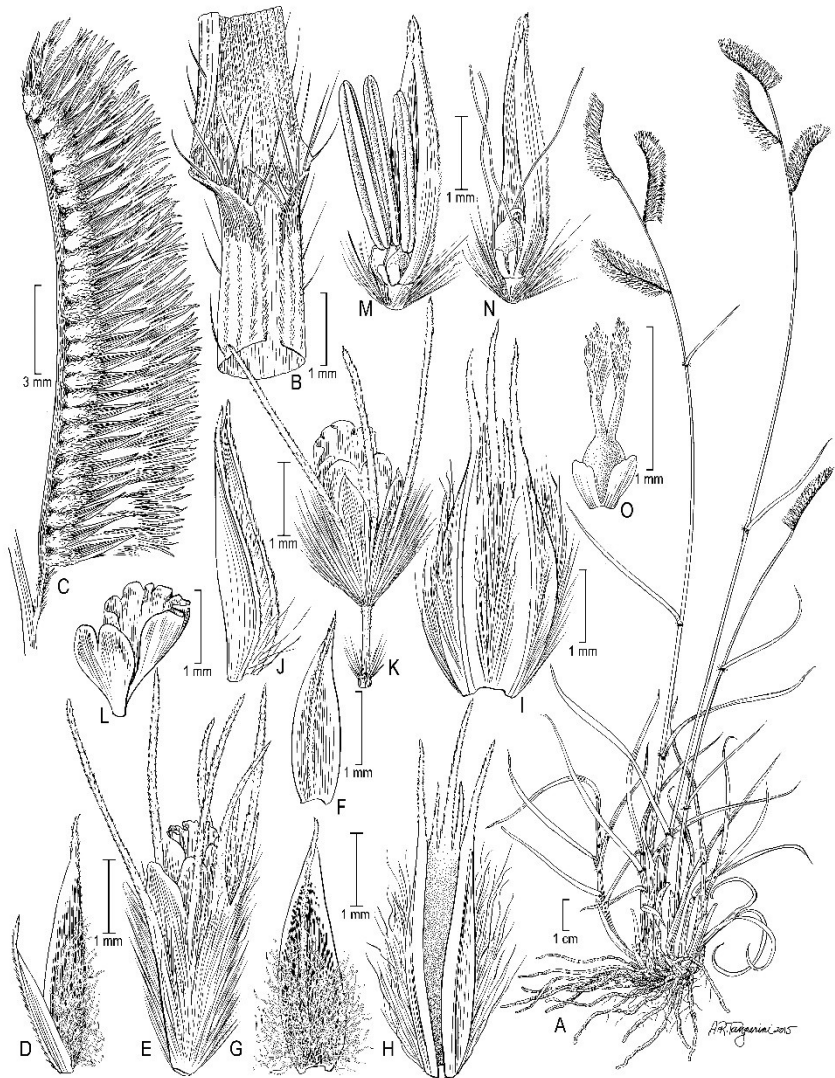
This paper is posted on ResearchGate, a social networking site for scientists and researchers, where readers can post comments.

Grasses of Chihuahua, Mexico

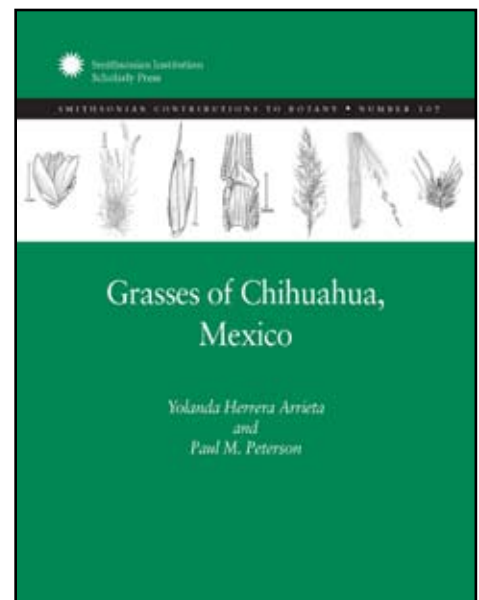
The publication, "Grasses of Chihuahua, Mexico" (*Smithson. Contr. Bot.* 107: 1–380; 2018. <http://dx.doi.org/10.5479/si.1938-2812.107>), is a culmination of a long and fruitful collaboration between Yolanda Herrera Arrieta (Instituto Politécnico Nacional, CIIDIR, in Durango) and **Paul Peterson**. Chihuahua is floristically diverse, bordering the United States on the north along the Rio Grande while containing the Barrancas del Cobre (Copper

Canyon), the deepest and most picturesque canyon in North America. The two scientists have known each other for more than 33 years, having first met while Peterson was on an expedition (extended camping trip) collecting grasses in Mexico doing his dissertation research on *Muhlenbergia*, a single-flowered chloridoid grass with a center of diversity in Chihuahua where 78 species are found. Eventually, Herrera Arrieta completed her doctoral studies in 1995 at McGill University in Montreal, also working on *Muhlenbergia*. The two agrostologists have coauthored 24 peer-reviewed manuscripts on grasses, ranging from floristic studies to monographs and phylogenetic classifications based on molecular DNA sequences.

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***Bouteloua herrera-arrietae* P.M. Peterson & Romasch., an endemic from Nuevo León, Mexico, was named to honor Herrera Arrieta (drawn by Alice Tangerini in *J. Syst. Evol.* 53(4): 351–366. 2015. <http://onlinelibrary.wiley.com/doi/10.1111/jse.12159/epdf>).**



Grasses

Continued from page 7

After finishing a floristic treatment of grasses in Zacatecas (Herrera Arrieta, Y., P.M. Peterson, and A. Cortés Ortiz. 2010. *Gramíneas de Zacatecas, México. Sida, Botanical Miscellany* 32: 1–239), the two began working on compiling a list of all the known grasses in Chihuahua while verifying all grass collections from the state tallied in the Mexican National database (CONABIO). Peterson has amassed nearly 12,000 collection numbers in Mexico, of which 1,521 are grasses from Chihuahua. Many of these were incorporated in the specimen examined section, documenting the occurrence of each species.

Mexico contains about 1,215 grass species, 385 of these are included in this new treatment of the Chihuahua grasses, and 257 of these (66%) are illustrated. In the next few years Herrera Arrieta and Peterson hope to finish many grass manuscripts, two notable projects are the grasses of San Luis Potosí and a revision of *Muhlenbergia* for Mexico.



Celebrating the Summer Solstice with Pollinators

The National Museum of Natural History (NMNH) celebrated National Pollinator Week 2018 in June in an effort to raise awareness of the decline of important pollinator populations. On June 23, the Smithsonian Institution hosted Solstice Saturday, a Smithsonian-wide celebration kicking off the summer season. Nearly every Smithsonian museum in the Washington area, the Smithsonian National Zoo, Smithsonian Environmental Research Center in Edgewater, Maryland, and Cooper Hewitt, Smithsonian Design Museum and the National Museum of the American Indian Heye Center in New York City, extended their hours until midnight, some with special themed and joint programming. NMNH had over 1,000 visitors to its bilingual Pollinator Family Night programs. Over three hours, visitors engaged in a wide variety of activities in Q?rius and Qjr, as well as visiting the Butterfly Pavilion and Insect Zoo.

During the Pollinator Family Night



Top: Barbara Stauffer (Office of Education and Outreach) introduces Kimberly Winter and Gary Krupnick for a question and answer session after a screening of “Pollinators Under Pressure” at a June 2018 Pollinator Family Night event at the National Museum of Natural History. (photo by Laura Cox, Tree Media)

Bottom: Some of the pollinator-friendly plant specimens from the U.S. National Herbarium that were on display. (photo by Gary Krupnick)

event, the film “Pollinators Under Pressure” was featured in the Q?rius Auditorium. The film is about the plight of pollinators around the world and the actions we can all take to ensure their survival and that of humans and ecosystems everywhere. **Gary Krupnick** (NMNH Department of Botany) and Kimberly Winter (U.S. Forest Service) participated

in a questions and answer session with the audience after each of the three showings. The Tree Media film, narrated by Leonardo DiCaprio, is available on the website <http://www.pollinatorsunderpressure.org> and on YouTube.

Krupnick also hosted a “Scientist is In” station sharing stories of important native plants for pollinators and display-

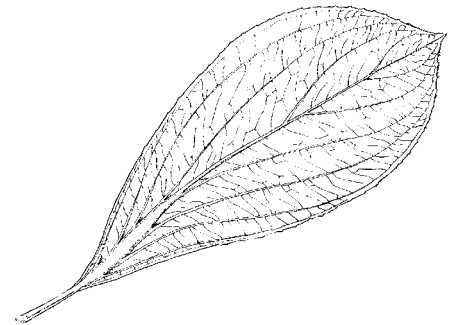
ing several plant specimens from the U.S. National Herbarium. Other activities in Q?rius included building a solitary bee home, examining insect specimens under magnification, creating orchid origami, participating in the build-a-bug photo station, and interacting with scientists from the Departments of Entomology and Vertebrate Zoology who displayed bee, bat, and bird specimens from the museum's collections.

Participants to the events each received the 2018 Pollinator Week poster, "Pollinators and Seeds." The poster, designed by Pittsburgh-based artist Lindsay Wright-

Durko, features a diversity of managed and native pollinators that support healthy wildlands and a nutritious food supply in North America. Krupnick served as the scientific advisor on the poster. The poster's website <<http://pollinator.org/shop/poster-2018>> has information about 10 plant species that provide us with important fruits and vegetables, and 12 important pollinating animal species.

Each year the Pollinator Partnership, along with a wide range of partners (including federal agencies, non-profits, and for-profits), design and distribute the educational pollinator posters to promote

Pollinator Week, a time to celebrate pollinators and native plants and to spread the word about what you can do to protect them. The posters are one of the most popular outreach material items offered.



Described 28 Years Post-Collection, New Grass Species Makes a Strong Case for Conservation

Adapted from Pensoft Publishers

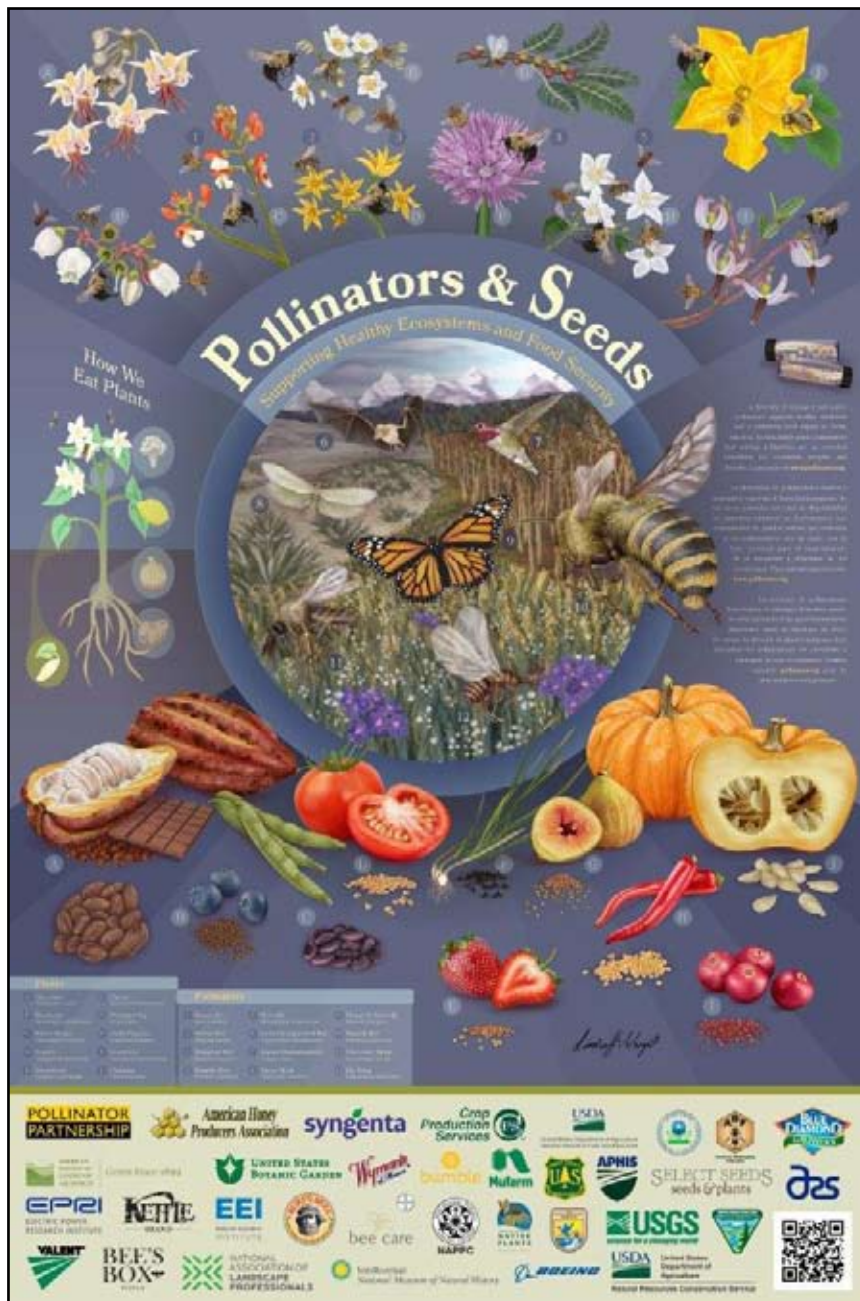
Originally collected 28 years ago in Ecuador, new species *Poa laegaardiana* has been just described, only to find out its prospects for surviving in its type location seem bleak nowadays. The study was published in the open access journal *PhytoKeys*.

When roaming in the Cordillera de los Andes of Ecuador, near the village of Facundo Vela, little did Smithsonian scientist and author, **Paul Peterson**, know that a small grass specimen will not only turn out to be an intriguing new species, but will also make a big statement on the importance of conservation.

Almost three decades after its original collection the new species *P. laegaardiana* has finally emerged from its herbarium collection, but the story took an unexpected twist.

It took the authors a single Google Earth search to find out that what used to be the natural habitat of the newly found densely tufted bunchgrass, is now occupied predominantly by small farms.

Heavy agricultural use of the terrain poses a good possibility for *P. laegaardiana* to have already been extirpated from this location. With the species currently known only from this area, chances are that this newly described species might in



Pollinator Week 2018 poster, "Pollinators and Seeds"

Continued on page 10

2011

2018



Google Earth image comparison between the area of collection in 2011 and today. With the area having been plowed, chances of the grass still existing there are small, however it may still be found along the margins of the fields. (photo credit: Left @2018DigitalGlobe; Right @2018Google @2018CNES/Airbus)

Conservation

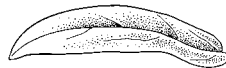
Continued from page 9

fact turn out to be already extinct.

“Further studies are needed to search the area and browse collections for specimens from different locations,” explains Peterson. “But, in fact, it may well be that with our study we are documenting a possible extinction of a species happening in the space of just 30 years. The story of *P. laegaardiana* serves to show how human-

induced habitat loss can indeed be a major threat to the survival of life on Earth.”

The new species was named after renowned Danish botanist Simon Laegaard, who has made extensive collections in South America, Greenland, Ecuador, and Bolivia (accompanied by the authors) contributing to the documentation of the flora to make informed conservation and management plans.



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Smithsonian Botanical Symposium

Graham Receives 16th Cuatrecasas Medal

The Department of Botany and the United States National Herbarium present the José Cuatrecasas Medal for Excellence in Tropical Botany to a botanist and scholar of international stature who has contributed significantly to advancing the field of tropical botany. The award is named in honor of Dr. José Cuatrecasas, a pioneering botanist and taxonomist, who spent nearly a half-century working in the Smithsonian Institution's Department of Botany. Cuatrecasas devoted his career to plant exploration in tropical South America and this award serves to keep vibrant the accomplishments and memory of this outstanding scientist.

The winner of this prestigious award is selected by a committee made up of four botanists on staff in the Department in consultation with other plant scientists outside of the Smithsonian Institution. Nominations for the Medal are accepted from all scientists in the Botany Department. The award consists of a bronze medal bearing an image of José Cuatrecasas on the front with the recipient's name and date of presentation on the back. Highlights from past presentations to the recipients are available at <<http://botany.si.edu/cuatrecasas/cuatrecasasMedal.cfm>>.

Alan K. Graham is the 16th recipient of the José Cuatrecasas Medal for Excellence in Tropical Botany. Graham received B.A. (1956) and M.A. (1958) degrees from the University of Texas. His Ph.D. from the University of Michigan in 1962 under paleobotanist Chester Arnold was followed by postdoctoral work at Harvard University. He had a long tenure (1964–2002) as a Professor of Biological Sciences and Geology and distinguished teacher at Kent State University, and since 2002 has been a Research Associate at the Missouri Botanical Garden. He has published over 200 scholarly works, includ-

ing authoring four books. His latest book, *Land Bridges: Ancient environments, plant migrations, and New World connections*, was published in March 2018 by The University of Chicago Press. He has endowed research funds and been honored with *Paleobotany and Biogeography, A Festschrift for Alan Graham in His 80th Year* (Missouri Botanical Garden Press, 2014), and the Asa Gray Award from the American Society Plant Taxonomists (2009).

Graham's long interest in pollen and utilizing microfossils to track American vegetation history included starting a reference slide collection, as an undergraduate, that eventually grew to 25,000 slides when it was gifted to the Smithsonian in 2008. His long-term studies on Neotropical paleobotany were supported by the National Science Foundation and have focused on late Cretaceous and Cenozoic terrestrial paleoenvironments. The Cuatrecasas Medal selection committee took special note of Graham's focus on understanding the origins and history of neotropical floras that has culminated in impactful synthetic works. This paleo-perspective, which spans Central America, South America, and the Caribbean, is of special relevance to this year's Smithsonian Botanical Symposium.

The past recipients of the Cuatrecasas Medal are Rogers McVaugh from the University of North Carolina at Chapel Hill (2001); P. Barry Tomlinson from Harvard University (2002); John Beaman from the Royal Botanic Gardens, Kew (2003); David Mabberley from the University of Leiden, The Netherlands, and the Royal Botanic Gardens, Sydney (2004); Jerzy Rzedowski and Graciela Calderón de Rzedowski from Instituto de Ecología del Bajío, Michoacán, Mexico (2005); Sherwin Carlquist from Rancho Santa Ana Botanic Garden and Pomona College (2006); Mireya D. Correa A. from

the University of Panama and Smithsonian Tropical Research Institute (2008); Norris H. Williams from the Florida Museum of Natural History and the University of Florida, Gainesville (2009); Beryl B. Simpson from the University of Texas at Austin (2010); Walter S. Judd from the University of Florida at Gainesville (2012); Ana Maria Giulietti Harley from the Universidade Estadual de Feira de Santana, Brazil (2013); H. Peter Linder from Zurich University (2014); Paulo Günter Windisch from Universidade Federal do Rio Grande do Sul, Brazil (2015); Kamal Bawa from the University of Massachusetts Boston (2016); and Robin B. Foster from the Field Museum (2017).



Kenneth Wurdack presents Alan Graham with the 16th José Cuatrecasas Medal in Tropical Botany. (photo by Gary Krupnick)

Abstracts from the Speakers at the 16th Smithsonian Botanical Symposium

The 16th Smithsonian Botanical Symposium, “Plants in the Past: Fossils and the Future,” was held 18 May 2018. The invited speakers explored plants from their early origins to the more recent rise of the angiosperms, addressing current trends and the future of paleobotanical research. Below are the abstracts from the papers that were presented by the invited speakers.

Sir Peter Crane

Oak Spring Garden Foundation, USA

“The enigmatic ‘Mesozoic seed ferns’”

A dominant trend in paleobotany over the last several decades has been the dramatic expansion of a critically evaluated angiosperm fossil record and increased appreciation of its relevance for understanding major patterns in angiosperm evolution. The picture that has emerged is rich with new insights, and has revealed a pattern that is broadly consistent with evidence from the molecular phylogenetics of living plants. However, much more problematic have been attempts to understand the origin of angiosperms and convincing resolution of this question has eluded both molecular phylogenetic and paleobotanical approaches. Progress has seemingly ground to a halt indicating that what is needed are new sources of data. Central to many discussions of angiosperm origins have been two groups of so-called, “Mesozoic” seed ferns - the Caytoniales and corystosperms (Umkomasiales). New material, mainly discovered and collected on field expeditions over the past decade from the Early Cretaceous of Mongolia and adjacent areas of China, is providing new information on both groups. These new data, derived from exceptionally well-preserved lignified mesofossils and high quality impressions, as well as specimens permineralized in chert, help to clarify previous misunderstandings and are revealing surprising architectural commonalities among the ovulate reproductive structures of several groups of living and fossil seed plants. These discoveries raise interesting questions and suggest



Speakers, conveners, and award recipients at the 2018 Smithsonian Botanical Symposium at the National Museum of Natural History (from left): Laurence Dorr, Sir Peter Crane, Alan Graham, Kirk Johnson, Selena Smith, Surangi Punyasena, Andrew Leslie, Jonathan Wilson, Susana Magallón, Saharah Moon Chapotin, and Mónica Ramírez-Carvalho. (photo by Ken Wurdack)

new perspectives that are likely to have important implications for understanding seed plant evolution, including the origin of angiosperms.

Andrew Leslie

Brown University, USA

“Biotic seed dispersal, growth architecture, and the evolution of conifer cone diversity”

Conifer cones are some of the most recognizable and well-known botanical structures, and their evolution has long fascinated botanists. The fossil record has proven essential in understanding the origins of modern conifer cones from fertile shoot systems in Paleozoic ancestors, and cones remain a promising system in which to incorporate paleobotanical data into macroevolutionary studies. In particular, advances in comparative methods using dated phylogenetic trees may provide answers to persistent problems in conifer cone evolution, such as the origin of simplified and fleshy seed cone morphologies like the “berries” of yews. I use a combination of fossil data, ancestral state reconstructions, and models of character evolution to illustrate how the appearance of specialized animal seed dispersal strategies over the late Mesozoic and Cenozoic played a large role in the evolution of modern conifer cone diversity, although the exact morphological adaptations that clades exhibit depends on their branching

architecture. For example, the simplified fleshy cones found in some Cupressaceae and most Podocarpaceae evolved from small woody cones characteristic of conifers with highly ramified distal twigs bearing imbricated scale leaves. In contrast, conifer clades with large diameter branches bearing large cones never evolve fleshy tissues for biotic dispersal, but instead produce large dry seeds that animals pluck out of the cones. Because conifers combine rich living diversity with an extensive fossil record, they represent an ideal group in which to apply a variety of phylogenetic and comparative methods to deep-time evolutionary studies.

Susana Magallón

Universidad Nacional Autónoma de México, Mexico

“The different roles of fossils for time-calibrating phylogenies”

Time-calibrated phylogenies provide direct information about the age of clades, and represent the starting point of studies on morphological evolution, biogeographic history, and the dynamics of the process of diversification. It is clearly recognized that independent temporal calibrations are determinant to molecular clock analyses – far more relevant than the amount of molecular data, and clock method. Fossils have been used in varied ways and to different degrees in different clock methods. A few studies have entirely

omitted the paleobotanical record, drawing their calibrations from phylogenetically distant nodes or absolute substitution rates. Other studies are entirely based on fossil evidence, including estimating a confidence interval around the age of selected nodes, and a model that simultaneously estimates ages, diversification and preservation parameters. Relaxed molecular clocks combine molecular data with fossil information applied in different ways, to estimate divergence times and other parameters. Most conventionally, fossils are used to calibrate selected internal nodes, but are not included in the phylogeny, nor do they play a role in generating it. Tip-dating methods rely on total evidence data to simultaneously estimate phylogenetic relationships and divergence times among extant and fossil taxa. A recently developed, highly parametric method integrates extant and fossil taxa as part of the same diversification process under a common phylogeny-generating model, including estimation of the role of fossils as extinct terminals, or as ancestors of prevailing phylogenetic branches. These different roles of fossils in time-calibration methods will be exemplified with published and ongoing studies estimating angiosperm age.

Surangi Punyasena
University Of Illinois at Urbana-Champaign, USA

“Laying the foundations for automated pollen analysis”

Palynological data are derived from the expert identification of fossil pollen and spore specimens. Although the microscopes for observing palynological specimens have dramatically improved over the last century, our methods for comparison and classification are still largely visual and qualitative. Automated, machine-based pollen analysis holds the potential to transform the discipline. Automation would increase data throughput, producing more pollen counts per expert per unit of time, and improve data quality, by increasing the taxonomic resolution of identifications and by calculating explicit estimates of identification uncertainty for the first time.

I present three examples of research problems that we have successfully addressed using a generalized workflow for automated classification: automation of

pollen counts from species-rich airborne pollen samples from a Neotropical low-land forest; reconstruction of the extinction history of a North American spruce; and an investigation of the biogeography and diversification history of a pantropical legume clade. These diverse classification problems were solved using modified convolutional neural networks (CNNs), trained on image libraries created using optical superresolution microscopy and automated slide scanners.

The diversity of these problems demonstrate the generalizability and transferability of these machine learning methods to other visual classification problems. CNNs represent a powerful new group of computer vision algorithms. However, the efficacy of these automated approaches is limited by the training data available in any given analysis. The future of these automated analyses will largely rely on the development of expansive specimen image databases incorporating well-curated image data, derived from well-curated specimens.

Mónica Ramírez-Carvalho
Smithsonian Tropical Research Institute, Panama

“Late Cretaceous floras from northern South America and the evolution of Neotropical rainforests”

Tropical South America has the highest plant diversity of any region in the world

today. The origin and causal mechanisms that underlie this diversity remain an open question in evolutionary biology. Fossil floras from northern South America provide direct evidence of the timing of origin and diversification of Neotropical biomes, as well as their response to global perturbations in the geological past. Among these fossil floras are the Late Paleocene Cerrejón and Bogotá Floras, dating back to 58–60 million years ago, and considered to be the earliest known examples of Neotropical rainforests based on their paleoclimate, family-level taxonomic composition and comparable paleoecology with living rainforests. Even though these fossil floras have given a baseline for understanding the evolution of Neotropical rainforests throughout the Cenozoic, little is known about what kind of ecosystems and floristic associations existed in the Neotropics before this time. Using the pollen and leaf fossil record, we describe the floristic composition of Late Cretaceous forests in northern South America and evaluate the impact of the End-Cretaceous mass extinction on these early tropical forests.

The continuous pollen record across the K/Pg boundary indicates drastic plant extinction at the end of the Cretaceous that is also reflected in Late Cretaceous and Late Paleocene leaf assemblages. Fossil leaves collected in four Late Cretaceous sites show that many extant tropical plant

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Sir Peter Crane concludes that many of the seed-plant lineages we now treat as independent may be closely allied. (photo by Gary Krupnick)

Abstracts

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families such as Lauraceae, Arecaceae, Araceae, existed in the Late Cretaceous floras, these forests lacked the family-level composition typical of Late Paleocene and living Neotropical rainforests. Similarly, diverse and highly specific plant-insect associations seen in fossil leaf damage in the Late Cretaceous floras are replaced with distinct leaf damage traces in the Late Paleocene assemblages, indicating an ecological turnover. Plant extinction at the K/Pg boundary and the differences observed between the Late Cretaceous and Late Paleocene floras from northern South America indicate that the End-Cretaceous mass extinction could have enabled the evolution of Neotropical rainforests as we know them today.

Selena Y. Smith

University of Michigan, USA

“Plant paleobiology in the digital era: How X-ray microCT is helping to shed light on the history of plants”

Fossils provide critical data for understanding broad patterns of biodiversity, biogeography, ecology, and evolution over geological time scales. Challenges remain in various areas of interpreting the fossil record, including difficulties presented by variable preservation, accessibility to specimens, and accurately interpreting morphology in order to place fossils in the Tree of Life. A tool with much potential to help overcome some of these challenges is the use of 3D imaging via synchrotron-based or industrial X-ray micro-computed tomography (microCT). MicroCT is non-destructive, rapid, and provides 2D and 3D morphoanatomical data, making it ideal for fossils. In addition, digital data provide a lasting record of specimen morphology, preserving information in case of compromised integrity and enabling virtual sharing and examination of material. MicroCT facilitates acquisition of comparative morphological data from extant taxa. Using either fossil or modern datasets, virtual dissections and the creation of virtual fossils from these 3D datasets can be used generate hypotheses of expected morphologies from either extant or extinct taxa to aid in correctly placing fossils in a taxonomic and phylogenetic framework. Examples of the usefulness of



Susana Magallón discussing tools and methods that are used to estimate divergence times of flowering plants. (photo by Gary Krupnick)

microCT include understanding biodiversity in the Cretaceous-Paleogene Deccan Intertrappean Beds of India and helping to place fossils in a phylogenetic context in studies of specific groups like the Arecales (palms) and Zingiberales (gingers, bananas, and relatives). MicroCT is proving to be an invaluable tool for paleobotanical studies, enhancing our ability to study natural history collections and build comparative datasets that will ultimately help to elucidate broader patterns of plant diversity and evolution.

Jonathan Wilson

Haverford College, USA

“Ecophysiology of extinct plants”

Plants are unique among multicellular organisms because much of their physiology is biophysical, rather than behavioral, and the anatomy that defines these biophysical capabilities is preserved in the fossil record. However, many extinct plants lack close living relatives or morphological analogues for fossilized anatomical features, limiting the ability of experimental methods to provide a perspective on extinct plant growth, development, and function. Mathematical models, when applied to fossilized plant organs—particularly leaves and stems—can provide quantitative insight into the physiology and ecology of plants that have been extinct for hundreds of millions of years. Within the Euramerican Carboniferous tropical forests, key plants from seed and non-seed plant lineages occupied physi-

ological niches that were later explored by flowering plants, suggesting an early history of complex physiological behavior and environmental response. Furthermore, understanding the physiological properties of Carboniferous plants permits paleoenvironmental proxies, including geochemical proxies for carbon dioxide concentration, to be refined. Comparing the physiology of extinct plants with strategies that are currently employed by living plants sheds light on ecophysiological trajectories in plant evolutionary history and the history of plant-environment coevolution.

Profile

Continued from page 1

fossil record, Leslie was able to determine that proto-cones were modified shoots. The evolution of woodiness in long, thin, seemingly flexible cones was adaptively advantageous because it provided protection to their seeds from ever-evolving predators.

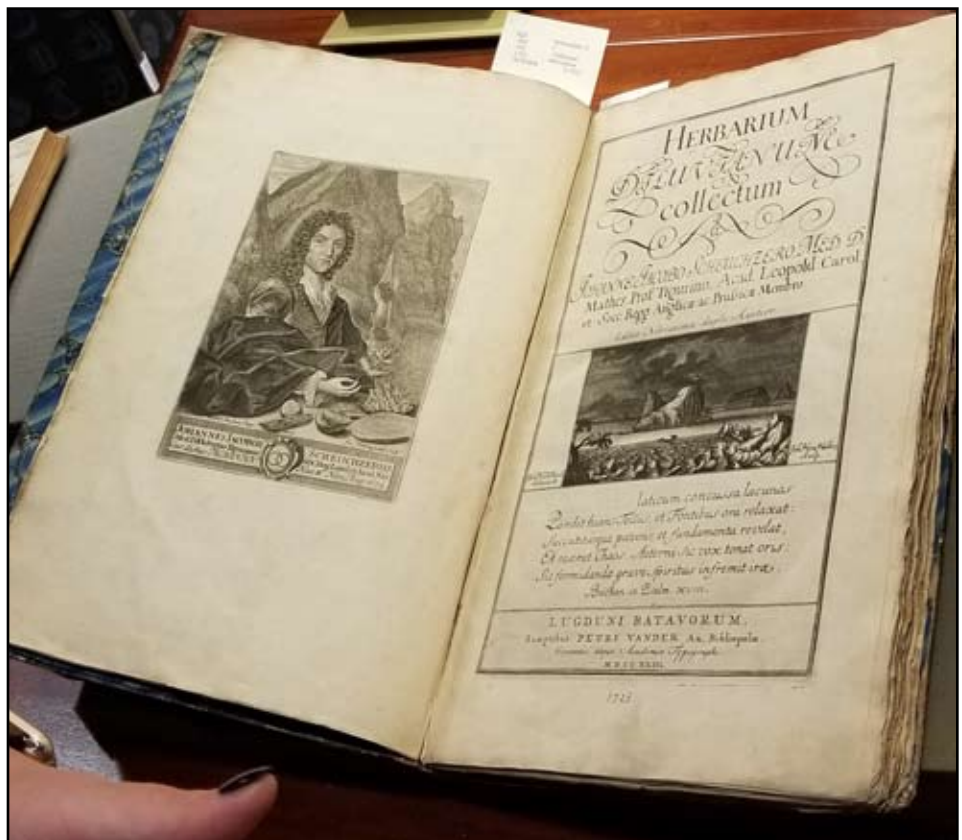
This discovery made Leslie question why small, fleshy, almost berry-like cones found in Cupressaceae and Podocarpaceae exist today. Unlike large, woody cones, the fossil record for these was scarce, and if any fossils did exist, they looked like “a black smudge within another black smudge that used to be a seed.” To work around this problem, Leslie developed a mathematical model that hypothesized transition rates between four cone types that could have existed: large, woody

cones; small, woody cones; large, fleshy cones; and small, fleshy cones. After striking out large fleshy cones as a possibility, Leslie examined the model. This model helped him theorize that a cone's morphology was dependent on the form of its tree's branches and how animals dispersed its seeds. A tree with small branches would not grow large cones, and a tree with thick branches would not develop fleshy cones.

In his talk, "Ecophysiology of Extinct Plants," Jonathan Wilson explained that the plant life we see today is a consequence of several hundred million years of evolution in response to the environment. Wilson told us that plants and their environments coevolved and each could tell us about the other. He advocated study of extinct plants as whole plants, rather than as disconnected fossil leaves or stems. He demonstrated that plants are integrated systems, and he used the example of a plant's water transportation (what he calls the key to plant physiology) in his discussion. Plants are essentially composed of tubes; if we study how water was transported around a plant and where to, it will tell us which parts of the plant were most important to its survival and how humid or dry its environment was.

Wilson explained that the first vascular plants were experimenting with vascular tissue. He introduced the audience to the three plants with unusual structure: the Paleozoic "seed fern" *Medullosa* (large leaves on small stems; xylem cells that are among the largest in the fossil record), the Carboniferous tree fern *Psaronius* (root mantle surrounds stem), and the climbing sphenophyte *Sphenophyllum* (climbing hooks on heterophyllous leaves). He argued that within the Carboniferous ecosystems, plants occupied both ends of the modern hydraulic spectrum: high water transport efficiency but unsafe (*Medullosa*, *Sphenophyllum*) and lower water transport efficiency with higher safety margins (*Psaronius*, *Cordaites*). He concluded that plants have evolved a wide range of ecophysiological strategies over the last 400 million years, including "extinct ecophysologies" that are not represented in extant ecosystems. Functioning of late Paleozoic tropical plants was more dynamic than inferred from phylogenetic relationships and it included the capability to force vegetation-climate feedbacks.

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Top: Leslie Overstreet and Allie Newman give background information about the Botanical fossil books on display at the Cullman Rare Book Library. Leslie also talked about the library and the services they offer. Questions are encouraged, so when asked where the best donations to the library have come from, the group was surprised to find out that most are acquired from retired Smithsonian Institution researchers. Oftentimes these donors know little of the history of the book.

Bottom: *Herbarium diluviarum* by Johann Jakob Scheuchzer was first printed in 1709. Scheuchzer theorized that fossils were leftovers from the Great Flood of Noah's Ark fame, which is depicted on this title page. (photos by Rose Gulledge)

Symposium

Continued from page 17

The afternoon session began with lectures on fossilized pollen and technology. The first was given by Surangi Punyasena on “Laying the Foundations for Automated Pollen Analysis,” and focused on her lab’s development of machine-learning artificial intelligence (AI), which had been applied to the recognition and cataloguing of fossilized pollen in microscopic images. She used a labor-intensive method to create a virtual 3D-image of pollen samples, tagged data on each of the pollen grains, and then fed these into a neural net. This was the starting point for teaching her machine how to become a pollen expert. Punyasena’s early tests have been running well, but she said that more data is needed to train the machine before it can reliably identify more complex pollen and beat trained humans. This new tool is exciting because it will be able to plow through large samples more quickly, and even identify broken, poorly preserved grains. Punyasena expanded the crowd’s idea of what is possible in paleobotany, from the sepia-tinged field of a hundred years ago, to one moving into the gleaming era of AIs and neural nets.

Continuing the topic of technology,

Acknowledgements

The success of the Symposium was due to the significant time and efforts of the following people:

Organizers

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And many others who had helped in a myriad number of ways.

Selena Y. Smith gave a lecture on “Plant Paleobiology in the Digital Era: How X-Ray MicroCT is Helping to Shed Light on the History of Plants.” Smith spoke about the powerful ability of industrial X-ray micro-computed tomography (microCT) scans to reconstruct otherwise fragile or damaged fossils without doing further harm to museum specimens. Smith illustrated the usefulness of this technology through the example of a walnut. Using traditional investigative methods to identify an unknown walnut seed preserved in a slab of rock, a researcher would need to find part of a shell, an outer husk, the seed itself, or be unable to extract and examine the specimen without destroying it. Each part has the potential to be seen as a different plant. With microCT, a broken and apparently blank rock could be scanned, rejoined, and the seeds within rotated and examined from any angle.

Smith presented a case study of the evolutionary history of the Zingiberales. She described a project that analyzes 50 seed characters of over 200 specimens of Zingiberales using both traditional light microscopy as well as synchrotron-based tomography. The use of synchrotron tomography allowed her to reexamine non-destructively many rare and endangered extant taxa and fossils for study. One result that she discussed was the discovery that two species of fossil *Alpinia* were actually three species of *Carpolithus* and one species of *Caricoidea* (Cyperaceae). She concluded that non-destructive X-ray tomography is a powerful tool for fossil and modern plant material. A future goal is to build large comparative anatomical and morphological datasets to evaluate fossil affinities, reconstruct past environments, and provide calibration points with more confidence.

The theme of the next talk alternated away from tools of the trade to research, with Mónica Ramírez-Carvalho’s lecture on “Late Cretaceous Floras from Northern South America and the Evolution of Neotropical Rainforests.” Carvalho collected fossils from Guajira, Colombia, at the site of the oldest known Neotropical rainforest (58–60 Ma) – now one of the largest open pit coal mines in the world. She examined these fossils to learn more about what Neotropical rainforests looked like before the Cretaceous–Paleogene (K/Pg) extinction event. Carvalho cataloged plant types, examined fossils of leaves for evidence of

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- United States Botanic Garden

insects, and identified pollen remains. She found high abundance of leaf damage, low species diversity, and the same family-level composition as in Neotropical forests of today.

Carvalho asked what pre-Paleocene tropical forests were like and how Neotropical forests changed throughout the Cenozoic. A study of 800 leaf samples plus 350 new collections shows that the pattern of family-level dominance in pre-extinction times (~70 Ma) was different from the late Paleocene. She also discovered that leaf damage diversity is notably higher in the Cretaceous floras. Over the next few years, Carvalho will be conducting experiments in temperature- and CO₂-controlled greenhouses at the Smithsonian Tropical Research Institute that test hypotheses related to dramatic environmental changes, such as the hyperthermals of the Early Eocene. The objectives of her study will be to test for increased evapotranspiration under high CO₂ and high temperature.

The last lecture of the day was given by Susana Magallón on “The Different Roles of Fossils for Time-Calibrating Phylogenies.” This talk focused on tools and methods that are used to estimate divergence times, with a special focus on flowering plants. She presented three objectives of her talk: the type of data used in the models, the specific role of fossils, and examples from studies that estimate the age of crown group angiosperms. She then presented five different methods that are used to estimate divergence times. The first two methods estimate diversity times by excluding the fossil record (for example, using amino acid sequence data of cytochrome C in different plant species) and by only using the fossil record (for example, using plant macrofossil records at the genus level). These two models give a divergence time estimate of angiosperms at 230–310 Ma and 133–152 Ma, respectively.



Speakers and guests interact at the closing reception and poster session of the 2018 Smithsonian Botanical Symposium. (photos by Ken Wurdack)

The next three methods to estimate divergence times involve a relaxed molecular clock, which allows the molecular rate to vary among lineages. One method uses fossils to calibrate phylogenetic nodes, the oldest discovered representative of the clade. Another uses fossils as phylogenetic terminals, in which fossils are treated as taxa and placed on the tips of the tree. The last uses fossils as part of the phylogeny-generating model and of the diversification process, in which fossils are represented either as tips or ancestors.

Also called the fossilized birth-death process, this final method gives a divergence time estimate of 150-182 Ma. Magallón's research will be important for future studies involving the timeline of plant evolution and diversification and other studies involving deep time dating.

The Symposium ended with a closing reception and poster session in the Conservatory of the U.S. Botanic Garden, and gave several more scientists the ability to present their research on a range of topics. This Symposium was, truly, a

deep dive into the deep time of plants. The 17th Smithsonian Botanical Symposium is scheduled to return to Baird Auditorium at the National Museum of Natural History on Friday, 17 May 2019. The theme will be structured around the topic of domestication of plants. Check the symposium website <<http://botany.si.edu/sbs>> for updates.



Supplementary Symposium Links on Web

The website to the 16th Smithsonian Botanical Symposium <<http://botany.si.edu/events/sbsarchives/sbs2018/>> has many links and documents related to the conference. Included on the website is the full program, abstracts of the talks, links related to the speaker's presentations, and selected images from the various events. Additional items related to the Symposium can be added to the list of links and documents by sending an e-mail to sbs@si.edu.

The Symposium archive page <<http://botany.si.edu/events/sbsarchives/>> also includes programs, abstracts and images from the past 15 symposia: "Linnaean Taxonomy in the 21st Century" (2001); "The Convention on Biological Diversity" (2002); "Botanical Frontiers in South-east Asia" (2003); "Botanical Progress, Horticultural Innovations, and Cultural Changes" (2004); "The Future of Floras: New Frameworks, New Technologies, New Uses" (2005); "Island Archipelagos: Cauldrons of Evolution" (2006); "Partners in Evolution: Interactions, Adaptations, and Speciation" (2008); "Genes, Genomics and Genome Evolution in Plants" (2009); "Food for Thought: 21st Century Perspectives on Ethnobotany" (2010); "Transforming 21st Century Comparative Biology using Evolutionary Trees" (2012); "Avoiding Extinction: Contemporary Approaches to Conservation Science" (2013); "Location, Location, Location... New Advances in the Science of Biogeography" (2014); "Next Generation Pteridology: An International Conference on Lycoplyte & Fern Research" (2015); "Bats, Bees, Birds, Butterflies and Bouquets: New Research in Pollination Biology" (2016); and "Exploring the Natural World: Plants, People and Places" (2017).

Art by Alice Tangerini

***Alpinia modesta* F.Muell. ex K.Schum.**

At the 2018 Smithsonian Botanical Symposium, "Plants in the Past: Fossils and the Future," fossilized Zingiberales was among the many plant groups discussed. As part of the Zingiberales program at the Smithsonian spearheaded by Curator John Kress and colleagues, Alice Tangerini was sent to the Harold L. Lyon Arboretum in Hawaii in July 1997 to make preliminary drawings from living specimens of plants in the Zingiberales, including *Alpinia modesta*. It was a summer of sporadic rains so drawing in the Arboretum always meant bringing a large plastic tarp to throw over her work when a shower came.

The floral details were illustrated at the education building in the evenings. Tangerini made additional sketches from specimens at the Smithsonian Botany Greenhouses the following summer.



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