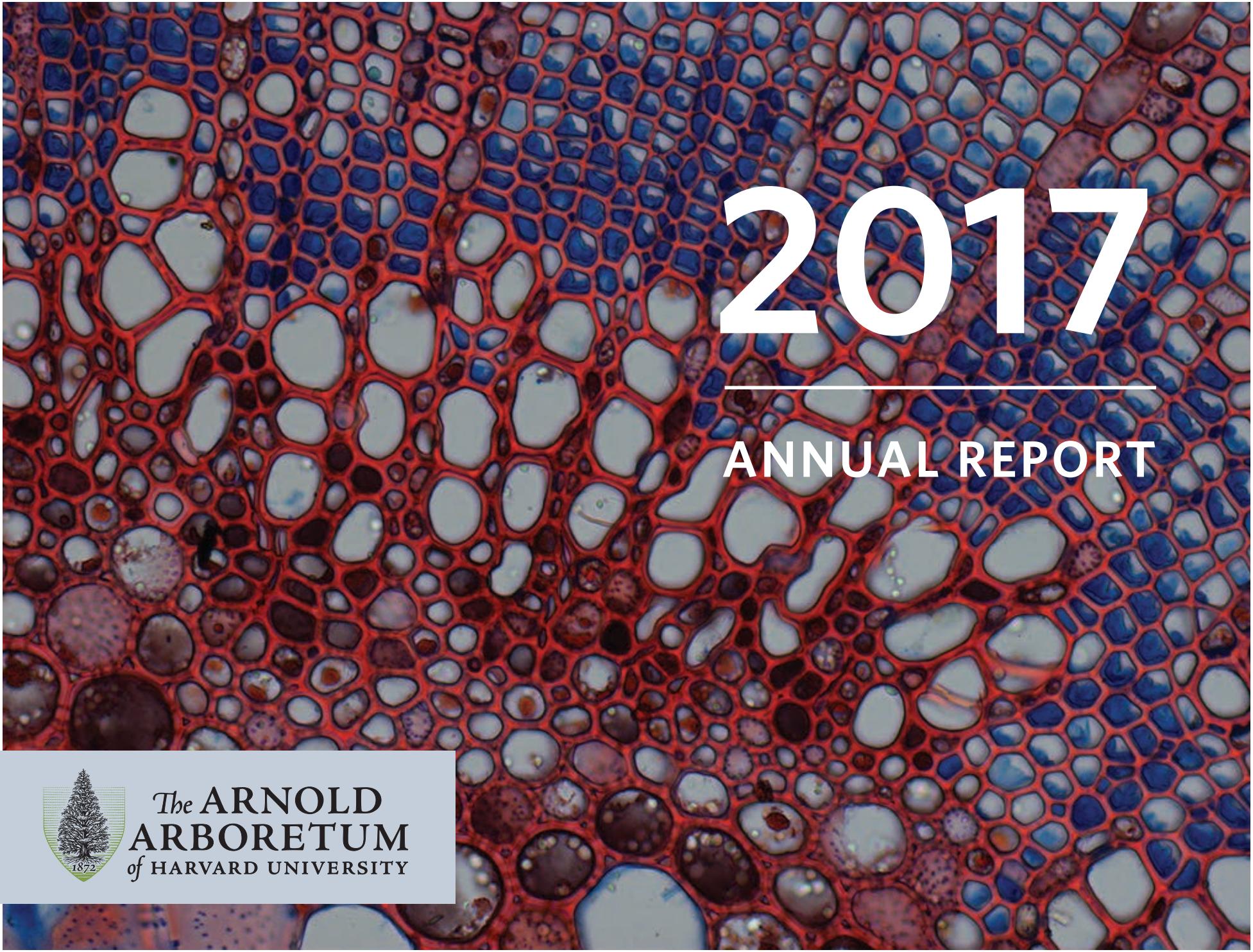


2017

ANNUAL REPORT

The ARNOLD ARBORETUM of HARVARD UNIVERSITY

Who We Are

A public-private partnership between the City of Boston and Harvard University, the Arnold Arboretum pursues excellence in horticulture, research, and education as an international center for the study of biodiversity.

A 281-acre preserve designed by Charles Sprague Sargent and Frederick Law Olmsted, the Arboretum stewards one of the world's most comprehensive and best documented collections of temperate woody plants, with particular focus on the floras of eastern North America and eastern Asia.

Although funded entirely through endowments, annual gifts, and membership revenue, the Arboretum remains free and open every day as a community resource. This jewel in the Emerald Necklace park system is among Boston's most beloved open spaces.

Cover: A cross section through a twig of *Sassafras albidum*, showing tissues that transport water, provide mechanical support, and store carbohydrates. Photo by Kasia Ziemińska.

Director's Report

William (Ned) Friedman
Director and Faculty Fellow of the Arnold Arboretum
Arnold Professor of Organismic and
Evolutionary Biology, Harvard University

In reflecting on the past year—my seventh growing season at the Arnold Arboretum of Harvard University and the 146th since its founding—I am astounded by how far we have come as an institution dedicated to discovery and scholarship. The Arboretum made a giant leap in this regard, seven years ago, with the opening of the Weld Hill Research Building, an event that coincided with my arrival as the Arboretum's eighth director in January of 2011. As that year and my adventure began, I shared our innovative 45,000-square-foot research facility with just two other people. Fast forward to 2017, and Weld Hill has blossomed into one of Harvard's most dynamic ecosystems for scientists at every stage of their training and careers, and the scope of studies spans the life and environmental sciences and sparks dynamic interactions around the globe.

In many ways, the growth and success of our revitalized scientific enterprise owes much to our times—particularly the intersection of critical advances in genomic information and the rising importance of understanding our global ecological crisis. As a university-based living museum of natural history, the Arnold Arboretum is uniquely equipped and historically positioned to contribute significantly to what we know about our most potent allies in mitigating carbon in our atmosphere—trees and other forms of plant life. Our work to understand how plants and their communities are responding to global change extends from the routine field checks we conduct on our roughly 15,000 curated specimens, to the study of plant and pollinator interactions and their co-evolution, to the rich observational data on plant life cycles collected by our volunteer Tree Spotters each season in our landscape.

What ties everything we do together and binds us to our parent institution, Harvard University—as well as our civic partner, the City of Boston—is our conviction that the Arnold Arboretum exists to inform, to elucidate, and to inspire. As you read this report on our activities in 2017, pay special notice to the many ways that the Arboretum, its staff, and our community participate in both sides of the learning equation. We are all teachers and all students, and by striving to discover and share new knowledge, we are also critical agents of change. When you take a class, attend a lecture, or share what you have learned from an Arboretum tour, you too are contributing to the culture of learning and enrichment that the Arnold Arboretum has cultivated for more than a century. By definition, all of the activities of a university and its affiliated institutions ultimately hinge on education: teaching, training, and helping individuals to define and reach their aspirations. They are also the means by which we as a society become something better.

This report on our annual activities can only highlight a fraction of the moments, interactions, and accomplishments that made 2017 such a pivotal time for this institution. I hope you will discover more in the many ways we share our progress with you—in public events and programs, in the pages of our publications, and online. As we consider where we have been and look forward to what lies ahead for the Arnold Arboretum, we have so many things to celebrate—a galvanizing Living Collections Campaign, new staff and systems to track and improve the care of our plants, and

fresh opportunities for students of all ages to engage with our landcape and the world around us. We also anticipate the approach of our sesquicentennial—in 2022, the Arboretum will commemorate 150 years as Harvard's living museum of trees and Boston's learning landscape. Thank you for the critical role you play in keeping our mission, our community, and our aspirations forever green.

COLLECT

The Arnold Arboretum collects representatives of Earth's woody plant diversity for study, conservation, and public enrichment. One hundred taxa of trees, shrubs, and lianas were collected on expeditions in 2017 as part of the Campaign for the Living Collections, including several plants with conservation status (in orange, right).

Keeper of the Living Collections Michael Dosmann (far right) and Manager of Horticulture Andrew Gapinski (far left) explore a mountainside in Sichuan, China, with collecting partners from the Chengdu Institute of Biology and the Bejing Botanical Garden, September 2017. Photo by Jonathan Shaw/courtesy *Harvard Magazine*.

Acer oliverianum • *Acer rubrum* • *Acer saccharum* ssp. *floridanum* • *Acer spicatum* • *Aristolochia tomentosa* • *Astilbe grandis* • *Baccharis angustifolia* • *Betula alleghaniensis* • *Betula fargesii* • *Betula insignis* ssp. *insignis* • *Betula pumila* • *Callicarpa americana* • *Cardiocrinum giganteum* var. *yunnanense* • *Carpinus caroliniana* • *Carpinus tschonoskii* • *Carya cordiformis* • *Carya glabra* • *Carya myristiciformis* • *Carya ovata* • *Carya pallida* • *Carya tomentosa* • *Celtis tenuifolia* • *Cercidiphyllum japonicum* • *Cladrastis kentukea* • *Clethra tomentosa* • *Cornus bretschneideri* • *Cornus controversa* • *Cornus foemina* • *Corylus americana* • *Davidia involucrata* var. *involucrata* • *Deutzia longifolia* • *Enkianthus deflexus* • *Euonymus obovatus* • *Euptelea pleiosperma* • *Fagus engleriana* • *Fagus grandifolia* • *Fothergilla gardenii* • *Fraxinus americana* • *Fraxinus paxiana* • *Fraxinus pennsylvanica* • *Gordonia lasianthus* • *Hamamelis virginiana* • *Hydrangea bretschneideri* • *Hypericum fasciculatum* • *Hypericum prolificum* • *Hypericum tenuifolium* • *Ilex bioritsensis* • *Juglans nigra* • *Larix laricina* • *Larix mastersiana* • *Lilium leucanthum* • *Lilium regale* • *Liquidambar styraciflua* • *Maclura pomifera* • *Magnolia grandiflora* • *Magnolia sinensis* • *Magnolia wilsonii* • *Malus coronaria* • *Malus hupehensis* • *Malus ioensis* • *Menispermum canadense* • *Nyssa biflora* • *Opuntia humifusa* • *Osmanthus americanus* • *Ostrya virginiana* • *Persea palustris* • *Phoebe faberi* • *Physocarpus opulifolius* • *Pieris phillyreifolia* • *Pinus armandii* • *Pinus banksiana* • *Pinus palustris* • *Pinus resinosa* • *Pinus taeda* • *Polygonatum kingianum* • *Populus grandidentata* • *Populus tremuloides* • *Pterocarya macroptera* • *Quercus ellipsoidalis* • *Quercus macrocarpa* • *Quercus nigra* • *Quercus velutina* • *Rodgersia aesculifolia* • *Sassafras albidum* • *Schisandra chinensis* • *Stewartia malacodendron* • *Taxodium distichum* • *Tilia americana* • *Tilia americana* ssp. *caroliniana* • *Tilia chinensis* • *Trachelospermum difforme* • *Tsuga canadensis* • *Tsuga chinensis* • *Ulmus alata* • *Ulmus rubra* • *Vaccinium macrocarpon* • *Viburnum lentago* • *Viburnum rufidulum* • *Zanthoxylum americanum* • *Zenobia pulverulenta*

Expeditions Across the Temperate World

The Living Collections at the Arnold Arboretum are more than a just a beautiful assemblage of plants. They are also a living repository for research and conservation. In 2015, the Arnold Arboretum launched the Campaign for the Living Collections to increase the scientific and conservation value of the collections by broadening species and genetic diversity. The Campaign set an ambitious decade-long goal of acquiring some 400 taxa to add to the Arboretum landscape. Now in its third year, the Campaign drives the Arboretum's efforts in everything from collecting, to propagation, to providing the optimum conditions, care, and oversight for new plants and their place in one of Olmsted's finest landscapes.

Husks and nuts of American beech (*Fagus grandifolia*) collected during the fall 2017 Wisconsin expedition.

Wisconsin

Manager of Plant Records Kyle Port and Manager of Plant Production Tiffany Enzenbacher kicked off 2017's expedition season with a trip to Wisconsin in late August, traveling from the southeast of the state to the Door Peninsula in the north. Braving thickets, swampland, and mosquitoes, the pair trekked over Nature Conservancy reserves and pursued target plants from roadsides to the edges of corn and soybean fields. Only three species proved to be too elusive, two being *Fraxinus* (ash), whose populations are in decline due to the Emerald Ash Borer, an invasive pest decimating the genus across the continent. Fortunately, the team found a single green ash (*F. pennsylvanica*) bearing abundant seed in Sauk County.

The expedition broadened the representation of many species in the Living Collections, primarily by sourcing species along the edges or outer limits of their native ranges. Particularly rewarding collections included *Betula pumila* (bog birch), *Fagus grandifolia* (American beech), *Larix laricina* (eastern larch), *Menispermum canadense* (moonseed), and *Tsuga canadensis* (eastern hemlock).

Sichuan

In mid-September, the Arboretum joined the North America-China Plant Exploration Consortium (NACPEC) expedition into the wilds of northern Sichuan. With the help of local guides, Keeper of the Living Collections Michael Dosmann and Manager of Horticulture Andrew Gapinski made their way through steep mountains and deep river valleys, following the footsteps of famed explorer Ernest Henry Wilson. Tromping through bamboo thickets and eroding mountain paths, they were able to reach an ancient *Cercidiphyllum japonicum* (katsura) that Wilson famously photographed over a hundred years ago. They collected seeds and herbarium specimens of this tree, as well as their own versions of the Wilson photograph.

Negotiating treacherous landscapes and tons of terrestrial leeches, the team obtained five targeted species on the Arboretum's list of desiderata, including *Acer oliverianum* (Oliver's maple), *Davidia involucrata* (dovetree), the exceedingly rare *Fagus engleriana* (Chinese beech), and fragrant *Lilium regale* (regal lily), one of the plants most associated with Wilson's travels.

Left: E. H. Wilson photograph of three men in front of *Cercidiphyllum japonicum* (katsura) in 1910; Right: the scene recreated by (left to right) Kang Wang of the Bejing Botanical Garden, Michael Dosmann, and Andrew Gapinski, photographed by Jonathan Shaw of *Harvard Magazine* in 2017.

At top, a two-pound *Maclura pomifera* (Osage orange) fruit collected in Bentonville, Arkansas. Below, Arboretum explorers gathered seed of *Dirca decipiens* (Ozark leatherwood) at Lake Leatherwood in Eureka Springs, Arkansas.

Arkansas and Missouri

A third expedition took Living Collections Fellow Robert Dowell and Plant Growth Facilities Manager Kea Woodruff into the heart of the Ozark Mountains in Arkansas and Missouri in late September. Keeping an eye out for targeted species and armadillos, they navigated woodlands thick with poison ivy (the dominant understory plant) and venomous snakes.

An ongoing drought left many plants without seed, so root cuttings were collected for plants such as *Cladrastis kentukea* (American yellowwood), *Ulmus alata* (winged elm), and *Ulmus rubra* (slippery elm). Additional highlights included gathering the parachute-like fruits of *Aristolochia tomentosa* (woolly Dutchman's pipe) and gigantic, brainy fruits of *Maclura pomifera* (Osage orange).

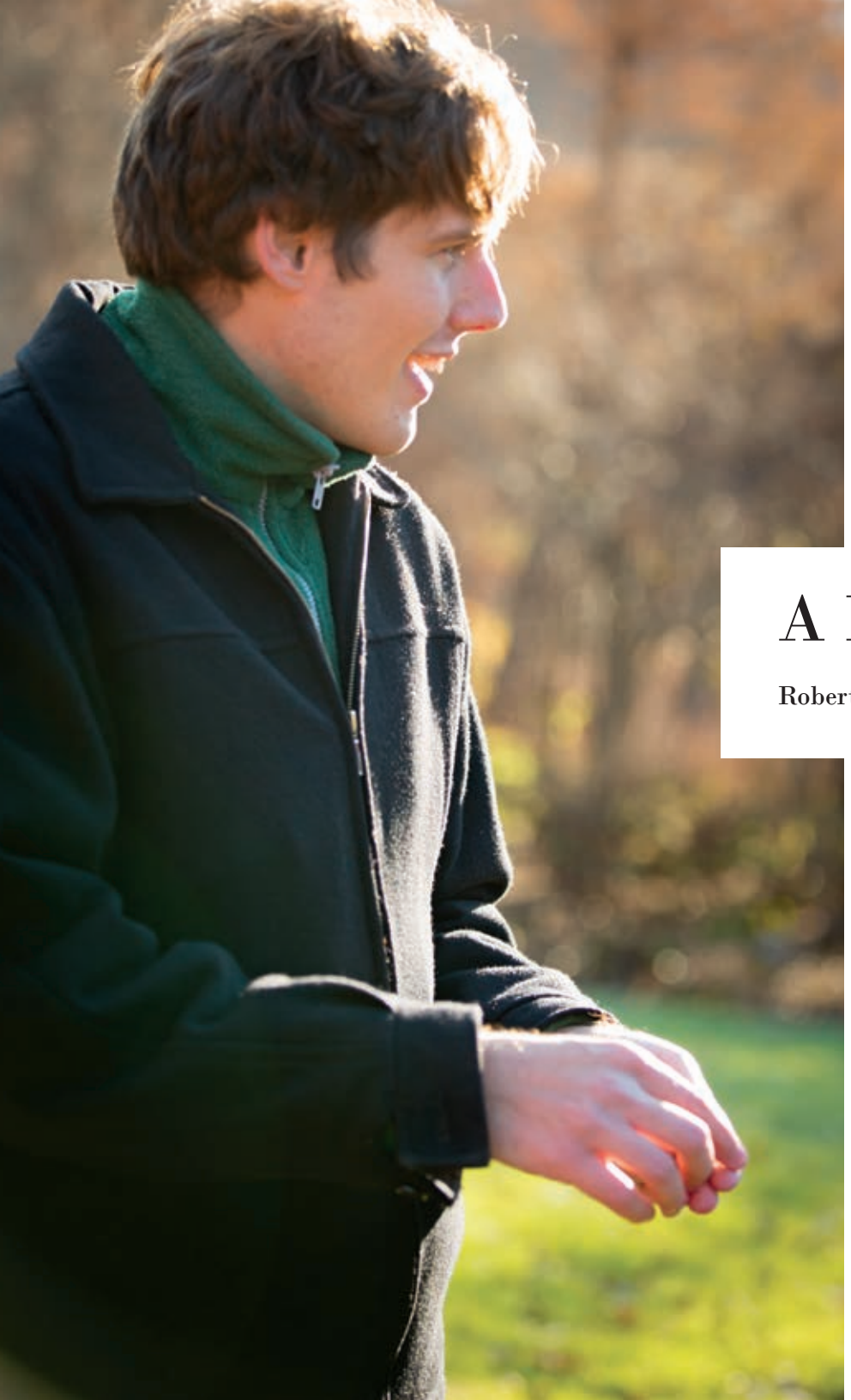
Despite the unyielding climate and swarming insect pests, the trip yielded a third of the species sought in the region, including *Celtis tenuifolia* (dwarf hackberry), an uncommon species previously represented at the Arboretum by a languishing sole accession (442-86*A).

North and South Carolina

Rounding out the expedition season, Living Collections Fellow Jenna Zukswert and Plant Propagator Sean Halloran headed for the coastal Southeast in mid October, where they joined representatives from five institutions (Polly Hill Arboretum, Mount Holyoke Botanic Garden, Morris Arboretum, Stoneleigh, and University of Delaware Botanic Gardens) in search of woody and herbaceous plants in the Carolinas.
The expedition started fortuitously with 12 collections on their first day in South Carolina, including the rare *Carya myristiciformis* (nutmeg hickory), *Callicarpa americana* (American beautyberry), and *Opuntia humifusa* (eastern prickly pear). In North Carolina, our explorers found two members of the tea family, *Stewartia malacodendron* (silky camellia) and *Gordonia lasianthus* (loblolly bay), as well as *Persea palustris* (swamp bay), a cousin of the common avocado.

The team waded through swamps, dodged snakes, and drove through inundated roads, aided by local forest experts. Luckily, no one encountered any alligators.

The expedition team that travelled through North and South Carolina.



LAUNCHING CAREERS

Living Collections Fellow Robert Dowell (2015 – 2017) supported significant initiatives in horticulture, curation, and plant production while working alongside leaders in the field. Following his fellowship tenure, Robert has taken a position at the Thomas Jefferson Center for Historic Plants at Monticello.

A Fellowship Like No Other

Robert Dowell, Living Collections Fellow

As a Living Collections Fellow I had the privilege to work closely with the Keeper of the Living Collections, Michael Dosmann, and the entire curation staff at the Arnold Arboretum. Primarily, I helped determine what taxa to collect for the Campaign for the Living Collections—and how, where, and when to do so. With the Arboretum's collection interests reaching as far afield as mountain ranges in western China and as close as our own backyard, my work involved detailed research into the native ranges of many species, pouring over hundreds of herbarium specimens to gather location details to shape collecting plans. Assembling this information revealed "hot spots"—areas where the target populations of many taxa under consideration overlap. These hot spots served as natural staging grounds for expeditions.

Living Collections Fellow Robert Dowell giving a Tree Mob™ on *Mespilus germanica* (medlar) in the Arboretum landscape.

As a result, I helped plan and organize expeditions for other Arboretum staff collectors, and I also led expeditions myself. In 2016 my colleagues and I ventured to the botanically diverse regions of the southern Appalachian mountains of Georgia, North Carolina, and Tennessee, where our team observed the rare *Buckleya distichophylla* (piratebush) in the wild. In 2017, we travelled to the Ozark Mountains of Arkansas and Missouri to collect *Dirca decipiens* (Ozark leatherwood) and *Cladrastis kentukea* (yellowwood) in their native habitats.

In my two years as a Fellow, I led weekend trips to local spots that served as field training exercises for our Isabella Welles Hunnewell Interns, to introduce them to expedition plant collecting at a scientifically-minded Arboretum.

Consulting with other collectors and documenting my own experiences organizing and leading expeditions, I compiled the *Arnold Arboretum Expedition Tool Kit* as a resource manual of academic and physical resources for expedition collectors. These resources include guidelines for designing digital storage repositories for investigative information, mapping potential collecting sites and using them to build a collecting itinerary, assembling and leading a team of collectors in the field, and maintaining the most accurate and comprehensive levels of documentation. Future collectors, both Arboretum staff and external collaborators, may leverage this blueprint to maximize their expedition success.

Producing the Next Generation of Plants

Nearly 200 seed accessions from expeditions were delivered to the Dana Greenhouses in 2017, where they set in motion a finely tuned propagation cycle. After recording each specimen or "lot," Plant Production staff separated and discarded fruit pulp, capsules, and other non-seed material that might harbor fungi, attract insects and rodents, or inhibit the seed from germinating.

Next, they assigned a tailored treatment to each species to break seed dormancy, such as cold stratification (a cold, moist period that mimics winter, typically 90 days at 36-38°F), both warm and cold stratification, or mechanical scarification (using sandpaper to penetrate

197

NEW SEED ACCESSIONS

363

PLANTS TRANSPLANTED TO THE PERMANENT COLLECTIONS

325

DISTRIBUTIONS TO OTHER BOTANICAL INSTITUTIONS

the seed coat). Many of the seeds from fall collections have already germinated, including *Betula alleghanensis* (yellow birch; Sauk County, Wisconsin), *Cercidiphyllum japonicum* (katsura; collected in Pingwu, Sichuan Province, China), and *Menispermum canadense* (moonseed; collected in Taney County, Missouri).

Once they are large enough to transplant, trees continue their progress in one of three long-term nurseries, and shrubs are potted in containers. From the time trees and shrubs enter the production facility as propagules, it takes anywhere from three to seven years before they are robust enough to be transplanted into the Arboretum landscape and begin their new life as part of the Living Collections.

With the Campaign for the Living Collections' third expedition season behind us and the Arboretum's sesquicentennial on the horizon, propagation lies at the forefront of our institutional focus. A meticulous documentation process, newly upgraded facilities, and dedicated and passionate Plant Production staff ensure success for the Arboretum's ambitious plans to expand and enhance the Living Collections.

Clockwise from bottom left: *Pinus armandii* (Armand pine) growing in the Dana Greenhouses; Manager of Plant Production Tiffany Enzenbacher; and Plant Propagator Sean Halloran.

STUDY

Availability and use of the investigative resources and extensive collections of the Arnold Arboretum support research across a broad array of disciplines, and provide a powerful platform for learning and scholarship.

Faculty Fellows of the Arnold Arboretum

THE FRIEDMAN LAB

The laboratory of William (Ned) Friedman, Arnold Professor of Organismic and Evolutionary Biology and Faculty Fellow of the Arnold Arboretum, primarily focuses on reconstructing the evolutionary origin and diversification of flowering plants, Darwin's so-called "abominable mystery." In 2017, the lab published work on embryo development in *Austrobaileya scandens*, an ancient flowering liana native to the rain forests of Australia. Work continued on the evolution of naked buds (overwintering buds that lack bud scales) in Juglandaceae (the walnut family).

New research focused on root development in *Isoetes* (quillworts) and double fertilization in conifers. Ned's graduate student Rebecca Povilus earned her PhD in Organismic and Evolutionary Biology in 2017 and started a postdoctoral position at MIT to continue her studies of the reproductive biology of plants. Her second dissertation chapter has been published in the prestigious *Proceedings of the Royal Society*.

THE WOLKOVICH LAB

One of the greatest challenges of our era will be to understand the effects of profound climate change on natural ecosystems. Researchers in the lab of Elizabeth Wolkovich, Assistant Professor of Organismic and Evolutionary Biology and Faculty Fellow of the Arnold Arboretum, have been studying how our changing climate impacts wine grape harvests, alters spring frosts, and affects trees that flower before they leaf out each spring.

Larger projects designed to understand and predict the timing for leaf-out of major tree and shrub species in New England forests also continue. In 2017, the lab planted more than a dozen species next to Weld Hill for long-term study—grown from seeds collected at study sites from Harvard Forest to the temperate-boreal biome boundary in Quebec. Work on making future projections for wine growing regions also progressed, with a new paper published in *Nature Climate Change* in early 2018.

Director of Research Facilitation Faye Rosin (top) and Jacob Suissa (below), a PHD candidate in the Friedman Lab and a Fellow of the Arnold Arboretum.

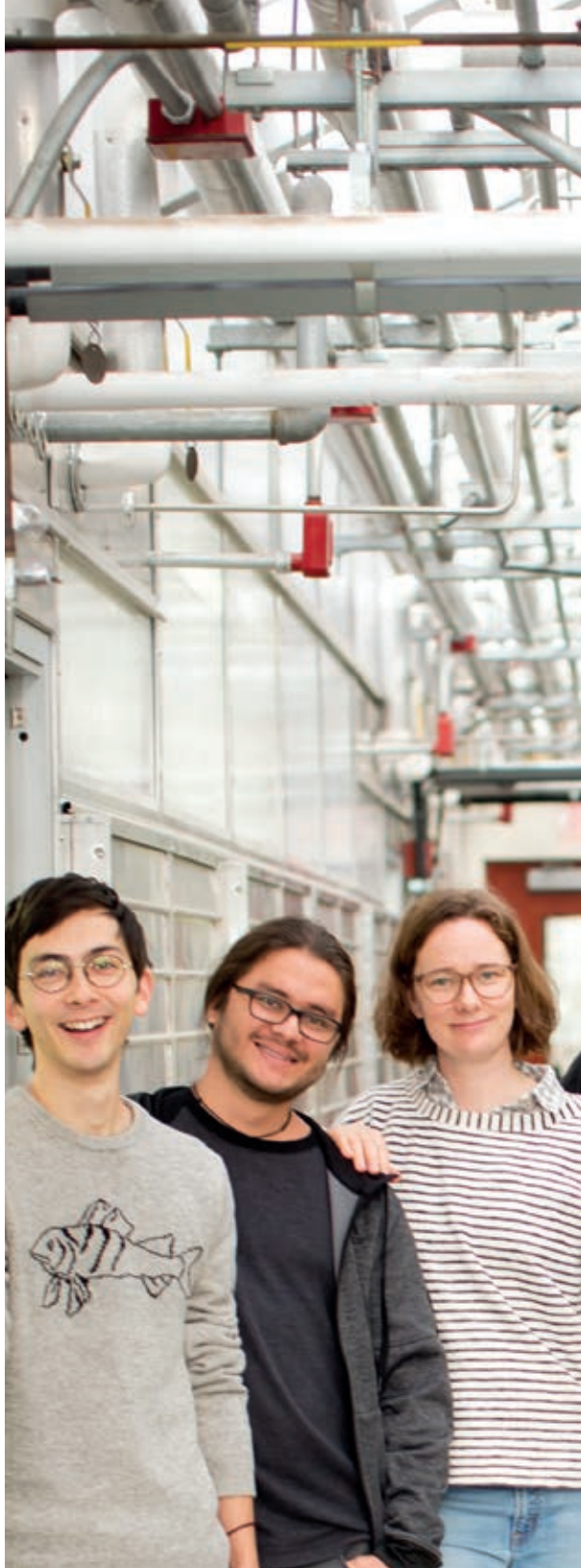
Faculty Fellows lead Arboretum-based research, mentor students and teach courses, and engage the public in science.

THE HOLBROOK LAB

Although scientists have long understood how sugars move in small herbaceous plants, less is known about how larger plants like trees handle sugar transport. Scholarship in the lab of N. Michele Holbrook, Professor of Organismic and Evolutionary Biology at Harvard University and Faculty Fellow of the Arnold Arboretum, focuses on the comparative physiology of woody plants. In 2017, scientists in the lab quantified how sugar-transporting vessels become wider and longer as trees increase in size. Their analysis reaffirmed a 1930 hypothesis by Ernst Munch that the pressure needed to drive sugar-rich sap to the roots is nearly independent of the transport distance.

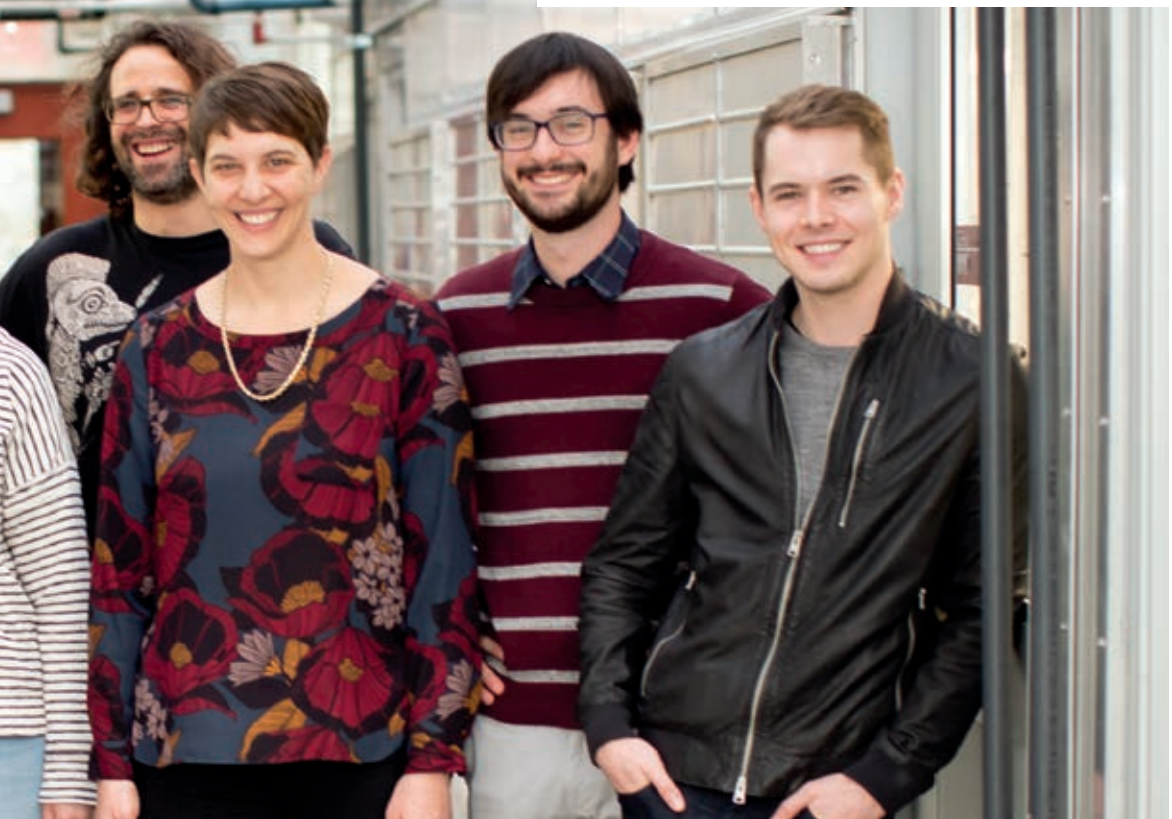
THE ELKIN GROUP

Rosetta Elkin, Assistant Professor of Landscape Architecture at Harvard University's Graduate School of Design and a Faculty Fellow at the Arnold Arboretum, developed a series of initiatives to elucidate how plants are used in sustainable landscape design. She examined plant behavior in varied conditions rather than isolated sites, including *Populus* spp. (poplars) in the desert biomes of Western China, *Acacia* spp. (wattles) in the grasslands of Colonial Africa, and *Rhizophora* spp. (mangroves) in the intertidal zones of America. In 2017, Elkin's study on the pine forests of Italy was awarded the American Academy Prize, taking her to Rome to pursue additional fieldwork.



THE HOPKINS LAB

Research in the laboratory of Robin Hopkins, Assistant Professor of Organismic and Evolutionary Biology and Faculty Fellow of the Arnold Arboretum, investigates how biological diversity evolves in plants. The lab uses field experiments, genetics, molecular biology, and controlled growth experiments to understand how and why populations and species adapt. Their research spans a variety of topics from the ecology of plant-pollinator interactions, to the genetic basis of adaptation, to the evolution of new species. In 2017, the Hopkins Lab's investigations included how plants choose mates through complex biochemical interactions between pollen and pistils, how hybridization between species can generate new plants diversity, how hybrids can also be maladaptive relative to their parental plant species, and how plants alter their pollinator reward in response to environmental stress.



Members of the Hopkins Lab include (left to right) Ben Goulet, Y. Franchesco Molina-Henao, Shayla Salzman, Federico Roda, Robin Hopkins, Matt Farnitano, and Austin Garner.

DaRin Butz Interns Class of 2017 (from left to right): Juliet Bramante, Asa Peters, Sruti Pandey, Ashley Bang, Jack Smith, Vivien Chen, Jessica Leslie, and Emily Rosa.

Undergrads Pursue Science

With its state-of-the-art research center at Weld Hill recognized as a focal point for plant biology at Harvard University, the Arnold Arboretum has taken significant steps in recent years to expand learning and research opportunities for undergraduates at Harvard University and beyond. The working groups of five Harvard faculty—along with numerous research associates, graduate students, postdoctoral researchers, and fellowship and awards recipients—comprise an enriching intellectual ecosystem for students interested in pursuing scientific study. With the establishment of a new research internship program last year, the Arboretum is committed to advancing opportunities for individuals pursuing careers in everything from investigative science to environmental policy and law.

In collaboration with the DaRin Butz Foundation, the Arboretum established the DaRin Butz Foundation Research Internship Program at the Arnold Arboretum. Over ten weeks last summer, eight future scientists from six universities took

their first steps in exploring research and scholarship as a career path.

Combining academic learning, practical training, and one-on-one mentoring, the program offers participants a robust and well-rounded introduction to research methods, directions, and careers. Each intern worked closely with an advisor, learning about the research interests of their laboratory and developing an independent research project of their own. Interns gained valuable experience conducting research, writing a research proposal, giving an oral presentation, and participating in a research symposium.

Under the guidance of Director of Research Facilitation Faye Rosin, our DaRin Butz interns also participated in a number of coordinated activities to increase their familiarity with the work, methods, and career opportunities of contemporary scientists. Each week, the interns participated in a journal club to increase their exposure to primary scientific literature and encourage discussion and debate.

Guest speakers representing a diversity of fields shared insights on their work to promote discussion and highlight career directions. The program also took full advantage of the Living Collections and the historical landscape to orient students to the Arboretum as a botanical institution and center for the study and understanding of woody plants at Harvard University.

The DaRin Butz Foundation Research Internship Program shares the primary goal of our flagship horticultural training program—the Isabella Welles Hunnewell Internship—in establishing a strong foundation for students to prepare for their future. By focusing on climate and the environment, the program goes a step further in promoting a better future for us all. To help our nation come to grips with the many challenges facing our planet, the Arboretum is committed to building capacity in the scientific community in the increasingly complex and interdisciplinary fields of climate change research, ecology, and plant biology.

Through this exciting and engaging channel for research and education, the Arboretum hopes to inspire a new generation of scientists devoted to investigating our environment, exploring biodiversity, and sharing discoveries with the public.

Interns enjoy many learning opportunities, including guided tours with Editor of *Arnoldia* Nancy Rose, pictured below.

Arnold Arboretum-Funded Research Fellowships & Awards

KATHARINE H. PUTNAM FELLOWSHIP IN PLANT SCIENCE

Elizabeth Spriggs
Putnam Fellow, Arnold Arboretum

Research: Examining genetic diversity and population structure of chestnuts and ashes (*Castanea* and *Fraxinus*) in relation to disease with an eye towards identifying individuals of conservation value

Kasia Ziemińska
Putnam Fellow, Arnold Arboretum

Research: The role of fibers and parenchyma in tree hydraulics and how wood anatomy impacts water storage

SARGENT AWARD

Michael Dietrich, Professor, Dartmouth College and **Scott Dietrich**, Co-Curator, Hong Kong Stair Archive

Research: The photography of Ernest Henry Wilson

David Basler
Postdoctoral Fellow, Harvard University, Richardson Lab

Research: Examining the relationship between plant phenology and genetic adaptation, utilizing an unmanned aerial vehicle (drone) to acquire high-resolution multispectral photographs of the Arboretum over time

ASHTON AWARD FOR STUDENT RESEARCH

Agusti Randi
Master's Student, Bagor Agricultural University, Indonesia

Research: The taxonomy, ecology and conservation of wild palms (genus *Pinanga*) in Indonesian Borneo

Stephanie Schmiege
PhD Student, Columbia University

Research: The response of conifers to stressful environmental conditions, particularly drought caused by climate change

SINNOTT AWARD

Margaret Kosmala
Postdoctoral Fellow, Harvard University, Richardson Lab

Research: The relationship between plant phenology and genetic adaptation, utilizing localized temperatures of the Arboretum over time

Jessica Savage
Assistant Professor, University of Minnesota

Research: Examining the relationship between the reactivation of water transport in the spring and plant phenology or life events such as flowering or leaf out

ARNOLD ARBORETUM GENOMIC INITIATIVE AND SEQUENCING AWARD

Aureliano Bombarely, Assistant Professor at Virginia Tech, and **Jose I. Hormaza**, Professor at IHSM La Mayora in Spain

Research: Sequencing the *Asimina triloba* (L.) Dun. (Annonaceae) genome of accession 12708*A, the oldest representative of this species in the Living Collections

Susan Strickler, Research Associate; **Fay-Wei Li,** Assistant Professor; and **Eric Richards**, Professor and VP research of Boyce Thompson Institute (BTI)

Research: Developing genomic resources for North American beech *(Fagus grandifolia)* to investigate the genetic markers for insect resistance

2017 Sinnott Awardee Jessica Savage collects tissue samples in the field.

Revealing the Science of Spring

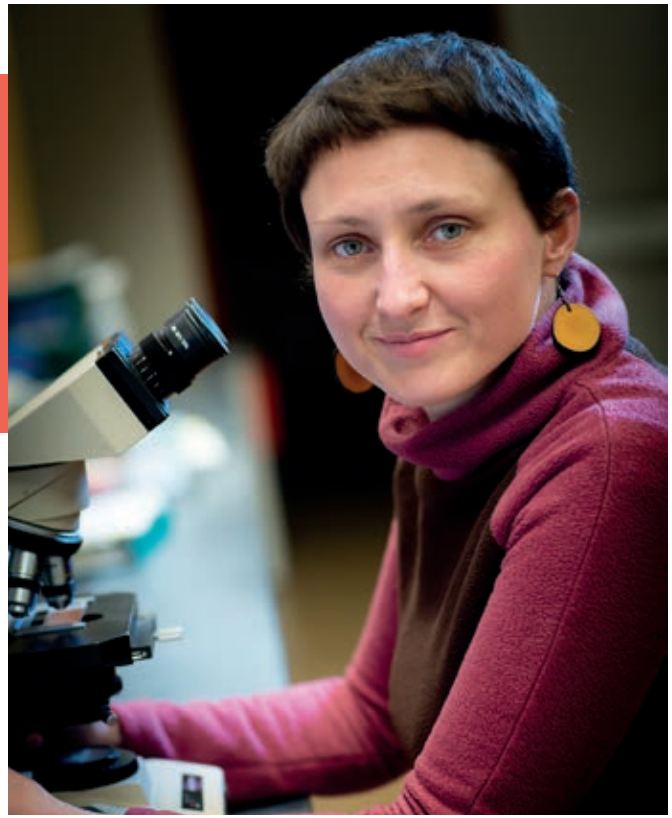
With the timing of seasonal temperatures in flux, scientists are adding to the growing evidence that suggests that our natural world's reaction to climate change varies by species. While some species leaf out early, others continue to leaf out late despite warmer spring temperatures. It remains largely unknown why there is this large variation in how plants respond to higher temperatures. Through the Arnold Arboretum's generous programs of fellowships and awards, scientists return to the Living Collections again and again to find out the answers.

First as a Putnam Fellow and more recently as a 2017 Sinnott Awardee, Jessica Savage has conducted research on spring vascular reactivation at the Arboretum, investigating whether variation among species in the timing of leaf out is tied to differences in their vascular tissue, specifically their wood anatomy.

Using the vast Living Collections, Jessica obtained data on the timing of leaf out from 50 different species. Analysis with the Arboretum's data on wood anatomy for the same plants collected during the same year will provide a robust dataset for examining whether there is a relationship between wood anatomy and leaf out time across species.

Conducting this study at the Arboretum opened new opportunities for collaboration and enabled Jessica to collect samples of diverse flora grown under similar climatic conditions. Starting as an assistant professor at the University of Minnesota–Duluth, Jessica hopes to build on her work at the Arboretum and uncover how seasonal changes impact the timing of growth and development in woody plant species.

What Helps Some Trees Store Water?



Putnam Fellow Kasia Ziemińska.

As global conditions continue to transform through climate change, scientists are seeking out and studying plants that can handle higher temperatures and drought, as they are more likely to survive a rapidly changing environment. As a Katharine H. Putnam Research Fellow, Kasia Ziemińska studies how plants buffer themselves from drought. Her tasks range from examining twigs under a bright-field light microscope inside the Weld Hill Research Building to working outside on 17-hour days gathering information from the Living Collections.

In 2017, Kasia investigated the structures and functions by which plants store and use water, and how those mechanisms differ across species. She measured the water content in twigs of 30 species in the Arboretum landscape and theorizes that some anatomical traits may be related to water storage.

Kasia was assisted by 2017 DaRin Butz Foundation Research Intern Emily Rosa, currently a senior at Sonoma University. (Read more about the DaRin Butz internship program on page 18.) Collaborating with Emily improved data analysis and gave Kasia the opportunity to give back in supporting another woman's career aspirations in science.

Kasia will continue to study how the relationship between tree anatomy and function shapes the diversity of plants and their ecological strategies. As a Putnam Fellow, Kasia has drawn knowledge and inspiration from researchers, staff, and associates in the Arboretum community, and has in turn contributed to this ecosystem of learning through her own writing and teaching.

The bark and outermost tissue is removed from a birch (*Betula* sp.) in the Larz Anderson Bonsai & Penjing Collection as the first step in air-layering. With the help of added hormones, the plant will eventually form root cells from the stem, allowing propagators to remove this part and repot the successful new clone.

Air Layering:

Borrowing from the Past

The Arnold Arboretum holds a world-class collection of maples (*Acer* spp.), considered among the most significant stewards of the genus for conservation purposes worldwide. Among some 60 species in the Arboretum, *A. yangbiense* stands out as perhaps the most endangered maple in the world. Known only to occur in a single locality in northwestern Yunnan Province, China, the tree resists all attempts at repropagation by conventional means like grafting or root cutting. Represented by just two individuals in fair condition at the Arboretum, greenhouse staff were faced with the seemingly impossible challenge of coaxing viable offspring from them.

The air layering project began in an attempt to propagate and save a rare maple, *Acer yangbiense*.

Fortunately, the Arboretum's plant propagation and care records date back more than a century, and sometimes exploring practices of the past can open pathways to innovation—and success. Robert Dowell (Living Collections Fellow 2015-2017) and Sean Halloran (Plant Propagator) researched experiments undertaken nearly seven decades ago by famed Arboretum horticulturist Donald Wyman on an age-old asexual propagation technique called air layering. More than just a tool to propagate plants, the practice embraces the Arboretum's rich history and offers a window into plant production and *ex situ* plant propagation.

Air layering derives from the simple yet effective propagation practice of layering: burying a plant stem in soil to encourage the development of roots. Instead of rooting occurring below ground, however, it occurs above ground on a branch. A girdle is cut around the branch and treated with a rooting hormone. Then a ball of peat moss is wrapped around the girdle and enveloped in plastic. The plastic locks in moisture around the peat moss, which serves the role of soil and creates a suitable environment for root development. The largest investment in this procedure is time, mostly spent creating all of the air layers and ensuring that moisture levels remain high during a hot summer. Once the layer is rooted, it can be removed from the parent plant, potted, and cared for like any other containerized plant.

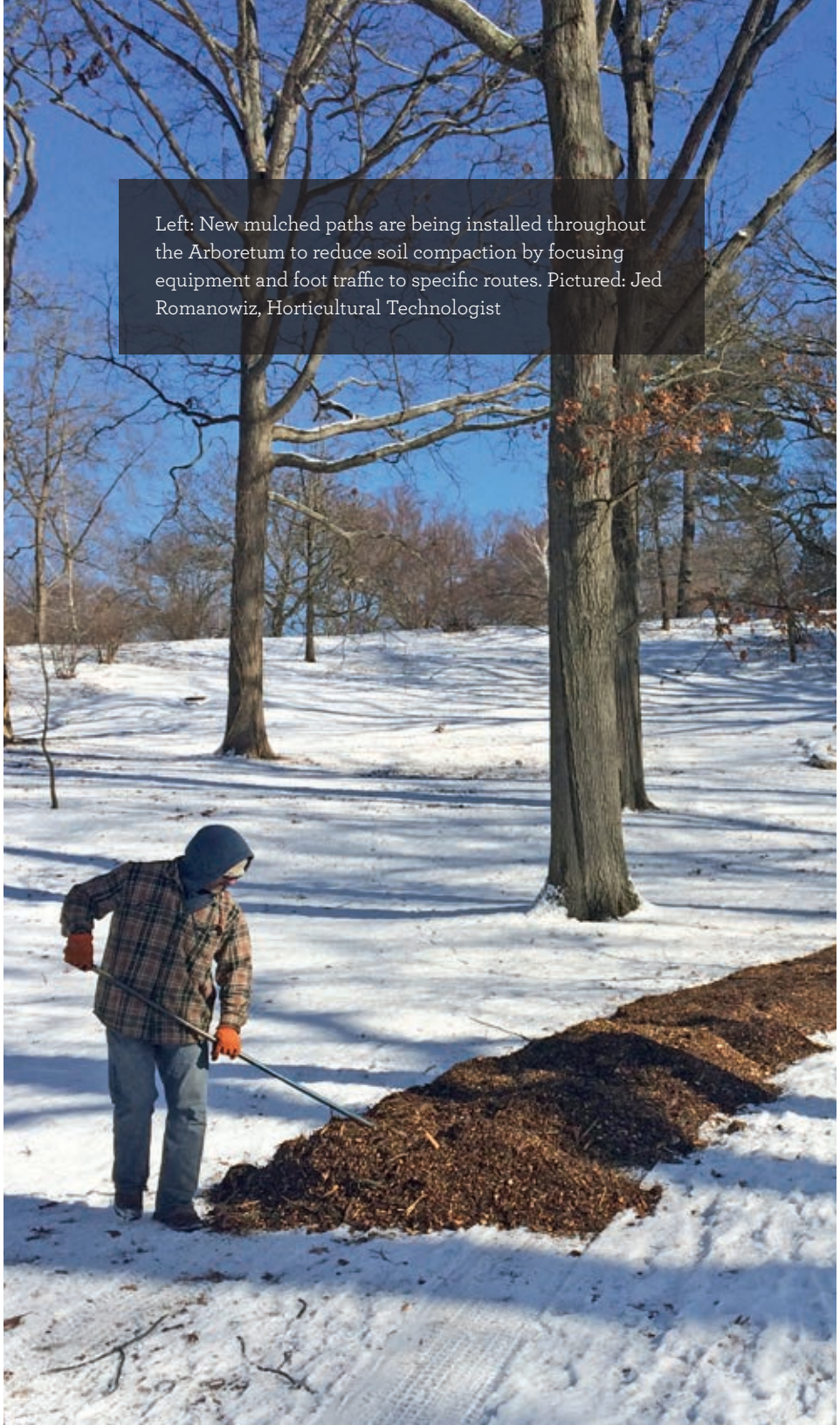
In October 1951, Wyman detailed a series of propagation experiments conducted on the Arboretum grounds in *Arnoldia*. That summer, air layers were installed on 250 species at the Arboretum. Robert and Sean focused their experiments on *A. yangbiense* and its close but more common relatives, which they presumed would demonstrate similar responses to propagation regimes. Six individuals each of *Acer diabolicum* (devil maple), *Acer sterculiaceum* ssp. *franchetii* (Franchet's maple), and *Acer pilosum* (stencilled maple) were selected for testing, and 55 air layers were installed in late May and early June 2017. Eight of these developed roots and were potted by December. Robert also expanded the pilot experiment to several coniferous species and one *Tilia* (linden) species.

While the results were inconclusive—and staff still hope to demonstrate proof of concept for propagation of *A. yangbiense*—air layering experiments will continue in coming years across additional genera. Identifying successful propagation protocols for rare and endangered plants in the Arboretum collections continues to be critical to their preservation for scientific study and conservation—and even bygone solutions can have new currency in getting nature to cooperate.

STEWARD

The Arboretum is committed to excellence in plant cultivation, preservation, and display. In 2017, the Horticulture Department (pictured right) planted 378 accessions of trees, shrubs, and lianas belonging to the 136 taxa listed on the next page. Plants in orange carry a national or international conservation status.

Abies balsamea • *Abies forrestii* • *Abies pindrow* • *Abies sachalinensis* var. *sachalinensis* • *Acer ceriferum* • *Acer erianthum* • *Acer japonicum* 'Green Cascade' • *Acer* sp. • *Amelanchier bartramiana* • *Arctostaphylos uva-ursi* • *Betula nigra* • *Betula pubescens* • *Campsis radicans* 'Judy' • *Carex amphibola* • *Carex pensylvanica* • *Carya* aff. *pallida* • *Carya illinoinensis* • *Carya ovata* • *Castanea pumila* var. *ozarkensis* • *Cedrus deodara* • *Cercis canadensis* • *Clematis virginiana* • *Cocculus carolinus* • *Cornus canadensis* • *Cornus florida* • *Cornus rugosa* • *Corydalis sempervirens* • *Corylopsis gotoana* • *Corylopsis sinensis* var. *sinensis* • *Crataegus viridis* 'Winter King' • *Dioscorea villosa* • *Eurya japonica* • *Fagus grandifolia* • *Fraxinus americana* • *Fraxinus bungeana* • *Fraxinus chinensis* • *Fraxinus chinensis* ssp. *rhynchophylla* • *Fraxinus paxiana* • *Gaylussacia baccata* • *Hamamelis japonica* 'Shibamichi Red' • *Hamamelis mollis* • *Hieracium scabrum* • *Hydrangea bretschneideri* • *Hypericum* 'Hidcote' • *Hypericum hypericoides* ssp. *hypericoides* • *Hypericum prolificum* • *Ilex crenata* 'Green Dragon' • *Ionactis linariifolia* • *Itea virginica* • *Lindera benzoin* • *Linnaea borealis* ssp. *americana* • *Liquidambar acalycina* • *Magnolia* 'Cairn Croft' × *Magnolia* 'Satellite' • *Magnolia* (undetermined hybrid) • *Magnolia acuminata* • *Magnolia wilsonii* • *Mahonia repens* • *Malus* 'Donald Wyman' • *Malus* 'Mary Potter' • *Malus sieboldii* • *Malus toringoides* • *Malus zhaojiaoensis* • *Monarda didyma* • *Nyssa biflora* • *Paeonia lactiflora* 'Duchesse de Nemours' • *Parrotia persica* • *Persea palustris* • *Persicaria careyi* • *Philadelphus pubescens* • *Physocarpus opulifolius* • *Pieris* 'Brouwer's Beauty' • *Pinus banksiana* • *Pinus cembra* • *Pinus wallichiana* • *Planera aquatica* • *Prunus hortulana* • *Prunus pumila* var. *depressa* 'Gus Mehlquist' • *Prunus serotina* • *Pycnanthemum muticum* • *Pyrus pyrifolia* • *Quercus alba* • *Quercus marilandica* • *Quercus montana* • *Quercus virginiana* • *Quercus* × *comptonae* • *Rhododendron arborescens* • *Rhododendron minus* • *Rhododendron periclymenoides* • *Rhododendron purdomii* • *Rhus aromatica* 'Gro-low' • *Robinia hispida* • *Rosa* 'Justine Mee Liff' • *Rosa* 'KORwest' • *Rosa* 'Mister Lincoln' • *Sequoiadendron giganteum* 'Idaho Endurance' • *Sericocarpus asteroides* • *Sericocarpus linifolius* • *Smilax rotundifolia* • *Spartina pectinata* • *Spiraea japonica* • *Stewartia malacodendron* • *Stewartia ovata* • *Symphyotrichum novi-belgii* • *Syringa* 'Betsy Ross' • *Syringa komarowii* • *Syringa laciniata* × *pinnatifolia* • *Syringa oblata* ssp. *dilatata* • *Syringa patula* 'JN Upright Select' • *Syringa patula* 'Pink Flower Select' • *Syringa pekinensis* 'Morton' • *Syringa pekinensis* 'Rising Sun' • *Syringa pubescens* ssp. *microphylla* • *Syringa vulgaris* 'Atheline Wilbur' • *Syringa vulgaris* 'Blue Delft' • *Syringa vulgaris* 'Dana Horton' • *Syringa vulgaris* 'Frederick Law Olmsted' • *Syringa vulgaris* 'Gertrude Child' • *Syringa vulgaris* 'Kate Bergen' • *Syringa vulgaris* 'Lee Jewitt Walker' • *Syringa vulgaris* 'Lesostepnaya' • *Syringa vulgaris* 'Prairie Petite' • *Syringa vulgaris* 'President Lincoln' • *Syringa vulgaris* 'Prof. Josef Brzezinski' • *Syringa vulgaris* 'Ukraina' • *Syringa vulgaris* 'Valentina Grizodubova' • *Syringa vulgaris* 'Vera Khoruzhaya' • *Syringa vulgaris* 'Znamya Lenina' • *Syringa* × *hyacinthiflora* 'Mary Short' • *Syringa* × *hyacinthiflora* 'Rowancroft Pink' • *Taxus canadensis* • *Taxus chinensis* • *Tsuga canadensis* • *Tsuga caroliniana* • *Zanthoxylum americanum* • × *Amelasorbus jackii* • × *Chitalpa* hybrid



Left: New mulched paths are being installed throughout the Arboretum to reduce soil compaction by focusing equipment and foot traffic to specific routes. Pictured: Jed Romanowiz, Horticultural Technologist

Ground for Improvement:

Soil Management

Across its 281-acres, the Arnold Arboretum is being prepared to receive a surge of new plant material as part of the Campaign for the Living Collections. Successful establishment of new accessions and care of the Arboretum's 15,000 existing specimens requires a dedicated team of highly skilled horticulture professionals involved in activities ranging from site selection and planting, to routine and structural pruning, to addressing issues affecting our plants as part of the Arboretum's holistic Plant Health Care (PHC) program. As a key PHC component, the Horticulture Department launched a soil health initiative to better understand current soil conditions across the Arboretum landscape and to inform future management decisions. This year's Living Collections Fellow played an integral role in coordinating these initiatives, helping form a Soils Advisory Committee, leading a landscape-wide soil survey, and collaborating with the U.S. Forest Service on a study to investigate plant nutrient uptake in the landscape.

In February 2017, our Soils Advisory Committee held its first annual meeting, with seven external members representing academia, public gardens, and government agencies. Committee members include Thomas Akin (U.S. Department of Agriculture), Scott Bailey (U.S. Forest Service), Serita Frey (University of New Hampshire), David Foster (Harvard Forest), Cindy Prescott (University of British Columbia), Casey Sclar (American Public Gardens Association), and Brandon Smith (U.S. Department of Agriculture). These specialists brought insights from each of their disciplines including agricultural soils and agronomy, forest soil ecology and management, geology, entomology, and composting systems. The recommendations set forth by the committee spurred an ambitious set of initiatives for 2017.

Initial work began with the completion of a robust, landscape-wide soil survey. Samples were drawn from 120 areas based on existing USDA Soil Classification Survey maps, topography, and the various collections or plant groupings in the Arboretum. Samples from each area of the organic topsoil (A horizon) and mineral soil beneath (B horizon) were sent to the University of Massachusetts for nutrient and organic matter analyses. These data are now stored in the Arboretum's mapping database (ArcGIS) and provide a solid baseline of the condition of our soils for committee review and to inform action steps moving forward. With soil nutrient data in hand, efforts turned to addressing questions about plant nutrient uptake and factors affecting this process. Scott Bailey collaborated with Richard Hallett (U.S. Forest Service Research Ecologist) to launch a research project investigating relationships between foliar nutrient levels and soil quality across the Arboretum.

This research focuses on *Acer saccharum* (sugar maple), *Tsuga canadensis* (eastern hemlock), and *Quercus alba* (white oak), three species growing in abundance in a variety of management regimes. In addition to collecting foliar samples from these trees, staff completed basic tree health assessments and measured chlorophyll fluorescence (an indicator of the level of photosynthetic activity) as a tool for early detection of plant decline. Measurements taken from more than a thousand trees in urban areas across the United States will allow us to compare the health of our trees and environmental impacts with those in other urban areas.

An important component of the Arboretum's Soil Heath Initiative is a review of maintenance practices including the development of a more effective composting system and implementing measures to reduce soil compaction. In order to improve the use of "greenwaste" materials and add more organic matter and nutrients to the soil, staff revamped the existing compost system in 2017 and created new protocols. To reduce the impact of equipment and foot traffic that lead to soil compaction—and thus reduced root growth in trees—new mulched paths were installed throughout the landscape. The 2017 Hunnewell Horticultural Interns also contributed to the soils initiative with a group project on the Arboretum's herbaceous layer, surveying the composition of the forest floor in the linden (*Tilia* spp.) and beech (*Fagus* spp.) collections.

With a solid baseline of information gathered on Arboretum soils across the landscape in 2017, Horticulture staff will continue to work with the experts of the Soils Advisory Committee toward improved care and oversight of our growing collection.

Living Collections

2,139 SPECIES

representing
3,812
TAXA*

belonging to
10,857
ACCESSIONS**

15,740
INDIVIDUAL PLANTS
(including nursery)

Herbaria

122,297
SPECIMENS in the Herbarium of Cultivated Plants at the Arnold Arboretum

1.5 million
SPECIMENS in the Harvard University Herbaria

Horticultural Library

26,991
BOOKS AND SERIALS

66,000
PHOTOGRAPHS AND VIDEOS

350
ARCHIVAL COLLECTIONS

*Includes plant species, subspecies, varieties, formae, cultivars, and hybrids
**A plant (or plants) of one name obtained from one location on a given date through one mode of propagation

TAKING INVENTORY

Kyle Port, Manager of Plant Records (left), has personally visited every single tree, shrub, and liana in the Living Collections (more than 15,000 plants) in rotation every five years over the past decade. Here, he prepares to collect data in the field with Curatorial Assistant Matt McDermitt.

Reflections From the Field

Kyle Port, Manager of Plant Records

In the days leading up to the 2017 summer solstice, curatorial staff were poised to document an unprecedented flowering event—never before had the inflorescence of *Cardiocrinum giganteum* var. *yunnanese* (Himalayan lily) graced the Arboretum landscape. For over a year, the Explorers Garden microclimate, soil, and its horticulturist nurtured three plants. Originating from the Taibai Mountain National Forest Park in Shaanxi Province, China, these North America-China Plant Exploration Consortium propagules held great promise. As two flower buds developed, a vigil commenced.

Beneath the dappled shade of our *Heptacodium* (seven son flower) Collection, a pioneering ant led an army through

Beneath the branches of E.H. Wilson's inaugural introduction of *Acer griseum* (paperbark maple, 12488*B) to North America, Manager of Plant Records Kyle Port (left) and Curatorial Assistant Matt McDermitt (right) adjust a records label. Commencing in the spring and ending in the fall, annual inventory work is comprised of mapping, labeling, and recording plant health observations.

For the first time in our history, *Cardiocrinum giganteum* var. *yunnanense* flowers graced the Explorers Garden.

coarse mulch to Himalayan lily, accession 310-2015*C. The seemingly unbroken line of insects traced the length of the lily's meter-long stem, then fanned out across each unopened flower. In trade for surveillance, the lily would serve nectar to its defenders, albeit too late to assuage the slug herbivory suffered by its heart-shaped leaves. Within two days, on June 13, five of six flowers opened and the ants took leave. Open flowers revealed vivid red-purple streaks at the base of each tepal and emitted an exhilarating scent. Four months and ten days later, seeds were gathered from the lily's capsule. Held by our propagator under ideal conditions at the Dana Greenhouses, these next generation seeds will be sown in April 2018.

New species sited in our permanent collections typically receive a higher frequency of field checks during their establishment years. Even so, curatorial staff visit each plant on a regular inventory schedule. Beginning in spring and ending in fall, a fifth of the Living Collections are inventoried annually. Over five years, the health and performance of the more than 15,000 accessioned plants at the Arboretum are databased, plant labels are adjusted, and maps depicting plant locations are verified.

At the conclusion of field work, the inventory team meets with the horticulturist assigned to each zone (garden area) and Living Collections managers to share curatorial insights and discuss management regimes. While Explorers Garden plants received considerable attention in 2017, additional Bussey Hill landscapes were also inventoried and subsequently improved. From the thinning of unaccessioned *Rhododendron calendulaceum* (flame azalea) under the oaks along Valley Road to the refinement of *Kalmia latifolia* (mountain laurel) boundaries near South Street gate, each orchestrated horticultural renovation improved viewsheds and access while opening planting space for new accessions.

The abundance of data gleaned from the Living Collections in 2017 frame a storytelling pallet unrivaled in New England. Undoubtedly, the next first-of-its-kind event is a mere observation away.

Where Are They Now?

Ninety-nine years ago, Arboretum plant explorer John George Jack (1861-1949) first introduced *Linnaea borealis* (twinflower) and *Cornus canadensis* (creeping dogwood) to the Arnold Arboretum. Dug in the fall of 1919 from the Alpine Garden on New Hampshire's Mt. Washington, these groundcovers were reared in the Arboretum's greenhouses for a year then transplanted to the Rockery alongside Valley Road. By 1925, proof of their survival tapered off, yet not the desire to domesticate each one.

Up to the present-day, 7 accessions (4 plants) of twinflower and 20 accessions (20 plants) of creeping dogwood have been trialed at the Arboretum. All have perished except for recent acquisitions collected by Arboretum staff in northern Idaho in 2015. While scouting for cones amid majestic conifers, these remarkable groundcovers came into view.

Not far from the scenic shore of Lake Pend Oreille, Idaho's largest body of water, a team of botanists and naturalists led by Manager of Plant Records Kyle Port made their first collections of the 2015 North Idaho Expedition: *Pseudotsuga menziesii* (Douglas fir). A specimen loaded with cones beckoned the team to break trail, though the approach to its massive trunk was difficult due to dense

Thoughtful siting and expert horticultural care improve our chances of establishing twinflower and creeping dogwood.

underbrush. After considerable discussion and dozens of yards of clambering, the understory opened and another magnificent Douglas fir lay tipped before them. To their delight, the mound and pit around the upturned roots hosted both twinflower and creeping dogwood, which are often found growing together in montane habitats across the Northern Hemisphere. Glacial soils accepted a trowel easily and the group lifted and bagged plants of each species. With additional documentation (photographs, herbarium specimens, and notes) compiled, a red squirrel's call of "chickaree! chickaree!" coaxed the intrepid explorers away. Several cone caches later, they reached the Douglas fir earmarked from trailside, and a third collection was made.

In 2017, after a hiatus from the permanent collections, twinflower and creeping dogwood were planted in the raised bed paralleling Chinese Path in our Explorers Garden. Establishment of delicate groundcover species can prove a challenge. However, robust nursery stock coupled with thoughtful siting and expert horticultural care will improve the chances of establishing twinflower and creeping dogwood for generations of scientists to study and Arboretum visitors to admire.

Left: *Linnaea borealis* (twinflower) and *Cornus canadensis* (creeping dogwood) growing on the forest floor in Farragut State Park, Coeur d'Alene Mountains, Idaho; Right: Wild-collected *Cornus canadensis* in the Dana Greenhouses, where it will grow until mature enough to be planted in the landscape.

In 2017, only one snakebark maple from the original Sargent lineage remained. When snowfall reached 11 inches, the esteemed Sargent lineage was in danger.

Graft unions placed across a hot-callusing pipe at the Dana Greenhouses.

Safeguarding a Valuable Lineage

Although the Plant Production team's work germinating wild-collected seed plays a central role in bringing new germplasm to the Living Collections, the critical work of replicating existing accessions through clonal propagation renews historically important germplasm. The Dana Greenhouses' specialized facilities enable several techniques, including rooting cuttings and grafting, aimed at reproducing progeny plants identical in genotype to a source plant.

While working in the landscape, staff of the Living Collections Departments identify plants that are struggling due to biotic issues (pests, disease-causing pathogens, animal damage, or vandalism) or abiotic issues (storm or wind damage, soil compaction, or nutrient problems). Currently, 170 accessions with special histories are on the repropagation list due to their decline in recent years. These include type specimens (individuals selected to serve as a reference when a taxon is first described); taxa introduced by the Arnold Arboretum; species that are rare in cultivation; and historic lineages with special meaning to the Arboretum, such as collections made by

Founding Director Charles Sprague Sargent or famed plant explorer Ernest Henry Wilson. Plant Production staff prioritize the list by significance and plant health. They determine the most effective propagation protocol by researching past attempts, consulting articles and scientific literature, and collaborating with colleagues both near and far afield.

Greenhouse staff completed 98 repropagations in 2017, but one accession of snakebark maple (*Acer capillipes,* 12469-1) represents a particular victory. Originally from Japan, the species was introduced to the West by Sargent in 1892. As the common name suggests, this small (35 feet tall), often multi-stemmed tree is best recognized by its young olive-green bark with white snakeskin-like lines. For over 100 years, Arboretum staff have attempted to reproduce this lineage from the inaugural 1892 specimen with varying success.

In 2017, only one snakebark maple from the original Sargent lineage remained. When snowfall by mid February 2017 reached 11 inches, the storm damage caused the entire tree to tip over and the esteemed Sargent lineage was in danger of being lost forever. Triage ensued—staff salvaged all living branches of 12469-1*B downed by winter storms. Scions (dormant stem cuttings for grafting) were immediately taken for grafting—the process of joining two plants together so they grow as one. Arboretum propagators grafted the scions onto rootstock of *A. palmatum* (Japanese maple), *A. rubrum* (red maple), *A. saccharum* (sugar maple), *A. tataricum* (Tatarian maple), and *A. truncatum* (purpleblow maple), which will become the lower portion of the new trees.

Acer capillipes (snakebark maple) grafted onto rootstock of *Acer rubrum* (red maple) in the Dana Greenhouses.

Using a variety of techniques, staff completed 15 grafts. For several weeks, the grafts stayed in a cool greenhouse with periodic insertions into a heat or callus pipe to stimulate the active tissue growth necessary to join their tissues. After nurturing the grafted plants through the 2017 growing season, only two individuals survived—those grafted onto red maple rootstock. Production staff has planned softwood cuttings (stem cuttings from the current season's growth) from these valuable plants for summer 2018, hoping to increase the quantity of this prized lineage. In a few years' time, clones derived from the original Sargent *A. capillipes* introduction to North America will once again grace the landscape, with the potential to tie the Arboretum's long history of exploration to our future—a 2018 expedition to Japan may secure an exciting new lineage.

SHARE

A partner in the educational mission of Harvard University and a leader in community engagement, the Arnold Arboretum offers a multitude of diverse learning and enrichment opportunities for students and visitors of all ages.

Why, during eclipses of the Sun, if one makes observations of them through a sieve or through leaves…or by joining the fingers of one hand to those of the other, the beams become crescents on the ground?

So wrote Aristotle more than 2 millennia ago. We now know that tiny gaps between overlapping leaves of a tree create a pinhole camera, projecting the eclipsed sun onto the ground. Director William (Ned) Friedman captured the effect beneath the branches of *Fagus sylvatica* 'Tortuosa' (tortured European beech, at left) during the solar eclipse that crossed the entire contiguous United States on August 21, 2017.

This once-in-a-lifetime spectacle spurred a unique viewing experience on the Arboretum's Bussey Hill, where hundreds of visitors gathered to celebrate the partial eclipse. Valerie Wilcox and Adrianna Plavetsky of the National Park Service shared projection equipment, safety tips, and detailed information. Attendees shared their own viewing devices, from eclipse glasses to cereal box pinhole cameras, so that everybody could witness the phenomenon—the first of its kind in 99 years.

Left: Visitors tour the Dana Greenhouses;
Right: Volunteer guides in the Field Study Experiences program learn about floral transformation from bud to fruit.

Community Engagement

Along with a mission to elevate and steward science, horticulture, and botanical diversity, the Arboretum also honors a deep commitment to its community. A private-public partnership of Harvard University and the City of Boston, the Arboretum cooperates locally with a wide array of organizations including the Emerald Necklace Conservancy, the Boston Parks Department, the Boston Park Rangers, the National Parks Service, the Department of Conservation and Recreation, the City of Boston, and advocacy groups and neighboring businesses. The beauty of the landscape is, of course, an attraction in and of itself, but the Arboretum's many programs, events, classes, lectures, art exhibitions, and tours provide key opportunities for people of all ages to engage with plants, nature, and science on a deeper level.

In 2017, the Public Programs department at the Arboretum emphasized physical and mental well-being with two new offerings. In July, instructors Adrienne Sharigian and Kiara Segal held free outdoor yoga classes in the tranquil Arboretum landscape. The yoga sessions focused on improving health and well-being through physical poses, breathing exercises, and meditation, and took place in the Leventritt Garden. These classes were co-sponsored with the National Park Service Frederick Law Olmsted National Historic Site, the Emerald Necklace Conservancy, and the Brigham and Women's Faulkner Hospital.

From September through November, Tam Willey, Forest Therapy Guide in Practicum, guided participants on forest therapy walks in the Arboretum, drawing on principles of Shinrin-yoku—the ancient Japanese method of preventive health care and healing known as "Forest Bathing." Tam's walks helped visitors to experience the healing power of nature by slowing down, unplugging, and


LIPPERS

Left: ***Three Not Dandelions*** **by Susan Pettee, watercolor botanical illustration.**
Right: ***South Street Looking Northeast*** **by Andrew Haines, oil paint on canvas.**

building awareness of their surroundings while practicing a series of sensory exercises for well-being. These walks were extremely popular with visitors, ensuring that Forest Bathing will return to the Arboretum in 2018.

The Arboretum also continued its tradition of free guided tours, including wellness walks, collections-themed experiences, family explorations, birding walks, and other programs that encouraged visitors to explore lesser-known areas of the grounds. Inside the Hunnewell Building, unique exhibitions by local artists offered visitors a chance to view the landscape through various methods of artistic expression. These included botanical illustrations by Susan Pettee, woodturned pieces by members of three local associations, photographs of the Arnold Arboretum by Kippy Goldfarb, paintings of Forest Hills by Andrew Haines, and observational drawings by students at Brookline High School. Documentary screenings, musical performances, poetry, and storytelling offered many ways to connect with and enjoy nature.

From Harvard students taking classes toward their degrees at the Arboretum, to research talks held throughout the year, to a close partnership with Boston Public Schools, the Arboretum's educational mission is deeply embedded in its programming. Adult Education at the Arboretum offers unique practical classes in horticulture, gardening, and propagation, drawing on the knowledge of expert staff to provide helpful and fun learning experiences. In addition, renowned guest speakers offer the public the chance to explore and discuss pertinent scientific topics and issues including botany, ecology, climate change, and more. In 2017, the Arboretum hosted award-winning authors, landscape designers, phenology experts, climate change scientists, museum curators, and conservation cartoonists, to name a few.

Of course, cultivating an interest and understanding of plant science starts at a young age. Throughout 2017, students and teachers from across Greater Boston came to the Arboretum for free programming designed to boost science education and environmental awareness in public schools. Beginning with pre-schoolers and extending to visitors of all ages, the Arboretum promotes and facilitates a lifetime of learning about the natural world.

In 2017, Field Studies Experiences at the Arnold Arboretum engaged some 2,200 students from Boston Public Schools in science learning at the Arboretum. Volunteer guides contributed nearly 2,500 hours to share the Arboretum and its collections with students.

Lilium canadense (Canada lily), from a series of approximately 75 lily photographs captured by Wilson at home between 1928 and 1930.

SUPPORTING RESEARCH

2017 Sargent Award recipients Scott and Michael Dietrich mined the Arnold Arboretum Archives for a forthcoming book on the photographic legacy of plant explorer Ernest Henry Wilson.

The Photography of E. H. Wilson

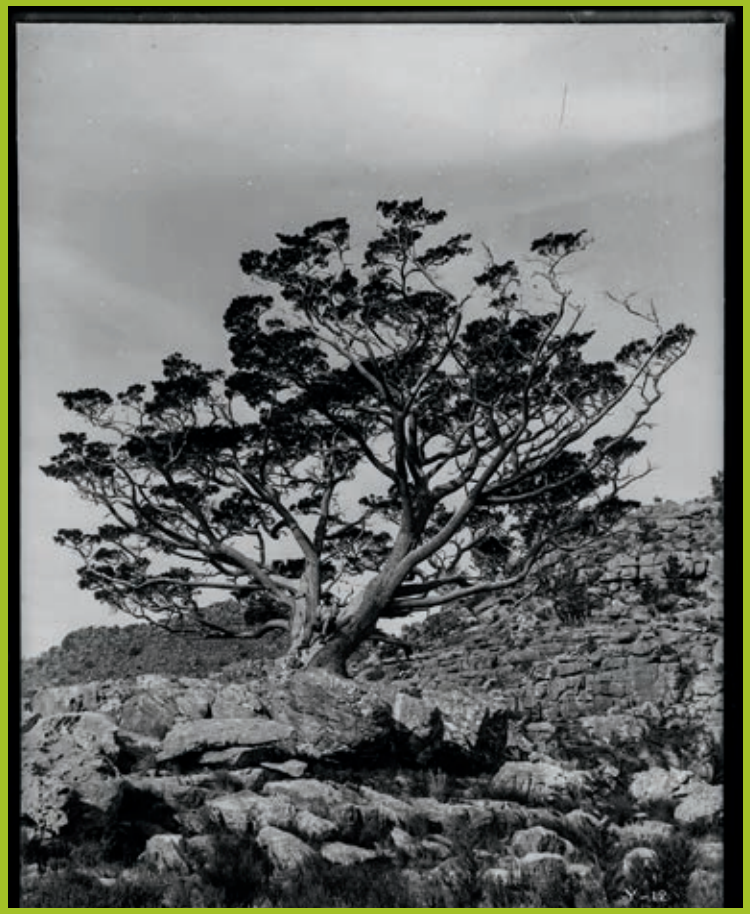
Scott Dietrich, Sargent Award Recipient

The generous support of the Sargent Award at the Arnold Arboretum allowed us to spend almost seven weeks researching the archives of Ernest Henry Wilson, Keeper of the Arnold Arboretum from 1927 to his untimely death in 1930. When Charles Sargent hired Wilson to collect in China for the Arboretum in 1906, he insisted upon photography as a means of documentation. Wilson used a large format Sanderson glass plate camera with a dry-plate process that turned the act of photographing into an endeavor similar to that of collecting plants. The results comprise one of the most significant archives of photographic documentation created by a single person in the pursuit of scientific knowledge, bearing witness not only to the collection of plants but to Wilson's journey of discovery.

We set out to conduct a systematic review and assess the contemporary relevance of the work Wilson created with the Sanderson plate camera. During our time at the Arboretum,

we digitized over 600 glass plate negatives that can now be added to the digital archive of Wilson's work, including photographs from his 1920–1922 trip that took him "around the world" and approximately 100 images of lilies he cultivated at his home, perhaps the last images he made. We spent a considerable amount of time during our survey looking for images of exceptional photographic quality, of which there are many, and images that highlight various themes that we think reflect on Wilson as a person and a collector. The images and information collected with the help of Head of the Library Lisa Pearson will allow us to continue our work on several articles and a book, *The Photography of Ernest Henry Wilson*, to reflect on his photographic legacy. We are also pursuing a project to map Wilson's photographs and produce an interactive website.

The opportunity of the Sargent Award provided us with an invaluable opportunity to come to a deeper understanding of Wilson's life and work. Without the almost seven weeks spent in the Archive, it would have been impossible for this project to progress at all. The Visual Archive of Wilson's photographs was our inspiration for this project, and it is to the Arboretum's credit that they preserve and offer access to this remarkable resource. We also had the opportunity to share our discoveries—including the only typed manuscript of a Wilson lecture to have come to light—with the Arboretum community during a Tree Mob™ tour of several Wilson plants in the landscape. We are looking forward to continuing our work on Wilson's photography and producing a book worthy of his life's work and of the Arnold Arboretum.



Top: *Widdringtonia juniperoides* [syn. *Widdringtonia wallichii* or Clanwilliam cedar] photographed at 1300 meters in the Clanwilliam Mountains in Cape Colony (present-day South Africa). Bottom: *Andansonia digitata* (baobab), photographed in Mombasa (present-day Kenya) in January 1922. Both images were taken during Wilson's 1920-22 tour of botanical gardens and arboreta of the world.

Making an Impact:

Education Fellow Ana Maria Caballero

Somewhere in Boston, a classroom of fifth graders is using giant magnolia leaves to measure distances between the floor and ceiling. In another classroom, students are recording seed dispersal data as they stand on chairs and drop winged fruits to the ground. These leaves and seeds from nature found their way to urban classrooms in the Boston Public School (BPS) network through the Arnold Arboretum's Summer Institute.

For the past two summers, this free professional development program for Boston area educators has helped boost science curricula in classrooms thanks to the coordination and agency of our dedicated Education Fellow, Ana Maria Caballero.

Ana Maria came to the Arboretum in 2010 after more than 20 years teaching third graders. "I was burned out in the classroom," she explains, "but I wanted to continue to have an impact on the lives of students and teachers." With the help of a generous donor, the late Henry H. Meyer III, the Arboretum was able to engage Ana Maria as Education Fellow for two years to expand on our partnership with Boston Public Schools. The two years are almost up and Ana Maria is just hitting her stride.

A life-long learner and veteran teacher, Ana Maria taught herself everything she needed to know about learning (and teaching) in the landscape. "Learning in nature," she notes, "is one sure way to engage kids." When Ana Maria arrived, the Arboretum was working with a very small Boston Public School population and wanted to reach many more children. It made sense to help teachers get comfortable with nature to teach plant science using whatever open-air space was closest to them.

As Education Fellow, Ana Maria worked with Manager of Children's Education Nancy Sableski to expand the Field Studies Experiences, which for nearly 35 years have taught life science curriculum to public school students in grades Pre-K to 5 under our trees. Ana Maria amplified the program's success by expanding its focus to include the professional development of those who continue leading the students in their science studies after they leave the grounds—the teachers.

To extend the benefits of the Field Study Experiences to additional classrooms, Ana Maria created two programs to promote self-study by BPS teachers. Arboretum for Educators is a monthly workshop through which elementary and middle school teachers earn professional development points for attending multiple times—though they keep coming back to take advantage of the individual attention the program offers.

The second program Ana Maria helms is the annual Summer Institute, which began as a three day intensive training program and has grown to four. Open to teachers from grades Pre-K through middle school, the Institute was inaugurated in summer 2016 with 17 educators excited to learn about plant evolution. A talk by Harvard University plant biologist Elena Kramer kicked things off with a focus on looking closely at plants. Then the teachers headed into the landscape, collecting samples from moss to angiosperms to help them understand the evolutionary progression that resulted in flowering plants.

The 2017 Institute drew 21 teachers and focused on the form and function of roots, leaves, stems, flowers, and fruit. Content and practices were designed to be in keeping with the 2016 Massachusetts Science, Technology, and Engineering (2016 MA STE) Life Science standards, and the Next Generation Science Standards (NGSS).

The 2018 Summer Institute is titled "Investigating Ecosystems Through Field Work," and is designed to reach teachers in grades 3 through high school. Ana Maria wants to spend as much time in the landscape as possible, helping teachers learn fieldwork techniques that students can use to collect data to learn about the complexities of ecosystems.

This is where the most exciting learning and teaching takes place. The fun and enrichment lies in learning about nature and our environment in a beautiful green space and bringing that knowledge—as well as the seeds and leaves collected—back into city classrooms to enlighten students.

Thank You for Your Support

Janetta Stringfellow, Director of Institutional Advancement

Ten months ago, I was an average Brookline citizen regularly wandering the Arnold Arboretum appreciating the trees but not really seeing them. When I came to interview, I realized how much I had never noticed. I saw Boston Public School children measuring a tree trunk on Hemlock Hill. I saw a cluster of water lilies that are extinct in Rwanda but exist in a Rubbermaid tub in our labs. I listened to Michael Dosmann, Keeper of the Living Collections, tell me about searching for the paperbark maple (which now, of course, I refer to only as *Acer griseum*) in the forests of China.

Now that I work here, I can identify a magnolia in the dead of winter. And I get into heated Facebook discussions with "friends" who are misidentifying 'Arnold Promise' witch-hazel as an early blooming forsythia. Today I learned about the difference between "excurrent" and "decurrent" tree forms from Andrew Gapinski, our Manager of Horticulture. Earlier this year it was "exaptation" and "homoplasy" from director Ned Friedman. Well into my first year, I still learn multiple things every day. Surrounded by the work we do, I trust that will be the case for many years to come. You can sense the diversity and depth of our endeavor in the pages of this annual report. Everything we do here—propagation, arboriculture, curation, research, education, arts—reveals a deep respect for the past while working firmly in the present to make our future world a better place.

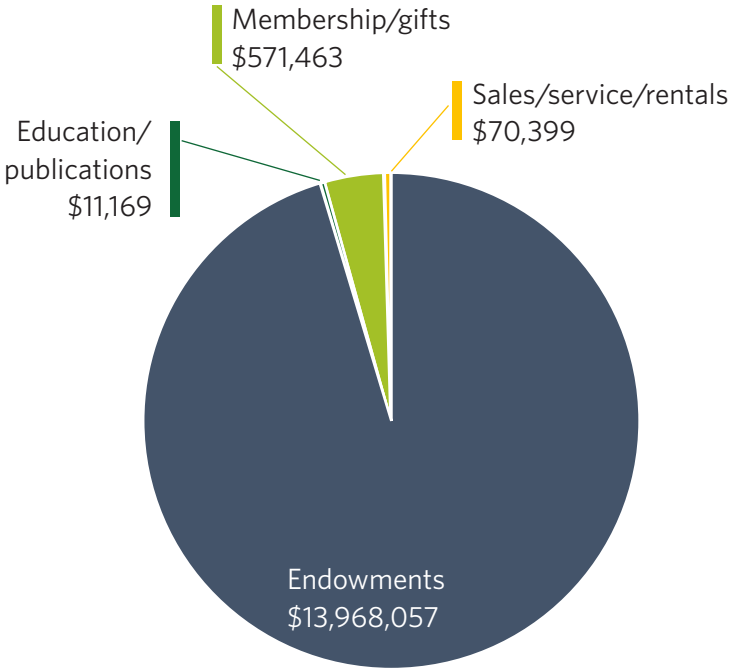
I started my journey at the Arboretum in June 2017 after 20 years of development experience at independent schools. I still have much to learn in acclimating to the environments of Harvard and the Arboretum, but thanks to my colleagues and to you—our robust and knowledgeable group of members, donors, and volunteers—the fun has been in the discovery. At the Arboretum I continue to do many of the things I did before: build relationships and engage a community, dig deeper into places that I love, and raise funds for education and children and science.

With your philanthropic help, we can ensure that the Arboretum meets strategic priorities in our landscape, greenhouses, and labs as we anticipate the celebration of our sesquicentennial in 2022. Thank you to everyone who supported our mission in so many generous ways in 2017. I look forward to getting to know you all—and this remarkable institution—even better this year.

Statement of Activities

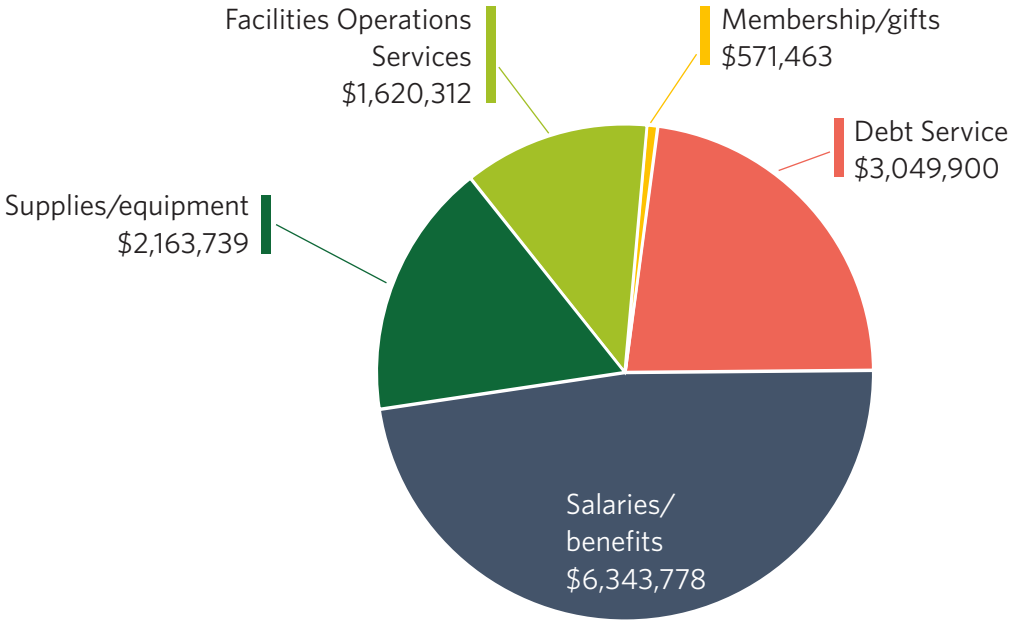
The Arnold Arboretum of Harvard University relies almost exclusively on income derived from the past and present philanthropy of friends and members, who have given generously to support the institution for nearly 150 years. The information provided below reflects the financial activities of the Arboretum in the 2017 fiscal year (July 1, 2016–June 30, 2017).

INCOME: $14,621,156



EXPENSE $14,033,743

NET CHANGE IN CASH: $587,413*



*This cash increase reflects a one-time accounting transaction. The FY17 increase will be used to help reduce our debt on the Weld Hill Research building ($20.4M at 06/30/17) and to fund critical building maintenance projects.

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Every effort has been made to ensure the accuracy of these lists. We regret any errors or omissions and as that you notify the development office of any you find. Please email janetta_stringfellow@harvard.edu

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- Sarah Fox, University of Pennsylvania, Plant Production Intern
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- Marcus Jansen, Iowa State University, Horticulture Intern
- Rachel Lawlor, University of Massachusetts-Amherst, Horticulture Intern
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Research Publications

Arnold Arboretum Staff
Visiting Scholars, Fellows, and Associates
Putnam Fellows
Arnold Arboretum Award Recipients

Bell BA, Fletcher WJ, Ryan P, Grant H, Ilmen R. 2017. Stable carbon isotope analysis of *Cedrus atlantica* pollen as an indicator of moisture availability. *Review of Palaeobotany and Palynology* 244: 128-139.

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