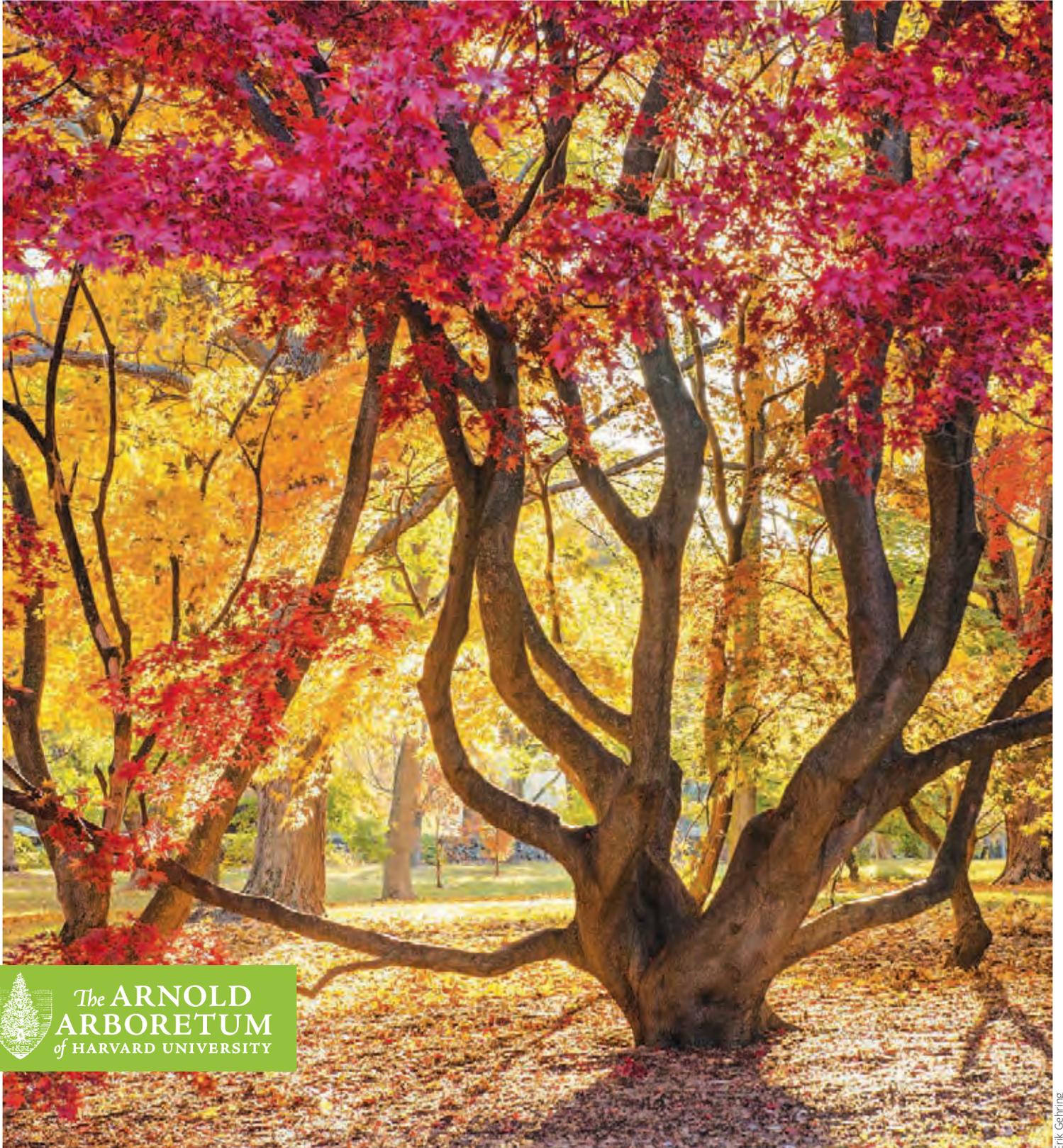


2020 ANNUAL REPORT

The Arnold Arboretum of Harvard University



The ARNOLD
ARBORETUM
of HARVARD UNIVERSITY



Andrew Gabinski

About Us

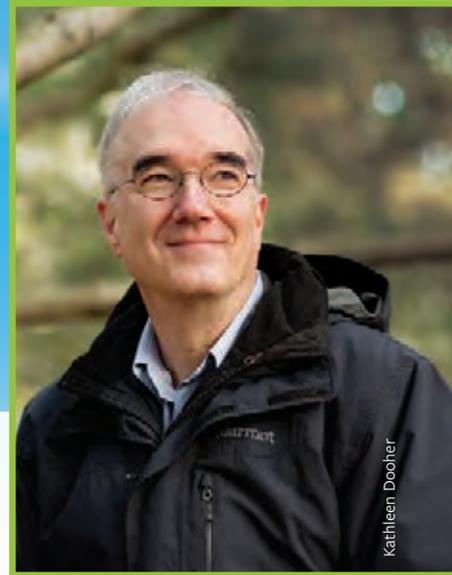
A 281-acre preserve in the heart of Boston, the Arnold Arboretum of Harvard University is a premier destination for deepening our knowledge and appreciation of plants and biodiversity. The institution is the nation's first public arboretum, established in 1872, and stewards one of the world's most comprehensive and best-documented collections of temperate woody plants, with particular focus on the floras of eastern North America and East Asia. The living collections, herbarium, and library and archives support research by scientists and interdisciplinary scholars from the Arboretum and around the world. Free and open every day, this historic landscape in the Olmsted-designed Emerald Necklace park system engages the public through free educational opportunities and programs for all ages.



Note from the Director

WILLIAM (NED) FRIEDMAN

DIRECTOR OF THE ARNOLD ARBORETUM AND
ARNOLD PROFESSOR OF ORGANISMIC AND
EVOLUTIONARY BIOLOGY, HARVARD UNIVERSITY



Kathleen Doohar

Like the storied trees we plant, which are intended to grow and develop over centuries, the Arnold Arboretum was established to be adaptive, resilient, productive, and long-lasting. Created by the President and Fellows of Harvard College in 1872, the Arboretum has endured and flourished despite two world wars, a global depression, and challenging times of unrest and social strife. Yet nothing since the Arboretum's founding seemed quite like 2020, and perhaps no single year in our history has ever demonstrated how essential the Arboretum is as both a global and local resource for horticulture, research, education, and urban open space.

In 2020, the rise of the COVID-19 pandemic demanded a quick response from public institutions to ensure the health and safety of all. What set the Arnold Arboretum's response apart from nearly every other public garden and museum around the world was our decision to keep our 281-acre landscape open on our regular schedule—every day from dawn to dusk—throughout the crisis. For me and my colleagues, it was unthinkable that the Arnold Arboretum might shut down during the pandemic when the public needed us more than ever. The response was remarkable and, perhaps, unprecedented. Digital counters installed at our gates indicated that somewhere between two and three million visitors made the Arboretum their restorative refuge. Data on cellphone usage in our landscape over the year also indicate greater levels of diversity among our visitors than we imagined, placing us among the most diverse cultural institutions in Boston.

This awareness and sensitivity to our audiences has never been more critical. Events of the year also demanded we reflect deeply on the Arboretum's public promise and its responsibilities in supporting the national and international movement for racial equity and social justice. As a free public garden, the Arboretum is an integral part of the lives and well-being of people from around our community, including historically excluded neighborhoods in our immediate proximity. As an institution, we are uniquely equipped to welcome all comers and to connect people not only to plants but to one another. Honoring this value and advancing progress on equity of access and environmental justice at the Arboretum motivates many of our ambitions and structural planning as the institution approaches its sesquicentennial year in 2022.

Of the many lessons we learned or were reminded of in 2020, perhaps the most important is this: like the trees we preserve in our living collections, the Arboretum thrives as a living and evolving entity that nonetheless requires the thoughtful care and nourishing support of people. While we made sure the Arboretum stayed open and available for the public, the kind words and philanthropic support we received from our members kept us buoyed through an exceptional and challenging year. As we plan for our 150th birthday and what lies beyond, this vibrant partnership with our community will continue to strengthen and inspire us toward a future of endless possibility.



Essential Gardening

As Boston teetered on the brink of the pandemic in early 2020, Dahurian azaleas (*Rhododendron dauricum*) flowered at the Arnold Arboretum, the petals colored like bubblegum. Spring would arrive with unabated brilliance. This meant that a small, rotating team of horticulturists continued working on-site, even while other staff recalibrated to work-from-home routines. The continuity of horticultural care was true at public gardens across the country, regardless of whether the landscapes could remain fully open. Horticulture at public gardens is essential, and it cannot be done remotely. Plants do not wait.

In the summer issue of *Arnoldia*, horticulturists from the Arnold Arboretum and eleven other public gardens wrote about experiences in their landscapes during the first months of the pandemic. Many of the horticulturists described incongruous scenes. At the Arboretum, which remained open throughout the pandemic, the last weeks of March 2020 brought an enormous surge of visitors. “It felt like everyone was arriving for our largest event of the year, Lilac Sunday,” horticulturist Greg LaPlume wrote in his account. “But the lilacs were still more than a month from blooming. Tree branches were still bare and leafless.” Meanwhile, at gardens where the gates closed, thousands of tulips and daffodils put on shows without a public audience. Horticulturists were among the few who witnessed these quiet displays. Many were left with a new appreciation for the vibrancy that visitors impart on the landscape. After all, what is a public garden without the public?

These experiences reveal an essential truth about horticulture at places like the Arboretum: horticulturists are not simply caring for plants; they are also caring for everyone who turns to these shared landscapes for inspiration and renewal. Visitors, in turn, bring energy and purpose. When the full team of Arboretum horticulturists returned to the landscape as the summer began, they worked rotating schedules. Among their projects, they continued installing new mulch paths, welcoming visitors into different corners of the collections. The horticulturists are stewarding plants for conservation and research, of course, but also, fundamentally, for public enjoyment.

At the Arboretum, visitors made the most of the languid summer evenings. It was a space where people could freely meet and gather. One evening, a young family was among the promenade, a large number-shaped balloon announcing a two-year-old’s birthday. A couple, with masks momentarily down, kissed near a rose-covered arbor. Children wheeled by on scooters. Four friends meandered, occasionally stopping to photograph plants. The flow was ceaseless: runners, bikers, dog walkers, and those simply appreciating the peace beneath the storied trees. Horticulture creates space for connection, and in 2020, this function was more essential than ever.

—Jonathan Damery, Editor of *Arnoldia*



After all, what is a public garden without the public?

Propagating Success Through Strategy

The transition to remote work for the majority of Arnold Arboretum staff in March 2020 coincided with the verge of the busiest and most consequential time for the living collections teams.

Keeper of the Living Collections Michael Dosmann and Head of Horticulture Andrew Gapinski had just selected permanent planting locations for 41 trees in the nurseries at the Dana Greenhouses. Our early response planning included a strategy for essential staff to accomplish the necessary, labor-intensive work of prepping and moving more than 100 trees into the landscape.

Spring-planted trees at the Arboretum are typically dug after soil thaws and before budbreak. Although root ball diameters for each specimen are individually determined and skillfully hand dug by horticulturists, outer roots are nonetheless severed during the ball forming process. By planting in early spring and supplying supplemental irrigation throughout the growing season, we provide our spring-planted trees the best opportunity to become established in their final locations.

Plans went into effect on March 12, following Dosmann's release of the first spring planting bulletin. With the season's abrupt arrival—seemingly earlier each year—the timing was crucial for tree transplanting. Plant Records Manager Kyle Port placed anodized aluminum labels on these accessions, and



We accomplished the 2020 spring planting in record time.



Photos by Jon Hetman

digging commenced on Monday, March 16. Separate digging and planting teams worked on staggered schedules, enabling social distancing, increased spacing during meal breaks, and schedule adjustments for those with children learning at home. With so many unknowns and contingencies to consider, we treated every day in March as if it might be the last permitted on-site.

Greenhouse Horticulturist Chris Copeland spearheaded efforts to heel in and care for ball-and-burlapped trees and container plants while they awaited their turn at transplanting.

Dosmann and Gapinski continued to stake out locations for trees with the issue of second and third spring planting bulletins in mid-March. The push to find spots for nearly 200 containerized plants included four subsequent planting bulletins that followed in April. With thoughtful and thorough advance planning and the can-do, all-in commitment of our remarkable horticulture staff, we accomplished the 2020 spring planting in record time. While cooperating to keep each other safe during the onset of a pandemic, the Arboretum welcomed hundreds of new plants in the landscape.

—Tiffany Enzenbacher,
Manager of Plant Production

Advancing Plant Care

The Landscape Management System

Responding to the needs of our plants in a changing climate, the Arboretum has adopted an adaptive management perspective with an eye toward continuous adjustment and improvement of collections and landscape care. During my term as Arboretum Living Collections Fellow, I shepherded a two-year effort with staff in horticulture, curation, and information technology to translate this philosophy into a suite of practical tools called the Landscape Management System (LMS) for debut in 2020.

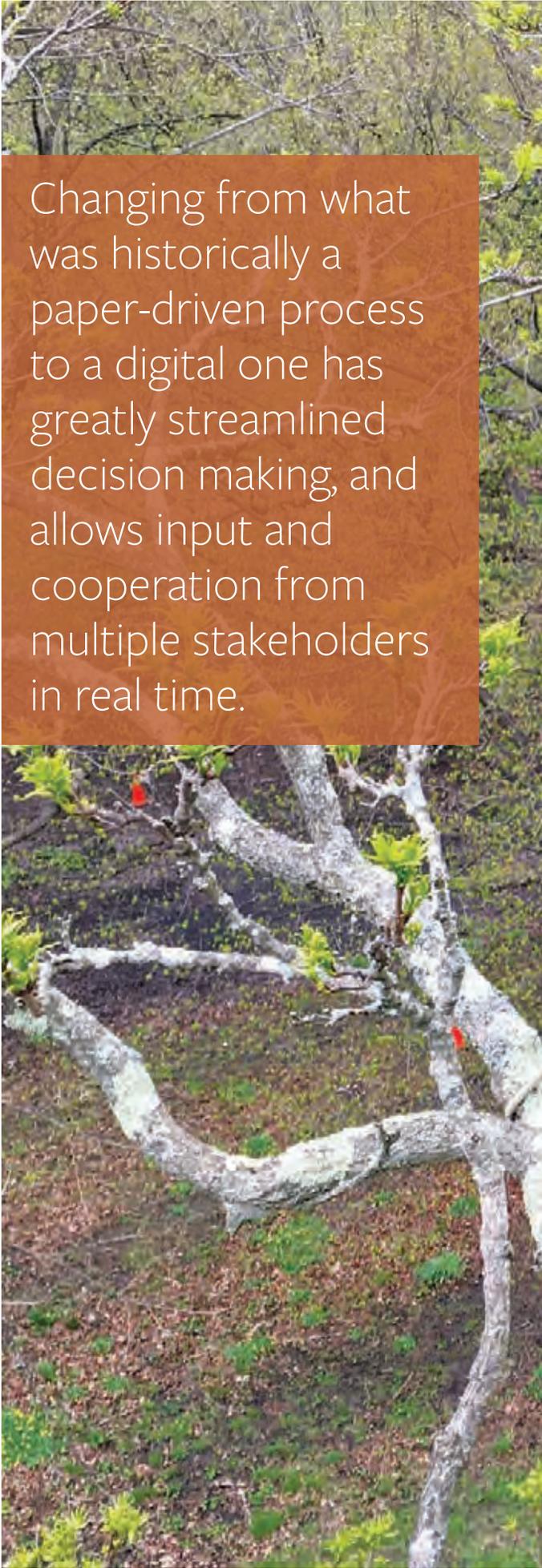
The LMS integrates adaptive management into the daily work of Arboretum staff through new digital tools, websites, updated mapping information, and more. A new mobile application—called ArbManager—allows staff to communicate and collaborate on plant care needs using a smartphone or other mobile device. Changing from what was historically a paper-driven process to a digital one has greatly streamlined decision-making, and allows input and cooperation from multiple stakeholders in real time.

ArbManager ties together an extensive array of information and assets to help horticulturists do their work and leverage deep personal and institutional knowledge on individual plants, including condition notes, photographs, GPS coordinates, and phenological observations pertaining to budbreak or autumn color. Importantly, these data are automatically transferred to the Arboretum's plant records database, BG-BASE. This automation represents a major technological advancement in connecting various repositories of information and ensuring this data is preserved for all time. Together, these individual snapshots in time—for instance, records tracking prevalent pests to the use of organic soil amendments—offer abundant new data toward a healthier living collection.

To further improve communication and centralize access to plant information, the team developed ArbDashboard, a new website. With ArbDashboard, staff can visualize key characteristics, infrastructure, and natural features on the digital map; review and update the maintenance requirements for each of the Arboretum's 91 horticultural management zones; track plant health issues or scouting efforts; and download key articles or reports. Significantly improving access and transparency, ArbDashboard provides multiple layers of resources needed to make the best horticultural decisions and ensure the highest quality of plant care.

True to its ideals of free access, the Arboretum is working to share this innovative technology to benefit the entire public garden community. In June 2020, our staff presented the LMS and its suite of tools to the annual conference of the American Public Gardens Association. Further conversations in 2020, both internally and with colleague gardens, hold promise for further development and expansion of these resources in coming years. For nearly 150 years, the Arnold Arboretum has endeavored to grow and preserve germplasm collected from around the world in its living collection in Boston. By improving communication and access to information, the Landscape Management System will help Arboretum staff transform practices to meet the challenges of the 21st century.

—Jared Rubinstein, *Living Collections Fellow*



Changing from what was historically a paper-driven process to a digital one has greatly streamlined decision making, and allows input and cooperation from multiple stakeholders in real time.



Curating Information

Past and Present

With plant records going back almost 150 years, the curation team is always transferring old archival notes

and observations from paper to BG-BASE, our plant records database. Under normal circumstances, staff chip away on these “back burner” projects during rainy days or when the mood strikes, but the pandemic provided a new opportunity for Curatorial Assistants Devika Jaikumar and Kathryn Richardson and Manager of Plant Records Kyle Port to tackle them in earnest from home. Although most of this flurry of activity related to data entry, the team also reviewed existing datasets for accuracy and completeness, making corrections and annotations as needed.

The projects have blossomed into a richer and more comprehensive chronicle of the Arnold Arboretum’s documented collections, providing insights into many questions we encounter in our work about individual plants. Questions like: “Who sent it to us?” We assessed and clarified nearly 5,500 records of the individuals, institutions, and businesses that have provided plants historically to the Arnold Arboretum. “Where was it collected?” We audited geographic data associated with our wild-collected plants, including 6,175 from China. “When and how did we get it?” We reviewed handwritten and typed accession books from 1937 to 1950 (representing 11,296 accessions), adding new information to existing records and creating 7,560 entirely new records for accessions that for one reason or another never made it into our permanent collections. We even tackled questions like “When does it bloom?” We reviewed and databased detailed flowering records—nearly 2,500 in all—from 2001 to 2003 for nearly 600 plants growing in the Bradley Rosaceous Collections.

—Michael S. Dosmann,
Keeper of the Living Collections

Plant Collections in 2020



As of December 31, 2020, the Arnold Arboretum living collections (including nursery holdings) comprised:

17,395 individual plants • **11,085 accessions**

3,856 taxa • **2,184 species**

480 accessioned plants were added to the permanent collections in the landscape and **285 plants** were

deaccessioned. The Herbarium of the Arnold Arboretum contained some **1.49 million specimens**, and the

Herbarium of Cultivated Plants contained

120,642 specimens.

Botanizing in Boston

Collecting for a Solar Meadow

With international expeditions for the Campaign for the Living Collections suspended due to the pandemic, plant exploration and collecting efforts in 2020 shifted to local collaborations and fieldwork in ecosystems only a short drive from the Arboretum landscape. Unforeseen opportunities have often played an important role in the success of the institution's expeditionary efforts. In this case, the pause in international travel aligned with horticultural planning for the landscape of the new solar array at the Weld Hill Research and Education Building.

The solar array at Weld Hill—the largest and most advanced system of its kind at Harvard University—was specifically engineered to accommodate a diverse, native pollinator meadow between and beneath the panels. Custom specifications from the Arboretum directed engineering decisions for panel height, spacing, and angle, allowing for greater plant diversity below. The design provides exciting opportunities to showcase both the institution's commitment to renewable energy as well as the health and biodiversity of our local ecosystem.

While compiling a planting list for the meadow, staff observed plant compositions in local habitats and consulted with experts who specialize in native plants, pollinators, and meadows. The resulting targets for local collection included a mix of native grasses, graminoids, ferns, forbs, and low-growing shrubs. Among the dozens of herbaceous species are familiar names like little bluestem (*Schizachyrium scoparium*), butterfly milkweed (*Asclepias tuberosa*), sweet goldenrod (*Solidago odora*), common mountain mint (*Pycnanthemum virginianum*), and blue wood-aster (*Symphotrichum cordifolium*). Shrubs include meadowsweet (*Spiraea alba*), sheep laurel (*Kalmia angustifolia*), and sweetfern (*Comptonia peregrina*).





Wild collecting these plants enhanced the Arboretum's relationship with local preserves and organizations while honoring the institution's historical preference for cultivating plants of documented provenance.

Wild collecting these plants enhanced the Arboretum's relationship with local preserves and organizations while honoring the institution's historical preference for cultivating plants of documented provenance. Sourcing seed locally may also help preserve genes from regional populations, reinforcing their ecological value as locally adapted species. Detailed notes captured at collecting sites—including descriptions of habitats and associated plant communities—contribute to the Arboretum's rich documentation of its plants and provide valuable ecosystem data to our partner organizations.

Seeds collected throughout 2020 from these localities will be planted around the panels beginning in 2021 and continue over several seasons. As the solar meadow grows and comes into its own in the coming years, the landscape will contribute meaningfully to the Arboretum's environment and perhaps establish a measure of harmony between nature and technology. It will also bring some of the character of natural areas in our region to the Arboretum's own backyard.

—Brendan Keegan, *Horticulturist*

A More Sustainable Arboretum

In a Changing World

Climate change continued to threaten the earth's biodiversity in 2020—one of the three hottest years on record. In response to this threat, the Arboretum redoubled a historical commitment to protecting biodiversity abroad and at home through an number of sustainability initiatives.

When the switch was flipped on for the Weld Hill solar array and battery storage system in early 2020, the Arboretum increased its solar production by over 90 percent. In its first year of operation, the Weld Hill solar array generated 515,000 kilowatts of clean energy—equal to our target goal of 25 percent of overall energy demand—to power plant biology research at the Weld Hill Building. In tandem with the solar array, the Tesla battery storage system achieved significant reductions in on- and

off-peak energy demand, reducing our reliance on carbon-emitting “peak” power facilities. Below the Weld Hill array panels, the Arboretum continued to develop the native-plant-focused pollinator meadow—the first of its kind in Massachusetts.

The Arboretum also made significant strides towards preparing the living collections for a hotter, drier future. In 2020, the institution completed the first phase of a major initiative for drought preparedness: a donor-funded emergency irrigation system capable of efficiently delivering supplemental water to over 40 acres of irreplaceable collections in the vicinity of the Centre Street Gate. In fall 2020, plans were completed for an expansion of the system on Bussey Hill and along Conifer Path, along with plans for a separate system covering fifty-five acres of Peters Hill—the Arboretum's driest area, currently served by a single water connection.

Beyond these planning efforts, the Arboretum expanded its communications around these efforts by highlighting sustainability work in the pages of its newly designed website, where visitors can dig deeper into the institution's wide-ranging climate initiatives. In response, the Arboretum received recognition from the American Public Gardens Association's Climate and Sustainability Alliance for demonstrating excellence in Climate Adaptation and Risk Management.

—**Danny Schissler**, *Project Manager*

Toward an Improved Perimeter

The year proved a pivotal moment for capital improvements at the Arboretum, planned and executed through city and community partnerships. Major accomplishments include the completion of a two-year restoration of the Arboretum perimeter walls funded by the Boston Capital Improvement Program and managed by the Boston Parks and Recreation Department. Through this project, over 1,400 linear feet of historic wall were repaired or rebuilt, including large sections along the Arborway, Bussey Street, and South Street.

South Street saw much-needed safety and aesthetic improvements through the efforts of the Boston Public Works Department. The department resurfaced the roadway from Forest Hills to Archdale Road. Stormwater infrastructure maintenance and improvements included in this project have further improved the conditions along South Street and in Bussey Brook Meadow. New pavement markings at South Street Gate and the 383 South Street Gate have improved accessibility for Arboretum visitors.

The Arboretum continued planning and design work for the Roslindale Gateway Path, a proposed ADA-accessible multiuse pedestrian and cycling path through Bussey Brook Meadow and Peters Hill. As part of two City of Boston initiatives—Boston Green Links and Go Boston 2030—the path will extend the



Jonathan Damery



Danny Schissler

Southwest Corridor path system from Forest Hills MBTA Station to Roslindale Village. It will provide carbon-free commuting options and connect Boston residents with the natural environment close to where they live. In addition to proposed path connections, the Roslindale Gateway Path will establish two new formal entrances to the Arnold Arboretum, providing safe and welcoming access to a key link in Boston Emerald Necklace system of parks for thousands of Roslindale residents.

In 2020, the Arboretum made substantial progress on the design and permits for the first phase of the project, which will establish a new formal entrance at Arboretum Road and a multi-use path connection. This work will completely transform an underused portal and landscape to provide safe and welcoming passage for communities along Washington Street in Roslindale.

The Arboretum also commissioned conceptual designs for another phase of the project, which aims to connect the Arboretum Road Entrance and the intersection of Bussey Street and South Street with an ADA-accessible elevated boardwalk. This structure has been designed with durability and longevity in mind by two leading landscape and sustainability architects, Rosetta Elkin and Kiel Moe. Their conceptual plans incorporate sustainably sourced local hardwoods (black locust, *Robinia pseudoacacia*) and a minimalistic substructure that harmonizes with the surrounding landscape. Beyond serving as a critical connection in the overall path system, the Bussey Brook Boardwalk will offer visitors unique views through the canopies of surrounding trees. But next we need to raise the funds to construct it. Pursuant with redoubled efforts to ensure equity of access for all, the Roslindale Gateway Path and Bussey Brook Boardwalk projects represent what will ultimately be a historic investment in connecting the institution to the diverse populations it serves.

—**Danny Schissler**, *Project Manager*



Brendan Keegan

In 2020, the Arboretum worked to make its operations more sustainable on multiple fronts, including the acquisition of electric cargo bikes for use by Horticulture staff. The bikes hold their charge for over a week of use, and help improve the visitor experience by reducing the number and associated impacts of large vehicles on Arboretum roads.

Securing the Pursuit of Discovery

When workplaces around the nation shut down or adjusted to remote operations in March of 2020, the Arboretum's Weld Hill Research Building was no different. Our first priority was health and safety, which meant we put in-person research on pause. Despite this, 2020 was marked by tremendous flexibility and community building. While we welcomed Assistant Professor Benton Taylor of the Department of Organismic and Evolutionary Biology at Harvard University to his new research base at Weld Hill, we also trained new staff via Zoom and shared interactive research talks online.

Pandemic restrictions also demanded creativity in caring for the plants in Weld Hill's research greenhouses. Faculty and staff remained patient and adaptive, and a number of essential workers remained to care for the living collections and plants grown for ongoing projects. Among these personnel was Weld Hill Growth Facilities Manager Lee Toomey, who arrived on-site every day to ensure the vitality of our plants. "My experience with greenhouse work has often been solitary," said Lee, "so coming into work at the beginning of the pandemic was—despite the intense emotional labor of the situation—not all that different. Bearing witness to the plants glowing in the morning light and following their slow cadence of growth provided a much-needed contrast to the outside world and a gentle reminder to carry on."

While Toomey tended plants upstairs in the greenhouses, the Robin Hopkins Lab downstairs faced the challenge of thousands of their plants starting to set seed just as the initial stay-at-home orders were being extended. Charlie Hale, a research assistant in the Hopkins Lab, harvested seeds and stored them for when researchers would return to Weld Hill. Seed collection represented the culmination of half a year of work, so "it would have been really hard to start over if we hadn't finished it in time," Hale recalled. "It was surreal coming into an empty building usually bustling with life."

Formulating a reoccupancy plan took significant time and coordination with Harvard, so not until June were a small number of researchers welcomed back into the research labs, working in shifts to reduce occupancy and maintain physical distancing. Among them were members of the newly established Taylor Lab, whose work focuses on climate change. "One of the greatest joys of this period," Ben said, "has been seeing the members of my lab come together—despite being barred from most types of social interaction—to form new friendships and collaborations. Despite all the logistical challenges, our lab group has come out of the gates running."

Despite the challenges of 2020, the research community adapted, persevered, and advanced their work and studies in exciting directions. As Weld Hill continues to build its capacity with safety first, research teams continue to think dynamically and creatively about new projects and ideas, charged with hope for the future.

—Faye Rosin, *Director of Research Facilitation*
& Ellie Mendelson, *Research Assistant*



“Bearing witness to the plants glowing in the morning light and following their slow cadence of growth provided a much-needed contrast to the outside world and a gentle reminder to carry on.”



Faculty Fellows

of the Arnold Arboretum

The **Friedman Lab** is based at the Arboretum and focuses on reconstructing the evolutionary origin and early diversification of flowering plants, Darwin's so-called "abominable mystery." Additional investigations include the evolution of diversity in the structural patterns of resting buds in temperate trees, the evolution of water-conducting tissues among ferns, the case of the bee-killing magnolias, and the intellectual history of early evolutionary thought.

The **Hopkins Lab** studies the evolutionary and genetic processes underlying the formation of new plant species. Projects focus on plant genomics and the genetic changes underlying reproductive isolation, and the processes of self-incompatibility and interspecific incompatibility in plant reproduction. The Hopkins Lab is based at the Arboretum.

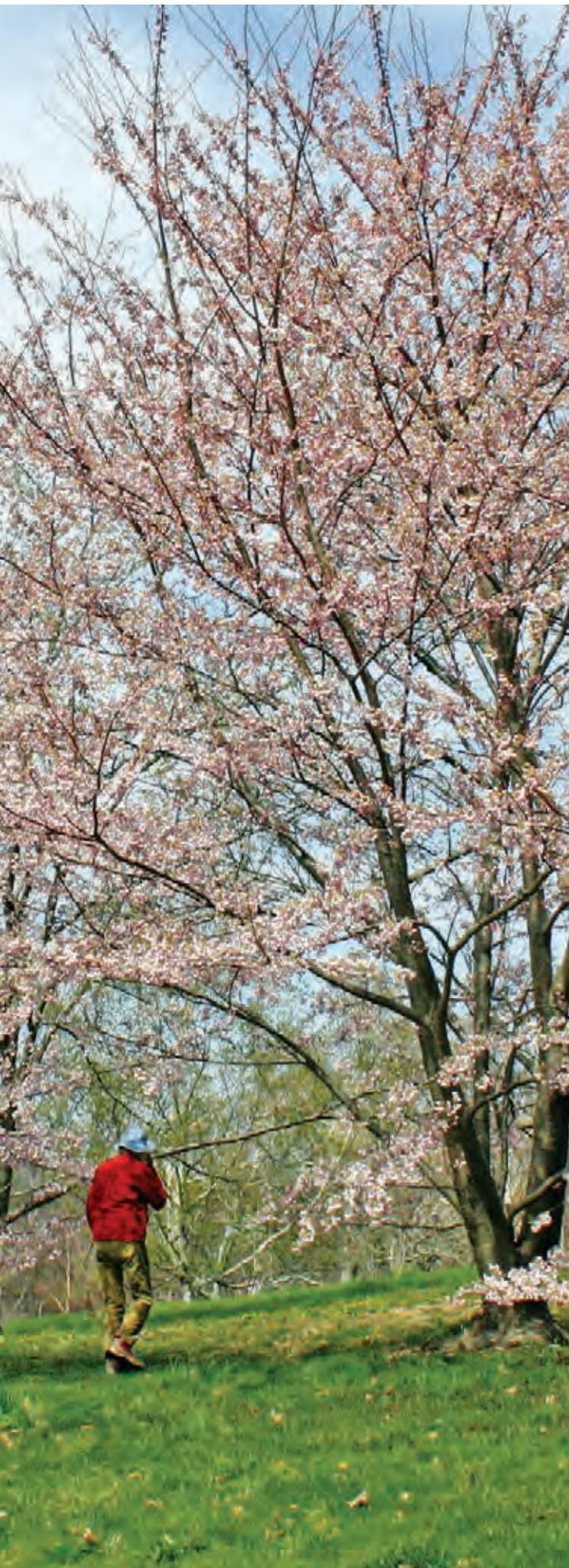
The **Taylor Lab**, based at the Arboretum, focuses on how plants respond to, and influence, the environment around them, particularly in light of global climate change. Investigations include examinations of the role of nitrogen fixers on the forest ecosystem and the growth of trees near volcanos with naturally elevated carbon dioxide levels.

Primarily based on the Harvard University campus in Cambridge, the **Holbrook Lab** conducts investigations at Weld Hill focusing on functional aspects of the water and sugar conducting tissues of plants. With the Arboretum, Noel M. Holbrook mentors and supports DaRin Butz Foundation research interns, graduate students, and postdoctoral fellows and is an instructor for the institution's summer short course in organismic plant biology.

The **Kramer Lab**, based on the Harvard University campus in Cambridge, conducts investigations at Weld Hill focusing on the evolution of floral morphology from comparative analysis of petal diversity to the formation of novel morphological features found with columbine flowers. Elena Kramer conducts research using the living collections and the Weld Hill facilities and mentors and supports Arboretum graduate students and postdoctoral fellows.

Rosetta S. Elkin taught landscape architecture at the Harvard Graduate School of Design, and her research explores the role of plants in design, especially the adaptations inherent to climate change. She and her students explore public projects at the Arboretum that prioritize public accessibility while maintaining the ambitions of the Olmstedian landscape. In the summer of 2020, she became an Associate Professor in the School of Architecture at McGill University in Canada while still maintaining close ties as an Associate of the Arnold Arboretum.





Arnold Arboretum-Funded Research Fellowships and Awards

ASHTON AWARD FOR STUDENT RESEARCH

Endro Setiawan, Master's Student, Universitas Nasional, Indonesia

The distribution and abundance of native and invasive orangutan food resources across a disturbance gradient

Diana Castillo Diaz, PhD Candidate, Guangxi University, China

Assessment of seedling recruitment limitation among eight *Ficus* species in southern China

DELAND AWARD FOR STUDENT RESEARCH

Jenna Rindy, PhD Student, Boston University

Effects of urbanization and forest fragmentation on tree health: removal of fine particulate matter by forest trees

Yingtong Wu, PhD Candidate, University of Missouri

"Nature or nurture": studying the phenotypic distinctiveness of a rare endangered species, maple-leaf oak (*Quercus acerifolia*)

JEWETT PRIZE

Adam Negrin, Adjunct Assistant Professor, Lehman College (CUNY)

Phenology and localization of secondary metabolites in temperate caffeine-containing plants

Julie Dawson, Assistant Professor, University of Wisconsin

De novo assembly of a draft genome for the American hazelnut (*Corylus americana*)

KATHARINE H. PUTNAM FELLOWSHIP IN PLANT SCIENCE

Morgan Moeglein, PhD candidate, Yale University

Untangling contributions to leaf development in seasonal, woody plants

SARGENT AWARD FOR VISITING SCHOLARS

Tim Utteridge, Head of Science, Royal Botanic Gardens

Systematics of woody plants of New Guinea: curation and identification of specimens in Harvard University Herbaria

Ryan Fuller, PhD Candidate, University of Chicago

Assessing morphological variation and phylogeny of *Rhododendron* subsection *Lapponica* from China's Hengduan Mountains

SHUI-YING HU STUDENT/POSTDOCTORAL EXCHANGE AWARD

Zhengyang Wang, PhD Candidate, Harvard University

Untangling *Rhododendron* pollination networks along an elevational gradient in the Hengduan Mountains

THE SINNOTT AWARD

Bailey Cowart, Undergraduate Student, Boston University

Comparing stomatal arrangement in samara and leaves of trees in differing water availability



2020 Website Redesign The Arnold Arboretum Online

The Arnold Arboretum welcomed visitors from around the world to a new platform for exploring the institution, its plants, and every aspect of its mission with the launch of a newly designed website in 2020. A collaborative effort with Boston-based design firm Upstatement, the two-year project enabled staff to reimagine how to engage and inspire diverse audiences.

In 2020, more than 280,000 unique visitors from nearly 200 countries visited the Arboretum website. The COVID-19 pandemic and the need for interaction to move primarily to the digital space only intensified the need for an accessible, intuitive website to connect the public with the Arboretum and the more than 17,000 accessioned organisms it collects. Moreover, the redesign team sought to simplify and beautify the site, improve navigation, and integrate the many tools and digital resources the Arboretum has developed and made freely available to researchers, plant professionals, and the public. A commitment to “radical accessibility” led efforts to make the website more welcoming, more usable, and more responsive to the needs of our audiences.

Debuting in July, the Arboretum’s new website is wide-ranging, dynamic, and unique among botanical gardens and arboreta, with the Arboretum’s plants and their stories out in front. New digital features, such as Plant Bios, Walks, and Collections are created and curated by Arboretum staff and offer rich ways to experience the living collections from either desktop computers or mobile devices. On these pages, readers discover extensive background information on Arboretum plants drawn from archival collections, historical and contemporary photographs, and herbarium records.

Beyond these exciting new features, visitors will also discover user enhancements such as simplified navigation, improved search tools, and targeted sections for researchers and educators. Since nearly half of our online visitors engage via mobile devices, the site is fully responsive and meets a high threshold of modern accessibility standards.

Since its unveiling, the website has continued to highlight new stories and introduce new features, such as content translated into Spanish and Simplified Chinese. Along with a suite of other recent digital initiatives—including the *Expeditions* mobile app and the Landscape Management System—the new website offers fresh, multifaceted views into the Arboretum and its work for audiences around the world.

—Danny Schissler, *Project Manager*

Connecting with Trees

Expeditions Mobile App

In May, the Arboretum unveiled *Expeditions*, a new mobile application to help users explore the Arboretum’s landscape and plant collections. Featuring over 60 plants and sites, *Expeditions* shares stories about botany, conservation, and Arboretum history through photos, text, and audio segments. In particular, the app tells the story of nearly 150 years of Arboretum plant collecting, illustrating how (and why) these plants were brought here, whether gathered on remote mountainsides in Asia or just a few miles from our landscape.

Among the informative audio segments are more than 50 interviews with members of the Arboretum staff, sharing stories of their work and the Arboretum’s plants. *Expeditions* highlights the many facets of the Arboretum’s work and mission—from plant collecting and scientific research to children’s education—demonstrating that anyone can develop deep connection with the natural world. The app can be explored at home on desktop browsers or downloaded directly to mobile devices for use in the Arboretum landscape. Funded by the generosity of a friend of the

Arnold Arboretum to honor the exploration legacy of Senior Research Scientist Emeritus Peter Del Tredici, *Expeditions* is available in English, Spanish, and Simplified Chinese/Mandarin.

—Amy Heuer,
*Visitor Engagement
Fellow*



Tracing the History of Arboretum Plant Exploration

The redesign of the Arnold Arboretum website marshaled the efforts and expertise of staff from every department to help tell the story of the Arnold Arboretum, its plants, and its people. For the Horticultural Library and Archives staff, this presented an exciting opportunity to greatly expand and organize materials showcasing the Arboretum's century-and-a-half of work in global plant exploration, collection, and study.

The reimagined plant exploration pages incorporate narratives and materials daylighted in a previous web project, *Expeditions Unveiled*, a guide to 150 years of Arboretum plant collecting trips. Building on this content for the redesigned site required many hours of remote work by library staff, including bringing the story up to date with entries from expeditions mounted as part of the current Campaign for the Living Collections. Expedition pages include a wealth of information on each trip, including maps, diary entries, and even herbarium specimens. Importantly, each expedition is brought to life by historical photographs—a core collection of the archives—with rich descriptions of plants, people, and places depicted.

Plant exploration continues to be the primary means for collection development and supports international collaboration around the research and conservation of biodiversity. While the plant exploration pages on the new Arnold Arboretum website reveal much about the historical importance of this work, they also offer a glimpse into what it means for the future of the Arboretum and its global collaborators.

—Lisa Pearson, Head of the Library and Archives



Jared Rubinstein

The Nature of Shakespeare Sharing Plants and Performances

One perfect day in late summer 2020, a small troop of actors, a director, and videographer traveled through the Arboretum's landscape to film selections from the works of William Shakespeare. Incorporating scenes and sonnets with a focus on the natural world, the video production *The Nature of Shakespeare* marked the Arboretum's third collaboration with Actors' Shakespeare Project of Boston.

Presented online in two hour-long parts in October, *The Nature of Shakespeare* emerged to underscore the timeless connections between humans and their environment. Stories told by Arboretum staff of landscapes featured in the filmed segments melded with the Bard's sensibility of language and sensitivity to humanity's fraught relationship with nature. With themes that resonate deeply with our times, the collaboration offered a unique way to showcase the Arboretum and celebrate its many roles in the life of our community. At a time when many visitors could not visit on their own, *The Nature of Shakespeare* offered an intimate opportunity to enjoy the eloquent beauty of the Arboretum in harmony with the richness of Shakespeare's poetry and worldview.

—Sheryl White, Coordinator of Visitor
Engagement and Exhibitions



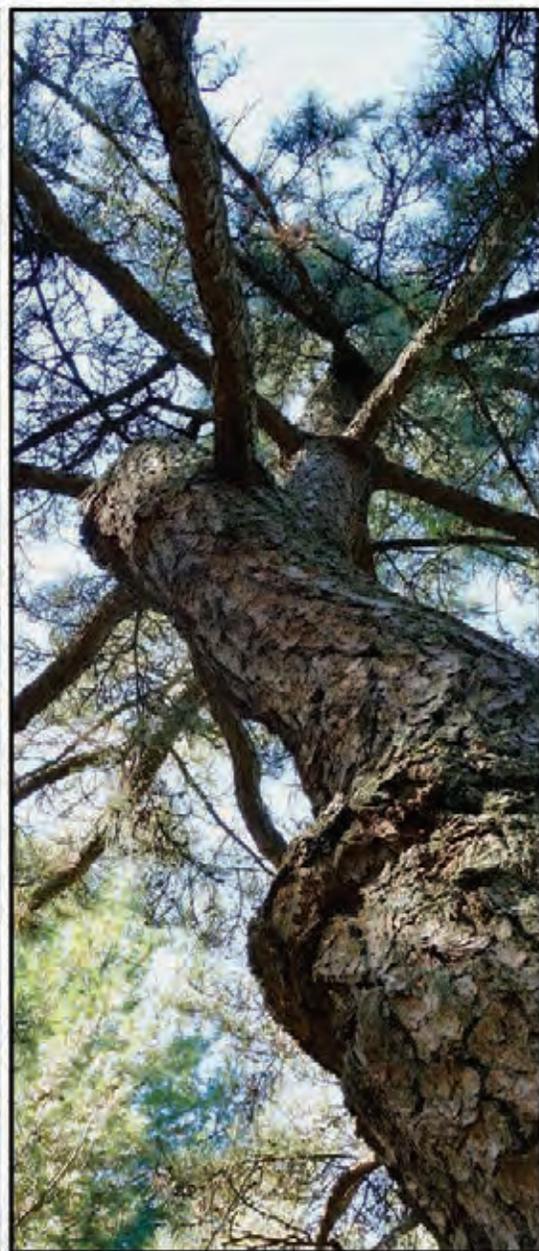
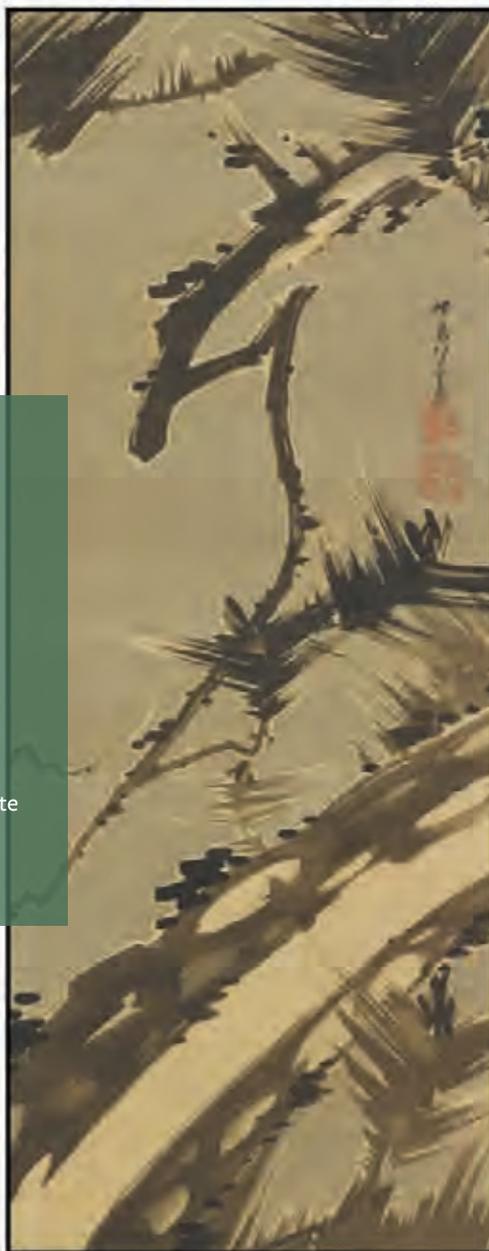
Sheryl White

Connecting to New Opportunities for Adult Education

In 2020, the Arboretum collaborated with Harvard Art Museums to present three online programs in conjunction with HAM's exhibition *Painting Edo: Japanese Art from the Fineberg Collection*. In addition, a field guide was created that paired Arboretum specimens with plants depicted in the exhibition's paintings, and the Visitor Engagement team offered workshops and opportunities for the public to write and share haikus on trees and nature.

Left: Itō Jakuchū, Old Pine, Edo period. Promised gift of Robert S. and Betsy G. Feinberg, Harvard Art Museums.

Right: *Pinus thunbergii*, William (Ned) Friedman.



For adult education, the year 2020 started out with great energy and plans laid out for a busy year. In January and February, we presented some of our standard winter workshops (topics included landscape design, winter tree identification, and biodiversity). We also hosted two of three scheduled speakers in the Director's Lecture Series: William (Ned) Friedman spoke about intercontinental disjuncts and Emily Broad Lieb discussed food waste policy. On International Women's Day, we hosted "Cultivating Space: Women in Horticulture and Place-making," a wonderfully successful half-day of presentations and panel discussion. Little did we know that this would be our last live event for the year.

On March 13, we were instructed to leave our offices for a one-or-two-week trial of remote working because of COVID-19. As March and April passed, it became evident that we weren't likely to return to our offices and in-person programming until, perhaps, September. Thus, we changed course and began presenting programs remotely via Zoom. In retrospect, this seems like such a tired, old story, but it was a giant leap.

What happened with Zoom was nothing short of amazing. Tree Mobs, which formerly engaged 15 to 50 participants in the Arboretum's landscape, now educated from 100 to 500 online learners. Lectures, which could accommodate up to 80 people live, now received from 300 to

700 registrants, and more than 1,500 in some instances. Programs once accessible only to those who could travel to the Arboretum in person became open to anyone with internet access, anywhere around the world. Based on feedback, we successfully "transported" attendees into the landscape, uniquely paired Arboretum plants and paintings through a collaboration with the Harvard Art Museums' *Painting Edo* exhibition, and kept members and new participants learning and engaged with their Arboretum. Most of our programs were recorded and are now available on our website and YouTube channel, for even more to enjoy.

—Pam Thompson,
Manager of Adult Education

Children's Education

Going ONLINE and Getting OUTSIDE

When the pandemic forced the cancellation of our Field Studies Experiences for elementary school students, staff in children's education and visitor engagement mobilized to keep nature programming at the Arboretum front and center in the communities they serve. Knowing that children and their families would need novel ways to learn from the Arboretum—while perhaps needing some emotional distance from the health crisis—the Arboretum made a quick pivot in spring 2020 to develop virtual educational programs and online opportunities with personal access to trees and nature as linchpins.

The first of these online programs to appear was Everyday Nature Tasks, a daily calendar of simple-to-execute, open-ended activities appropriate to all ages, with opportunities for deeper learning that children can explore on their own. Designed to highlight seasonal phenomena, the fun and creative tasks focused on a particular topic, like leaf margins or earthworms, and help children interact with nature, make careful observations, and record their observations in a journal. In this way, the

activities mirror the successful approach of the Arboretum's Field Study Experience programs in guiding children to cultivate scientific curiosity and the wonder of discovery in their own backyards.

With the immediate success of Every Day Nature Tasks and the strong desire to reconnect with visitors and families in the Arboretum landscape, staff in Children's Education and Visitor Engagement collaborated to introduce Arnold Arboretum Wonder Spots. Enriching, location-specific opportunities are designed to make self-exploration of the Arboretum landscape and its plant collections easy, fun, and enlightening. With topics related to plants, animals, and seasonal phenomena, Wonder Spots invite participants to study nature and science in actual location in the Arboretum landscape—yet can also be enjoyed from the comfort of home.

Everyday Nature Tasks and Wonder Spots provided the Arboretum's community with new ways to learn in the outdoors and offered powerful antidotes to the circumstances of the times. In addition to expanding the Arboretum's educational footprint both in and beyond its landscape, they continue to play a significant role in connecting children to the beauty and wonder of the natural world.

—Ana Maria Caballero, *Nature Education Specialist*



Everyday Nature Tasks and Wonder Spots provided the Arboretum's community with new ways to learn in the outdoors and offered powerful antidotes to the circumstances of the times.

Donors to the Arnold Arboretum

We deeply appreciate the donations to the Arnold Arboretum that have sustained our work this past year. With a dramatic increase in visitors in the landscape during the pandemic, our financial and staff resources have been stretched. The donations we have received, especially from the following significant donors of \$1,000 and above, have been invaluable to ensuring we could continue to keep our gates open, our pathways safe, and our landscape vibrant.

The following list reflects 18 months of donations from January 1, 2020, through June 30, 2021.

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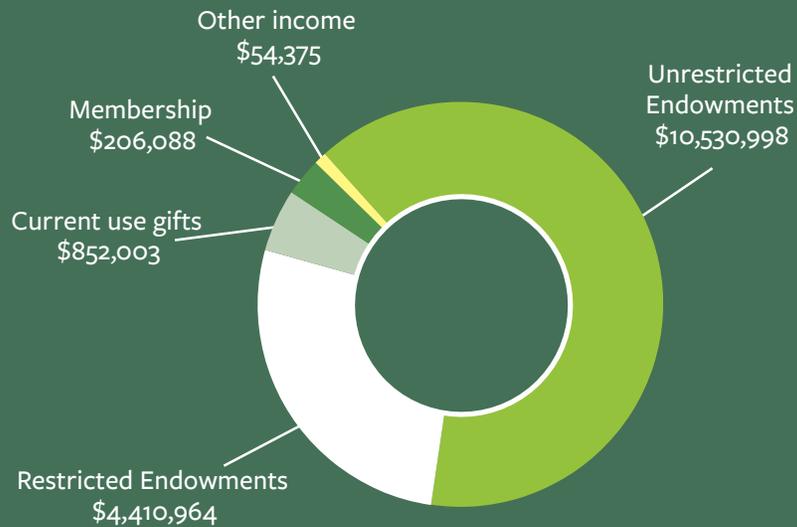
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Statement of Activities

The Arnold Arboretum of Harvard University relies almost exclusively on income derived from 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 2020 fiscal year (July 1, 2019–June 30, 2020).

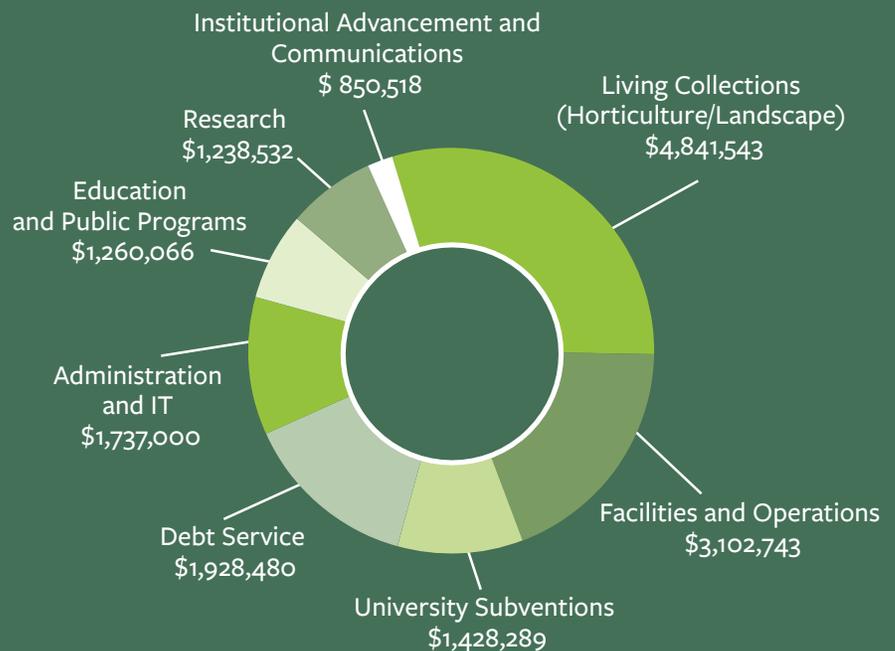
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INCOME: \$16,054,429



EXPENSES: \$16,387,169

NET CHANGE IN CASH \$(332,740)



The FY20 net change in cash reflects ongoing operations. Not included are \$2.8M of cash inflow to reimburse FY18-20 capital costs of the Weld Hill solar project from the Harvard Green Loan program; \$500,000 FY20 capital costs of the solar project (reimbursed per above); \$200,000 FY20 drought mitigation costs paid with FY19 donations; and \$250,000 of website redesign costs.



William (Ned) Friedman

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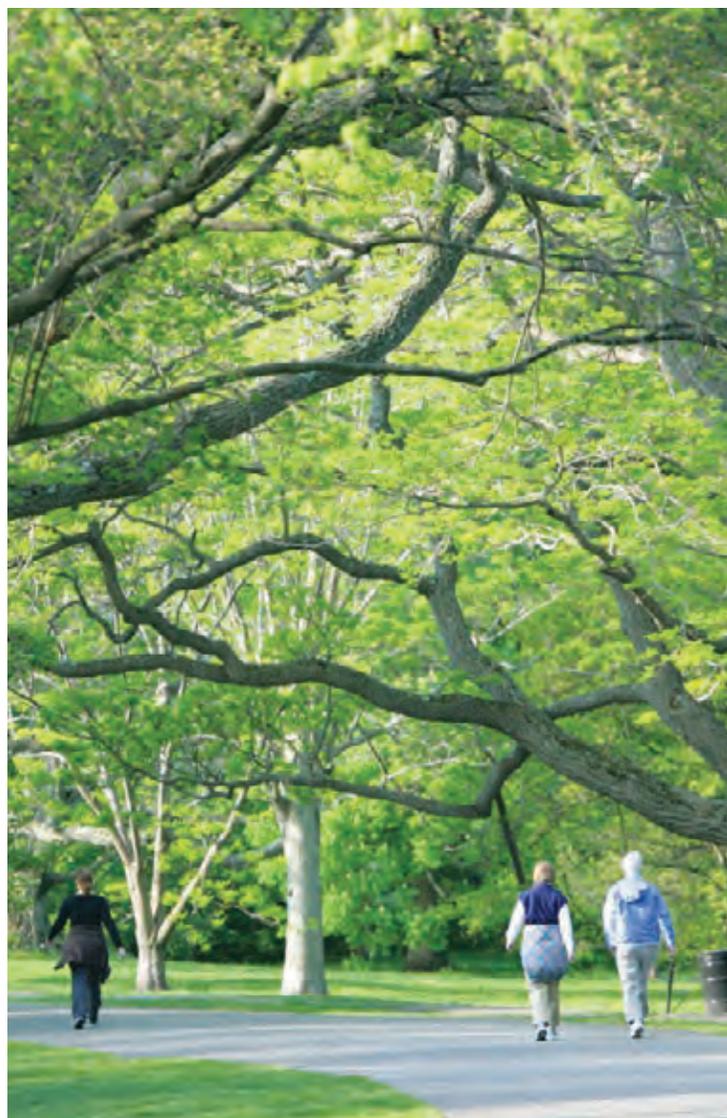
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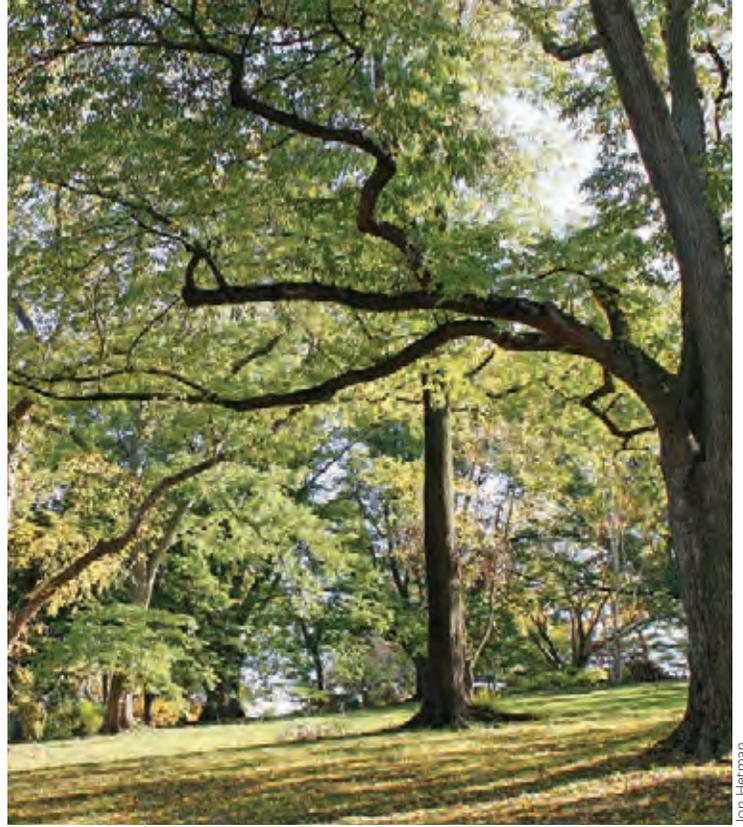
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TREE SPOTTERS

In its concluding year, the Tree Spotters citizen science program engaged 84 volunteers, logging 62,871 phenological observations of Arboretum plants for use in climate change research through the National Phenology Network. The program was moderated by Catherine Chamberlain, Suzanne Mrozak, and Danny Schissler. It continues today as a volunteer-run citizen science group at the Arboretum.



Research Publications

■ Arnold Arboretum Staff

■ Visiting Scholars, Fellows, and Associates



Award Recipient



Putnam Fellow



Research Intern

Blumstein M, **Hopkins R**. 2020. Adaptive variation and plasticity in nonstructural carbohydrate storage in a temperate tree species. *Plant, Cell & Environment*. pce.13959.

Blumstein M, Richardson A, Weston D, Zhang J, Muchero W, **Hopkins R**. 2020. Protocol for projecting allele frequency change under future climate change at adaptive-associated loci. *STAR Protocols*. 1(2):100061.

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Brach, AR. 2020. Pandemic digitization. *Arnoldia* 78(2): 2–4.

Clement, WL 🌱. 2020. New life for old collections. *Arnoldia* 78(1): 2–5.

Clerx LE, Rockwell FE, Savage JA, **Holbrook NM**. 2020. Ontogenetic scaling of phloem sieve tube anatomy and hydraulic resistance with tree height in *Quercus rubra*. *American Journal of Botany*. 107(6):852–63.

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De La Pascua DR, Smith-Winterscheidt C 🌱, Dowell JA, **Goolsby EW**, **Mason CM** 🌱. 2020. Evolutionary trade-offs in the chemical defense of floral and fruit tissues across genus *Cornus*. *Applications in Plant Sciences*. 107(9):1260–73.



Jon Hetman

Del Tredici, P. 2020. Closing the book on Sargent's weeping hemlock. *Arnoldia* 78(2): 8–33.

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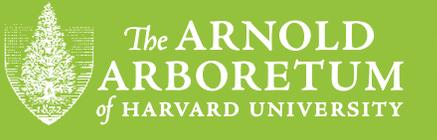
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