



The **ARNOLD**
ARBORETUM
of HARVARD UNIVERSITY



2011 ANNUAL REPORT

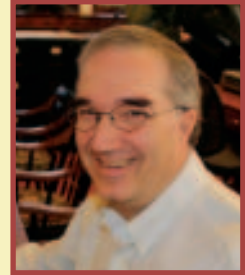


Jay Connor

The Arnold Arboretum of Harvard University

Founded in 1872 as the first public arboretum in North America, the Arnold Arboretum of Harvard University is a leading center for the study of plants and biodiversity. Its 265-acre landscape holds one of the most comprehensive and best documented collections of temperate woody plants in the world, with particular emphasis on the flora of the eastern United States and eastern Asia. The living collection supports research through comprehensive curatorial documentation, herbaria containing more than 1.4 million specimens, extensive library and archival holdings, and a state-of-the-art research center that opened in 2011. A resource for both scholarship and public education, the Arboretum offers programs for people of all ages to promote the understanding and appreciation of plants and their essential value to humankind. Open free every day, this jewel in the Emerald Necklace park system welcomes some 250,000 visitors annually and is among the most beloved open spaces in Boston.

Without question, the past year represents one of the most important periods of transition for the Arnold Arboretum of Harvard University in its 140-year history. In January 2011, we opened the Weld Hill Research Building, a 43,000 square-foot state-of-the-art research laboratory, plant growth facility, and teaching center. For the first time in more than 75 years—since Harvard’s Bussey Institution was transferred from Jamaica Plain to Cambridge—students and faculty scholars from Harvard, the Boston metropolitan area, and across the world have the means to fully access and investigate the more than 15,000 living plants and their associated documentation at the Arnold Arboretum. Simply put, this is a game changer.



Our resources at Weld Hill place our outstanding North American and Asian woody plant holdings at the center of our mission—to discover and disseminate knowledge of the plant kingdom to foster greater understanding, appreciation, and stewardship of Earth’s botanical diversity. At the Arboretum, our collections, landscape, and information technology resources enable us to support a broadly integrative set of research programs, including conservation and environmental biology, evolution and developmental biology, organismic and functional biology, and genomics. As the lines between these disciplines continue to fade through cooperation and new technologies, we have the opportunity to use our collections to approach plant science in new and compelling ways.

Weld Hill also embodies our responsibility as a university-based living collection to share what we learn and discover. This year we engaged in extensive discussions and planning to provide greater access to our work and collections, resulting in an ambitious expansion of our website. Online visitors may now explore the broad expression of science and learning at the Arboretum, from our newly expanded outreach education efforts for children and adults to the scope and depth of our collections.

In all of this we aspire to fundamentally change and enrich how people interact with plant collections and learn from them. In the months ahead, we plan to roll out new mobile technologies, engage more students in Boston Public School classrooms, offer citizen science opportunities, host urban ecology studies, and much more. In the following pages, we share some snapshots of our progress on this path and hope you will join us in discovering all that lies ahead.

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

Discovery



Rebecca Povilus

Optical section of an ovule of *Eschscholzia californica* (California poppy) before fertilization and development into a seed and plant embryo, respectively. Advanced resources available at Weld Hill—such as the laser scanning microscope that took this photograph—contribute significantly to the ease and efficiency of data collection and analysis.

Through 140 years of collecting and research, the Arnold Arboretum has played a critical role in shaping our understanding of plants and their environments. With new research facilities on site, the Arboretum possesses the means to expand its impact significantly.

As a center for the preservation and study of plant biodiversity, the Arboretum strives to serve as a nexus for scientists to integrate their approaches and make progress towards a more unified understanding of plants and their full complexity. Additionally, the Arboretum actively promotes scholarship that is derived from the opportunities presented by a world class collection of living organisms lying in direct proximity to advanced facilities for research.

Cultivating a New Center for Plant Research

State-of-the-art laboratories at Weld Hill build capacity for science



With the 2011 opening of new research facilities at Weld Hill, the Arnold Arboretum has amplified its capacity for botanical study and reasserted its leadership role in studying plant evolution, genetics, physiology, and ecology. With 43,000 square feet of laboratory, office, and lecture facilities, the Weld Hill complex positions the Arboretum and Harvard University to pursue important discoveries based on a platform of a world class collection of living plant biodiversity.

The laboratories and study spaces at Weld Hill enable Arnold Arboretum researchers and staff to engage in scholarly cooperation and exchange with scientists representing a wide range of disciplines from Harvard and from around the world. Open, shared laboratories and teaching spaces are designed to encourage collaboration and to foster a strong and dynamic intellectual community. Advanced greenhouses and growth chambers provide practical facilities and conditions to cultivate virtually any plant needed as the raw materials for study.

By relocating its research programs within sight of its extensive collections, the Arboretum honors its founding principal of cultivating and fully documenting wild-collected and domesticated

plants for their scientific use. Recent studies on biochemical signalling during conifer pollination, flower and fruit development in rose family plants, and modifications in leaf stomatal density tied to climate change have all benefited from this enhanced accessibility.

The resources at Weld Hill have also opened new opportunities for the Arboretum to participate directly in the education of Harvard undergraduates. A variety of classes and student groups have utilized Weld Hill spaces and equipment to supplement class activities and Arboretum field excursions. Last fall, Director William (Ned) Friedman, the Arnold Professor of Organismic and Evolutionary Biology at Harvard, offered a freshman seminar entitled “Getting to Know Charles Darwin.” Students read Darwin’s writings, including parts of his monumental work *On the Origin of Species* (1859), and recreated several of the famed Down House botanical experiments that were central to his theories regarding natural selection and evolution. Through this and similar institutional engagements, Weld Hill promises to forge closer bonds between the educational goals of the Arboretum and its parent university.

Biodiversity

An aerial photograph of a vast, dense tropical forest. The trees are lush green, with varying heights and canopy structures, creating a textured, layered appearance. The forest extends to the horizon under a clear sky.

An aerial view of Gunung Palung National Park, in West Kalimantan, Indonesia. Research plots established by Arnold Arboretum Senior Research Scientist Campbell Webb will enable his team to collect crucial data on tropical forest composition in this biodiversity hotspot.

In addition to cultivating and documenting one of the nation's most remarkable and diverse collections of woody plants, the Arnold Arboretum has long participated in efforts to study and preserve botanical diversity around the world.

Contributing to our understanding of the rich variety of woody plants on Earth remains one of the most important and enduring aspects of the Arnold Arboretum's work. In the midst of a genomics revolution that many characterize as the dawn of the "Century of Biology," the Arnold Arboretum is well positioned to build on its legacy and fully leverage its resources as one of the world's leading centers for the study of plants. With plant biodiversity as its unifying theme, the Arboretum conducts and supports research to advance knowledge about how plants function and develop, how they have evolved and diversified over time, and how they shape Earth's ecosystems.

Exploring a Biodiversity Hotspot

Arboretum scientists lead study of Indonesia's vanishing flora

Biodiversity varies greatly across Earth, with some areas—particularly the tropics—containing such a high level of endemic species that they are considered “hotspots.” Scientists believe that the thousands of islands comprising Indonesia may contain 10 percent of the world’s flowering plant species. However, timber harvesting, oil palm expansion, and the pressures of a population of more than 240 million people have drastically reduced Indo-



nesia’s lowland forests. These factors threaten to erase much of the country’s abundant plant life before it has been documented and understood by the scientific community.

In 2010, the Arboretum’s Senior Research Scientist Campbell Webb and Sargent Fellow Sarah Mathews received funding from the National Science Foundation to inventory and assess the plant diversity of the species-rich Indonesian archipelago. For three years, along with Indonesian collaborator Teguh Triono, Webb and his research team will photograph and collect plants in research plots on five Indonesian islands. Mathews will coordinate the analysis of molecular and genetic data from these specimens to determine their identity and to place the flora of Indonesia in an evolutionary context.

Field work for the project has pioneered new methods for recording tree species composition and environmental variables, amassing information that

illuminates both how the forests were assembled and how they will likely respond to environmental stresses and climate change. By offering training opportunities and joint expeditions with local scientists, and by participating in local park management efforts, Cam and his team also play a critical role in helping build capacity to preserve these forests. Thus, extensive information resources assembled by the project will not only increase our understanding of Indonesia’s biodiversity, but also contribute to the crucial endeavor of conserving its richness and vitality.



Above, the expedition set up a temporary research station in the interior basin of Gunung Palung National Park. Joining Cam was a team consisting of two local parataxonomists, two tree climbers, and several local villagers.

Above left, Cam Webb.

Cam Webb

Evolution

Director Ned Friedman (*at right*) and Post-doctoral Researcher Julien Bachelier observe plants in the greenhouses at the Weld Hill Research Building.



Unraveling Competition in Early Flowering Plants

As an evolutionary biologist, Director William (Ned) Friedman investigates the origin of flowering plants (angiosperms) and their subsequent diversification, often referred to as “Darwin’s abominable mystery.” Plant scientists have long theorized that the evolution of flowers led to an increase of insect pollination and triggered an intensification of competition among sperm donors—in this case among the tubes of pollen grains. In studying extant ancient lineages of flowering plants, Friedman and Post-doctoral Researcher Julien Bachelier discovered that angiosperms also may have benefited from an additional mechanism of gamete competition, but this time among egg-producing structures.

Evolutionary biologists have long viewed sexual competition as a “male function,” critical to ensure the genetic fitness of offspring and species survival. However, Ned and Julien showed that in *Trimenia moorei*—an Australian woody vine species that belongs to an ancient group of flowering plants—

the pattern of development and growth of the egg-producing structures are very similar to those of well-studied pollen tube competition. Over time, as many flowering plants co-evolved with their pollinators to form incredibly complex pollination mechanisms that ensure larger pollen loads and intense pollen tube competition, the phenomenon of female competition may have become obsolete.

This research was published in the *Proceedings of the National Academy of Sciences* and selected by the Faculty of 1000 as a must read. While many questions remain, studying the reproductive structures and strategies in extant ancient lineages of flowering plants provides insight into their origins and the essence of their complexity. Through this research and other investigations, the Arnold Arboretum seeks to expand our understanding of angiosperms, which represent the most numerous component of our terrestrial environment and a critical part of our food supply.

Gymnosperms and the Tree of Life

Resolving evolutionary relationships among non-flowering seed plants

For more than 150 years, scientists have been working to reconstruct the evolutionary relationships among species—both living and extinct—to understand how they fit together in the great Tree of Life. The advent of more efficient and less expensive genome sequencing technologies is rapidly pushing forward this effort, although with millions of organisms still unknown to science, the undertaking is monumental. Assembling the Tree of Life, a major research initiative of the National Science Foundation, represents a systematic attempt to decipher the genealogical history of life on Earth. In 2011, a scientific team led by Arnold Arboretum Sargent Fellow Sarah Mathews continued work on a five-year research effort to place all non-flowering seed plants (gymnosperms) on the Tree of Life.



Extant gymnosperms include approximately 1,100 species that are divided into four relatively ancient groups: cycads, *Ginkgo*, conifers, and gnetophytes. Compared with their flashier and far more numerous relatives, the angiosperms (flowering plants), gymnosperms have not been studied as extensively. However, exploring gymnosperms is essential to enhancing our understanding of the origins of angiosperms, and can provide key insights into basic questions about the evolution, morphology (physical form and external structure), and distribution of plants throughout the world.

As the principal investigator for the project, Mathews coordinates research activities in collaboration with plant experts at a number of North American universities. Her own laboratory focused its contributions on exhaustively sampling genetic material from living gymnosperm species, including many

in the living collection of the Arnold Arboretum. Her project colleagues also collected and analyzed morphological data on a core set of approximately 200 living species to make comparisons with the fossil remnants of extinct gymnosperms. The project's findings will be incorporated into a number of online resources, such as Tolkin.org and Encyclopedia of Life.

Mathews and her team hosted two symposia at the 2011 International Botanical Congress to present the project's results and support the synthesis of the collected data. She also has been collaborating with botanical gardens and arboreta to offer workshops for high school teachers demonstrating the use of living collections to teach basic concepts in biology and evolution—the centerpiece of the project's outreach efforts. Resolving the relationships of all known species on the Tree of Life remains one of the great challenges of the coming decades, and research using the Arboretum's living collection will continue to contribute to this vast undertaking.



Above, Sargent Fellow Sarah Mathews with colleagues and guides on a conifer collecting expedition on Mount Wilhelm in Papua New Guinea. **Above left**, Sarah Mathews.

Exploration



Tony Aiello

Curator of Living Collections Michael Dosmann (at left, kneeling) and his partners in the NACPEC Collecting Team gather specimens in Hong He Gu Forest Park in China's Shaanxi Province.

The Arboretum assembled its rich collection of plants through more than a century of plant exploration, and this work continues to play a fundamental role in shaping and stewarding the collection to fulfill its mission of research, conservation, and education.

By facilitating expeditions of its own design and collaborating with institutional partners worldwide, the Arnold Arboretum participates in multiple initiatives to explore botanical diversity at the regional, national, and global levels. Sourcing material from wild populations ensures its value for scientific study, whether as an accessioned plant for the living collection, a pressed specimen for the herbarium, or as germplasm for long-term preservation. Information obtained through plant exploration also supports efforts to protect plants and healthy environments in the face of habitat loss and global change.

Plant Exploration—a Collective Matter

Integrating efforts to identify, collect, and preserve China's biodiversity

The Arnold Arboretum amassed its world-class collections of living plants and herbarium specimens through a longstanding commitment to plant exploration, an often arduous approach that has nonetheless proven enormously



effective in collections development. More than a century of plant acquisition in Japan, Korea, and China made the Arboretum's holdings of Asian temperate woody plants among the most significant in the world outside of Asia. This work contin-

ues today, both on Arboretum-sponsored expeditions and through institutional collaborations. In fall 2010, Curator of Living Collections Michael Dosmann collected plants in China as the Arboretum's representative for the North America-China Plant Exploration Consortium (NACPEC).

Dosmann travelled for three weeks in parts of Shaanxi, Hebei, and Beijing Provinces. The expedition secured 42 unique seed and herbarium collections, including species of maple (*Acer*) and ash (*Fraxinus*), a number of which are new to the Arboretum. NACPEC expeditions have contributed significantly to holdings in the genus *Acer* among member institutions, five of which—including the Arnold Arboretum—hold national collections of maples as a bulwark for conservation. Ashes have also become a vital target for NACPEC, as plant scientists seek remedies to the emerald ash borer's (*Agrilus planipennis*) devastation of American ash populations. One of NACPEC's targeted ashes, *F. paxiana*, is being studied as a key species in horticultural efforts to cultivate ashes resistant to the pest.

Since 1991, NACPEC members have made a total of 14 botanical expeditions in China, searching for targeted species in varying climatic areas, habitats, and ecosystems across a wide geographic range. NACPEC seed collections are shared among participating institutions and integrated into their living collections. Efforts directed at individual taxa may include conserving vanishing species, selecting improved ornamental forms, and—after thorough testing and evaluation—introducing appropriate new species to Western gardens.

Identifying tough, adaptable plants that can thrive in the face of escalating ecological challenges represents a vital goal aligning the missions of NACPEC and the Arnold Arboretum. The rigorous documentation of these plants and their native ecologies, however, remains the most important shared value of NACPEC member institutions. The cultural and scientific exchanges that extend from NACPEC's partnerships play an essential part in the Arboretum's efforts to both understand and conserve China's remarkable biodiversity.



Above, the fall 2010 NACPEC collecting team in Shaanxi Province included (left to right) collecting assistants Mr. Zhou, Mr. Dong, and Mr. Liu; Tony Aiello of the Morris Arboretum; Michael Dosmann of the Arnold Arboretum; and Kang Wang of the Beijing Botanical Garden. **Above left**, Michael Dosmann.

Conservation

Jon Hetman



Rhododendron vaseyi, an azalea native to eastern North America, is one of several threatened plants collected by the Arboretum in cooperation with the Center for Plant Conservation. **Left**, former Putnam Fellow Abby Hird coordinated an assessment of conservation plants held by North American botanical institutions.

Quantifying American Plant Conservation Efforts

The Arnold Arboretum built its capacity for botanical research through more than a century of collecting, distributing, and studying plants from around the world, including those threatened in their native habitats. Whether cultivating endangered native plants for the Center for Plant Conservation or expanding holdings for its six national collections in concert with the North American Plant Collections Consortium, the Arboretum's collections safeguard many species threatened with extinction today and those at risk of disappearing in the future.

To better understand the scope and influence of these efforts, 2008-09 Putnam Fellow Abby Hird developed a systematic approach to assess and manage conservation-status plants at the Arboretum, creating a methodology that has been adopted by other botanical institutions. Partnering with the US office of Botanic Gardens Conservation International (BGCI-US) and the United States Botanic Garden, the Arboretum worked with Hird to expand her assessment to all botanical institutions

on the continent, to benchmark progress on global conservation goals established by the United Nations Convention on Biological Diversity.

Through a comprehensive survey of North American botanical institutions, the partners were able to identify, for the first time, the threatened North American species currently maintained in *ex situ* collections and detect gaps for further development. The results of the assessment were published in early 2011 in *Conserving North America's Threatened Plants*, a BGCI-US progress report on attaining targets set by the Global Strategy for Plant Conservation (GSPC). Based on data surveying 230 North American collections, Hird and her colleagues determined that just 39% of the 9,496 North American threatened taxa are maintained in germplasm or living plant collections in North America. The report provides a clear picture of where collections on this continent stand in regard to conserving threatened plants, and represents a call to action for gardens to acquire those species not currently represented in seed banks or living collections to insure against future loss.

The Dynamics of an Urban Wild

Bussey Brook Meadow designated as a site for long-term environmental studies

As we strive to make our cities more hospitable to living organisms, the need has intensified for sites where the systems of urban ecology can be studied over time. No institution could be better situated or prepared than the Arnold Arboretum to make a major impact in this emerging area of scholarship. A report published by the City of Boston Environment Department in 2000 included the Arnold Arboretum's Bussey Brook Meadow in its inventory of the city's significant "urban wilds"—areas that are allowed to grow naturally with minimal human interference. Unlike many of the locations included on the list, the 24 acres that make up Bussey Brook Meadow offer an ideal site for scientific study, because it is protected through the Arboretum's parkland indenture with the City of Boston and not subject to loss from future development.

In 1996, the Arboretum Park Conservancy partnered with the Arboretum to preserve this landscape, which was assembled from parcels of land that formerly belonged to the MBTA, the City of Boston, and Harvard University. Under the current management regimen, the meadow serves as a site where Arboretum scientists and visiting scholars can document long-term changes in plant succession and measure ecosystem functions including vegetation structure, wildlife abundance, phenology, and biogeochemical cycling. In addition, the Arboretum continues to maintain the Blackwell Path which crosses the parcel as a pedestrian link from the Forest Hills subway station to the historic Arboretum landscape.

In the past year alone, Bussey Brook Meadow has spurred four separate studies by researchers from Tufts and Boston Universities, and has been



Peter Del Tredici

The use of Bussey Brook Meadow as a site for urban ecological studies contributes to an important and rapidly growing field of plant science. Observations of spontaneously occurring plants, like the chicory and Queen Anne's lace pictured here, provide insight on a variety of botanical and environmental questions.

used by students from the Harvard Graduate School of Design, Harvard Medical School, and Brandeis University. The Arboretum has become a participatory member of two ULTRA-Ex (Urban Long-Term Research Area) exploratory projects funded by the National Science Foundation and USDA Forest Service. One is coordinated by the Geography Department of Boston University, while the second is a multi-institutional endeavor coordinated from the University of Massachusetts, Amherst. As such, Bussey Brook Meadow has become a permanent site for monitoring spontaneous urban ecology that can only become more valuable in efforts to assess these environments over time.

Collections



Jon Hetman

Comprising living plants, herbarium specimens, and library and archival holdings, the collections of the Arnold Arboretum are among the largest and best documented in the world, and represent one of the most significant resources for the study of Asian flora held outside of Asia.

As one of the museums that makes Harvard University a leader in the sciences, the Arnold Arboretum stewards collections that contribute to a greater understanding and appreciation of the natural world. In addition to a renowned living collection of temperate woody plants, the Arboretum curates important collections of pressed plant specimens and extensive library and archival resources. By enlisting new technologies, staff endeavor to expand how these collections are shared with scientists and the public around the world.

A REVITALIZED AND IMPROVED GARDEN FOR ROSACEOUS PLANTS

Bradley Rosaceous Collection undergoes a three-year renovation

The Arboretum's 2007 restructuring of horticultural maintenance procedures has created opportunities for staff to collaborate on long-term projects to enhance landscape infrastructure, elevate the breadth and value of the living collection, improve growing conditions, and enhance the visitor experience. One example is the renovation and redesign of the Bradley Rosaceous Collection, a three-year initiative to improve this garden of rose family plants. Partnering with landscape designer Julie Moir Messervy, the Arboretum restructured the arrangement of the collection to strengthen presentation and boost the quality of horticultural displays, improve circulation through the collection, and enhance opportunities for educational enrichment. The renovation also enabled the Arboretum to critically reassess one of its major plant collections from top to bottom, reconsidering the scope of rosaceous plants represented in the garden and assessing the curatorial value of individual plants in the collection.

Implemented by Arboretum staff and made possible through a fund established by the garden's original benefactor, Eleanor Cabot Bradley, the renovation marks the most significant change to the collection since its 1985 dedication. In 2009, the Arboretum implemented the redesign of the southern half of the Bradley Rosaceous Collection. Several planting beds along Forest Hills Road were removed in the *Prunus* (cherry) collection for the establishment of a "Cherry Promenade," and displays at the garden's center were reshaped to accommodate the creation of an orchard, improve movement through the collection, and enhance views from the interior of the garden. Redesign of the "Rose Roundabout" section in the northern




Jon Hetman

Above, Arboretum horticulture staff replant species and ornamental rose accessions in the Rose Roundabout area of the Bradley Rosaceous Collection.

portion of the garden commenced in 2010, and involved a curatorial review of existing plants and a reconfiguration of the planting beds for a more effective display. In 2011, these amended beds were replanted with a combination of original accessions and recently-collected specimens of roses.

In spring 2011, a wrought iron rose arbor was installed in the garden's Rose Roundabout to honor Elizabeth Cabot Sluder, a longtime rosarian, Arboretum supporter, and the daughter of the collection's benefactor. Created by local metal artist Peter Andruchow, the arbor was commissioned through the thoughtful contributions of Mrs. Sluder's extended family, and features accessions of two excellent climbing roses, *Rosa* 'New Dawn' and *R.* 'Sombreuil'. A second arbor was added to the Bradley Rosaceous Collection later in the season to establish a dedicated entrance for the garden along Meadow Road.



The Arboretum's collection of plants in the *Malus* (apple and crabapple) family has been the subject of a major effort to improve the condition of individual plants while verifying their taxonomy.

REJUVENATING THE *MALUS* COLLECTION

In *Flowering Crabapples: The Genus Malus* (1994), famed plantsman Father John Fiala refers to the Arnold Arboretum as “the mother arboretum” for flowering crabapples. Honoring this horticultural legacy, the Arboretum is conducting a comprehensive reassessment and rejuvenation of its 455-specimen *Malus* collection to improve its health, further its potential for collections-based research, and enhance its appeal to visitors.

With the help of the Arboretum's curatorial and horticultural staffs, Apprentice Miles Schwartz Sax initiated a comprehensive curatorial assessment of the collection last fall and applied an additional boost of horticultural care. The project centers on evaluating the Arboretum's historic and current holdings, identifying propagation targets to preserve historic lineages, and acquiring new cultivars and species to expand and enhance the collection. Through the comprehensive verification of fruit and flower characteristics for all trees in the collection, Miles has identified a number of plants that staff will continue to track for exceptional ornamental qualities and performance potential.

Originally established near the Forest Hills Gate and adjacent to other members of the Rosaceae (rose family), the collection was anchored by native species and Asian introductions collected by Charles Sprague Sargent and Ernest Henry Wilson. As the Arboretum continued to acquire and cultivate more species and botanical varieties of crabapples, the collection outgrew its space along Forest Hills Road and a supplementary display was established on the northern slope of Peters Hill. Today the collection includes original accessions of landmark Arboretum *Malus* introductions like *M.* ‘Blanche Ames’, *M.* ‘Mary Potter’, and *M.* ‘Donald Wyman’.

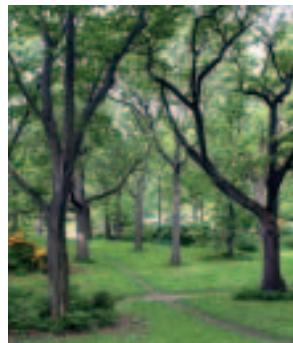
In addition to the ornamental interest the collection manifests in both flower and fruit, the scope and diversity of the Arboretum's holdings of *Malus* furnish a major resource for research. The collection has contributed to a wide variety of studies, ranging from basic plant taxonomy and systematics to orchard-crop physiology. Varieties cultivated here—attended by a century of rigorous documentation—may further contribute to ongoing efforts to evaluate and select superior cultivars based on their aesthetic value, insect and disease resistance, and cold hardiness.

Arnold Arboretum Collections at a Glance

Living Collections

As of June 2011, the living collections of the Arnold Arboretum comprised **14,937** individual plants belonging to **10,083** accessions and representing **2,166** species.

- Additions to the permanent collections: **303**
- Removals from the permanent collections: **249**
- Distributions to outside scholars and gardens: **457**
- Field checks of accessioned plants: **8,920**



Herbarium Collections

As of June 2011, the Herbarium of the Arnold Arboretum (A) housed in Cambridge at the Harvard University Herbaria held **1,433,988** mounted plant specimens. Also as of this date, the Cultivated Herbarium of the Arnold Arboretum held **133,259** specimens, of which **46,525** represented collections from accessioned plants.

- Herbarium specimens added to the Herbarium of the Arnold Arboretum (A): **5,941**
- Percentage of the living collection represented by specimens in the Cultivated Herbarium: **53%**



Library and Archival Collections

As of June 2011, the Horticultural Library of the Arnold Arboretum comprised **18,761** books; **10,500** periodicals; **47,000** film/video/photographic items; **18,000** digital images; and **427** linear feet of archival materials representing **325** separate collections.

- Volumes added to the collection: **630**
- Periodicals added to the collection: **706**
- Archival pages added to website: **1,058**
- Hours contributed by library interns: **840**
- Exhibitions mounted of library and archival holdings: **8**



Education



Director Ned Friedman and students examine wild cucumber plants in the Weld Hill greenhouses in his Harvard freshman seminar on Charles Darwin.

From pre-schoolers and elementary school students who participate in field studies, to Harvard students who are instructed in Weld Hill laboratories, and members of the community who participate in programs for personal and professional development, the Arnold Arboretum provides a lifetime of learning about plants and the natural world.

As a university-based living collection, the Arnold Arboretum shares a wealth of knowledge with the public in a way that is engaging, substantive, and long-lasting. Outreach efforts for education currently include children's education programs, adult education classes and lectures, and initiatives for visitor education. Now with the addition of dedicated teaching labs and learning facilities located in the Weld Hill Research Building, the Arboretum is positioned to enhance its contribution to the instruction of students at Harvard University and other institutions of higher learning in Boston.

Taking the Arboretum to Classrooms

Partnership nurtures young scientists at the Boston Teachers Union School

For nearly three decades, the Arboretum's programs for education have featured field studies in the Arboretum landscape for pre-school and elementary school students from public schools in the Boston Metropolitan Area. Programs enable students to visit the Arboretum to explore the collections and learn about such topics as plant and floral morphology, seed dispersal, and changing ecosystems. More recently, these efforts have extended from the landscape to the classroom through a program designed to enhance science instruction for students at the Boston Teachers Union (BTU) School in Jamaica Plain.

As part of a unique collaboration with a neighboring school, Arboretum educators Nancy Sableski and Ana Maria Caballero began visiting BTU School classrooms last fall to assist its faculty in teaching science to pre-school, Kindergarten, first grade, and second grade students. While lessons include hands-on investigations of plants

that draw on the successes of the Arboretum's field study experiences, the curriculum also facilitates a broad understanding of general science including topics like air and weather, earth and geology, and insect life. Students gain scientific literacy through discussion, experimentation, and sharing their observations with fellow classmates, participating in thought-provoking activities that foster curiosity about nature and the physical world.

Across learning levels at the school, these experiences help kids exercise reasoning skills and form logical connections between science and everyday activities. Lessons also stress the acquisition and internalization of specific scientific vocabulary intended to improve language proficiency and enhance future investigations. By recording their observations through words and drawings in their own science journals, students practice the art of documentation as an integral part of the scientific method. Journaling not only helps the students learn how to conduct their experiments like real scientists, it also instills a value for sharing knowledge that lies at the heart of the Arboretum's mission.

Collaborating with the BTU School has opened new avenues of discovery for both students and their instructors, and teachers and parents have reported a marked growth in the children's aptitude and enthusiasm for learning science. In addition to assisting in the classroom, Arboretum educators also led field study experiences in the Arboretum landscape for the students, inviting them to expand on their indoor experiments through an exploration of the living collection. The program's accomplishments have inspired discussions with school educators to further enhance how both students and teachers experience the Arboretum as a landscape for learning.



Nancy Sableski

Above, science lessons for students at the Boston Teachers Union School include field study visits to explore living organisms in the Arboretum's vast collection of plants.

From Species Descent to Silverswords

Director's Lecture Series Shares Perspectives on Current Science

Leveraging the strength of its collections, research and scholarship, and staff expertise, the Arnold Arboretum offers educational programming to engage the public toward a deeper understanding of the plant kingdom. When Director William (Ned) Friedman arrived in January 2011, one of his first orders of business was to work with staff to improve how the Arboretum fulfills this mission for the benefit of the communities it serves. The launch of a major expansion of the Arboretum website originated with this vision, and has significantly transformed how the Arboretum shares its work and resources with global audiences. Closer to home, the establishment of the Director's Lecture Series offers local constituents an accessible and compelling forum to connect with the Arboretum and current science.

"One of the greatest things about a university like Harvard is the opportunity it gives students to gain exposure to a diversity of viewpoints and to think critically about important societal issues," Ned explains. "With the Director's Lecture Series, we're bringing this fundamental aspect of university life to our neighbors and inviting them to join our pursuit of new ideas and a more nuanced understanding of our world. It's another way we can engage the public in a dynamic and ongoing conversation about science."

The series offers an annual slate of talks by internationally recognized experts on an array of contemporary topics, from plants and ecosystems to initiatives for conservation. Introducing the 2011 series with a talk of his own, Ned revealed the many theorists and writings that inspired Charles Darwin's lifelong search for the genesis of Earth's astounding biodiversity. Exploring cultivation and ecology, Professor Alan Townsend of the University of Colorado at Boulder discussed how the drivers of modern agriculture—nitrogen and phosphorous—have both improved productivity and created enormous challenges for our ecosystems. On the conservation front, University Distinguished Professor Robert

Robichaux of the University of Arizona shared his experiences combating invasive species and protecting vanishing flora on the species-rich Hawaiian Islands. The closing lecture featured the Honorable US District Court Judge John Jones III, who brought his unique perspective and insights in discussing his ruling in *Kitzmiller v. Dover* (2005) that it is unconstitutional to teach the concept of intelligent design as an alternative to the theory of evolution in public schools—a topic highlighting the intersection of science, law, and public opinion.

The Director's Lecture Series honors the Arboretum's historical commitment to provide lasting educational experiences to the public. The 2011 series proved a great success, drawing some of the largest numbers of lecture participants in recent memory. With a similar response seen in the 2012 lineup, the future appears bright for this unique program for community engagement.



Robert Robichaux

A lecture by Professor Robert Robichaux illustrated efforts that he and others have championed to study and preserve Hawaii's threatened endemic flora, like the silverswords (*Argyroxiphium sandwicense*), *above*.

Educational Outreach and Visitor Engagement



Children's Education Programs

During the 2010–2011 school year, the Arnold Arboretum conducted field study programs for Boston area students in pre-school through the fifth grade. During this period, Arboretum educators also participated in teaching science to students at a neighborhood elementary school.

- Field Study Programs conducted: **55**
- Classes Participating in Field Studies: **95**
- Number of children participating in Field Study Programs: **1,839**

Adult Education Programs

The Arboretum offers a variety of learning opportunities for adults centered on its collections of temperate woody plants and the expertise of staff. Courses, workshops, and lectures provide continuing education in botany, horticulture, the landscape and garden arts, and related disciplines.

- Classes/Lectures scheduled: **91**
- Classes/Lectures conducted: **79**
- Registrants to programs: **1,739**
- Partnering organizations for programs: **9**

Visitor Education Programs

Free and open to the public every day of the year, the Arnold Arboretum connects with the visiting public through the Visitor Center in the Hunnewell Building, as well as through interactions with docent tour guides, volunteer interpreters stationed in the landscape, and a variety of special programming and opportunities for families.

- Estimated visitors: **approximately 250,000**
- Visitor Center: **approximately 40,000**
- Guided Tours: **170**
- Tour Attendance: **1,715**
- Interpreter Interactions: **2,020**
- Volunteer Hours: **3,208**

Statement of Activities

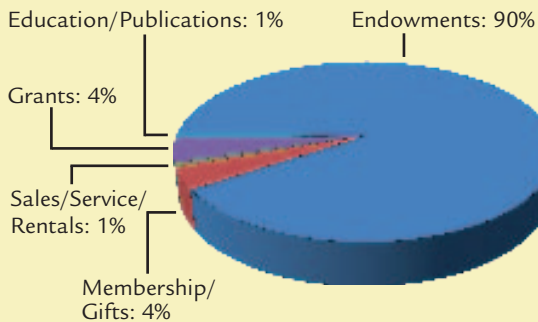
Fiscal Year 2011: June 30, 2010—July 31, 2011

Beyond funding secured for sponsored research, the Arboretum largely relies on the past and present philanthropy of its friends and members who, for 140 years, have given generously to the institution. The tables and figures here reflect the financial health of the Arnold Arboretum of Harvard University.

INCOME

Endowments	11,168,463
Membership/Gifts	487,425
Sales/Service/Rentals	76,328
Grants	539,515
Education/Publications	46,540

Total Income: 12,318,271

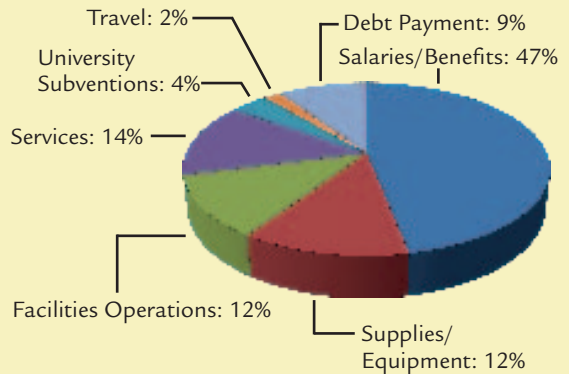


EXPENSES

Salaries/Benefits	5,946,079
Supplies/Equipment	1,585,121
Facilities Operations	1,479,442
Services	1,748,398
University Subventions	518,203
Travel	214,857
Debt Payment	1,190,982

Total Expenses: 12,683,082

Excess (Loss): (364,811)



Arnold Arboretum Staff

January 1—December 31, 2011

Administration

- Donna M. Barrett, *Accounting Associate*
- Cynthia Cushman, *HR/Payroll Associate*
- Amie Evans, *Executive Assistant*
- William (Ned) Friedman, *Director*
- Amina Hussain, *Human Resource Consultant*
- Andrea Nix, *Director of Administration and Finance*
- Karen Marie Pinto, *Staff Assistant*
- David J. Russo, *Facilities Manager*
- Tracy Smith, *Assistant Facilities Manager*

Curation

- Jonathan Damery, *Curatorial Assistant*
- Michael Dosmann, *Curator of Living Collections*
- Susan Hardy Brown, *Curatorial Assistant*
- Kyle Port, *Manager of Plant Records*
- Kathryn Richardson, *Curatorial Assistant*
- Samuel Schmerler, *Curatorial Fellow (until 12/6/11)*

Horticulture

- Kevin Block, *Horticultural Technologist*
- Matthew Connelly, *Horticultural Technologist*
- John S. DelRosso, *Head Arborist*
- Robert Ervin, *Arborist*
- Kirsten Ganshaw, *Horticultural Technologist*
- Scott Grimshaw, *Horticultural Technologist*
- Dennis Peter Harris, *Horticultural Technologist*
- Wesley Kalloch, *Horticultural Technologist*
- Jennifer Kettell, *Horticultural Technologist*
- Brendan McCarthy, *Horticultural Technologist*
- James Papargiris, *Working Foreman*
- Sue Pfeiffer, *Horticultural Technologist*
- Nima Samimi, *Gardener*
- Miles Schwartz Sax, *Apprentice*
- Stephen W. Schneider, *Manager of Horticulture*
- Kyle Stephens, *Arborist*
- Mark Alan Walkama, *Horticultural Technologist*

Greenhouse

- John Herbert Alexander III, *Plant Propagator*
- Bob Famiglietti, *Greenhouse Horticultural Technologist*
- Irina Kadis, *Greenhouse Curatorial Assistant*
- Oren McBee, *Greenhouse and Nursery Manager*

Information Technology

- Stephen Hill, *Systems Administrator*
- George Morris, *Director of Information Technology*
- Donna Tremonte, *Applications Programmer*

Library

- Sheila Connor, *Horticultural Research Archivist*
- Larissa Glasser, *Library Assistant*
- Lisa E. Pearson, *Library Assistant*

Education and Public Programs

- Marc Devokaitis, *Visitor Education Assistant*
- James Leighton, *Visitor Education Assistant*
- Michael Prusak, *Visitor Education Assistant (until 3/28/11)*
- Maggie Redfern, *Visitor Education Assistant*
- Nancy Sableski, *Manager of Children's Education*
- Pamela Thompson, *Manager of Adult Education*
- Julie Warsowe, *Manager of Visitor Education*
- Sheryl L. White, *Visitor Education Assistant*

External Relations and Communications

- Sheila Baskin, *Development Assistant (until 8/11/11)*
- Jon Hetman, *Communications & Stewardship Officer*
- Wendy Krauss, *Membership Coordinator*
- Jennifer Leigh, *Development Database Specialist*
- Barbara Murphy, *Development Assistant (from 3/1/11)*
- Audrey Rogerson, *Director of Development*
- Nancy Rose, *Editor of Arnoldia*

Research

- Julien B. Bachelier, *Postdoctoral Fellow*
- Stuart Davies, *Director of Asia Programs*
- Peter James Del Tredici, *Senior Research Scientist*
- Liz Delaney, *CTFS Program Manager*
- William (Ned) Friedman, *Arnold Professor of Organismic and Evolutionary Biology*
- Erin Kurten, *Postdoctoral Fellow (until 9/24/11)*
- Sara Lischynsky, *CTFS-AA Program Assistant (until 9/9/11)*
- Sarah Mathews, *Sargent Fellow*
- Brian Morgan, *Putnam Research Fellow (until 9/21/11)*
- Rebecca Povilus, *Graduate Student*
- Cary Pirone, *Putnam Research Fellow*
- Richard Ragin, *Director of Research Administration (until 9/1/11)*
- Faye Rosin, *Director of Research Facilitation*
- Francesca Secchi, *Mercer Fellow*
- Kurt Schellenberg, *Research Assistant (until 4/5/11)*
- Wayne Takeuchi, *Tropical Forest Biologist (until 6/30/11)*
- William Tootle, *CTFS-AA Program Manager (until 1/7/11)*
- Campbell Webb, *Senior Research Scientist*
- Maciej Zwieniecki, *Sargent Fellow*



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