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The Magazine of the Arnold Arboretum

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The ARNOLD ARBORETUM of HARVARD UNIVERSITY

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Front cover: Coastal azalea (*Rhododendron atlanticum*, accession 108-2007-D) is one of the North American deciduous azalea species in the Arboretum's Living Collections being studied by Alex Susko from the University of Minnesota. Photo by Nancy Rose.

Inside front cover: Kyle Port captured this unique early autumn view from the Arboretum's Meadow looking toward the Hunnewell Building, featuring blooming Jerusalem artichokes (*Helianthus tuberosus*), a prominent specimen of dawn redwood (*Metasequoia glyptostroboides*, accession 524-48-AA), and the early-coloring red maple cultivar 'Schlesingeri' (*Acer rubrum* 'Schlesingeri', accession 3256-A).

Inside back cover: Gray's bird cherry (*Prunus grayana*) is notable for several ornamental features including abundant white flowers in spring and striking yellow gold fall foliage. Photos by Michael Dosmann.

Back cover: When plants are moved from the Arboretum's propagation facilities to permanent locations in the collections their temporary tags are replaced with permanent labels. Photo by Kyle Port.

The ARNOLD ARBORETUM of HARVARD UNIVERSITY

CAMPAIGN FOR THE LIVING COLLECTIONS

We are now one year into the Campaign for the Living Collections, a ten-year initiative that will expand and refine the Arboretum's historically and scientifically valuable plant collections. Additional collecting trips this summer and fall have brought in new seed and plant accessions that will go through the Arboretum's propagation facilities, as described in the last issue of* Arnoldia. *In this issue, Manager of Horticulture Andrew Gapinski completes the Campaign article series by describing the process involved in moving plants to permanent locations on the grounds and the ongoing challenges of keeping the collections healthy and growing.

Rooted in the Collections

Andrew Gapinski

From its origin to the Arnold Arboretum's propagation facilities, much time and many resources have been invested in the planning, acquisition, and production of an accession in preparation for its ultimate installation in the permanent collections. Successful establishment of new accessions and care of the Arboretum's 15,000 existing specimens takes a dedicated team of highly skilled horticulture professionals who are involved in aspects from site selection and planting to aesthetic and corrective pruning, soil health management, and attention to various plant stressors as part of the Arboretum's holistic Plant Health Care Program. Across our 281-acre landscape, we are preparing the grounds for a surge of new material as part of the Campaign for the Living Collections (Friedman et al. 2016)—an initiative to acquire and cultivate 400 target taxa over the next ten years.

The Arboretum's historic collections scheme is based on the Bentham and Hooker system of plant taxonomy, devised in the late 1800s, with species grouped by genus in an evolutionary progression starting with the earliest of flowering plants, e.g., *Magnolia,* placed at the Arboretum's main gate. While taxonomic systems differ today, the Bentham and Hooker blueprint for incorporating new material into the permanent collections is generally still followed. Continued and expanded attention is also placed on utilization of the unique microenvironments, with their variable factors such as temperature, moisture, light, and soil type, that can be exploited for the successful cultivation of particular species. The Explorers Garden, nestled on the south side of Bussey Hill, represents one such area, long known as the spot for evaluating marginally hardy species not typically grown successfully in New England.

New landscapes continue to be added, including the Leventritt Shrub and Vine Garden, dedicated in 2002, which arose out of a need for a space to feature shrubs and vines requiring full sun, and the landscape surrounding the Weld Hill Research Building, completed in 2011, which provides an opportunity for development of a new plant collection at the hub of the Arboretum's research programs. Whether sited in a particular location for taxonomic, thematic, aesthetic, or practical cultivation purposes, the placement of each new specimen into our historic landscape is part of

The Explorers Garden's protected microclimate makes it an ideal site for trialing new accessions of unknown cold hardiness. This view shows (foreground to background) *Rhododendron yedoense* var. *poukhanense, Chionanthus retusus,* and *Fothergilla* hybrids. Photo by Richard Schulhof.

CONOR M. GUIDARELLI

Manager of Horticulture Andrew Gapinski, Manager of Plant ProductionTiffany Enzenbacher, and Manager of Plant Records Kyle Port compare *Pinus cembra* (accession 237-2001) siblings for overall health, vigor, form, and root development, assigning a ranking based on their condition. This information is used to determine whether each specimen is ready to be transplanted to the collections.

a well-thought-out decision making process, executed with sound horticultural practice.

Measure Twice, Cut Once

After being cultivated in the Arboretum's Dana Greenhouses and surrounding nurseries for about three to seven years, the process of determining which specimens are ready to find their place in the permanent collections starts in August of each year. A review by greenhouse staff of all accessions in the production facilities is undertaken and recommendations are made as to whether an individual plant is large and healthy enough for installation. With this information in hand, the Managers of Plant Production and Horticulture and the Curator of Living Collections visit each specimen for a final determination. Ideally, multiple individuals within an accession have been successfully grown to ensure the best chance of that lineage surviving the production cycle and many years in the collections. A comparison between these siblings for overall health, vigor, form, and root development is made, and individuals are assigned a ranking based on their overall condition. At this point, it is also determined whether spring or fall transplanting is most appropriate for the species under review. For example, many oaks (*Quercus* spp.), beeches (*Fagus* spp.), and hornbeams (*Carpinus* spp.) can fare poorly when transplanted in autumn, while other plants, including many conifers, acclimate just fine. For the past several seasons, fall planting has been limited or deferred altogether because of prolonged summer droughts that have persisted well into autumn. When conditions are favorable, getting a jump on the transplanting list in fall helps with the work

load of the busy spring season. Nevertheless, the vast majority of transplants occur in the spring when warming days, cool nights, and abundant precipitation create favorable rooting conditions. Depending on how many sibling individuals are needed for the permanent collections (typically three or four), surplus plants may then be offered up to other botanical institutions. The sharing of specimens at this stage of the process offers yet another opportunity for material to be "backed-up" elsewhere in the event of loss at the Arboretum.

With the list of graduates in hand, the process of finding planting locations begins. After nearly 150 years of collections development, finding locations for the approximately 250 annual plant additions to the permanent collections is no easy task. On paper, specimens are first loosely assigned to particular areas of the Arboretum. A number of different parameters are considered, including the species' taxonomic group (family, genus, etc.), known winter hardiness, moisture requirements, collections value of that particular lineage, and aesthetic and functional qualities of the species for use in various landscape projects across the grounds. Since our museum specimens are living organisms exposed to many environmental influences (drought, disease, winter storms, etc.), lineages of high value are sometimes duplicated across different parts of the Arboretum landscape as a means of internal backup. However, as a general rule, most of the plants within an individual accession are planted in the same collection area, with an occasional planting in an alternative section. Some designated areas, such as the *Carpinus* collection near Valley Road, are rather full of high-value trees and leave little room for development. When siting new accessions here, we may plant just one in this core collection area, and then plant the remaining two or three siblings together in another area. To avoid the look of random plants dotted through the landscape, we've recently begun to identify and designate nodes where new accessions within a genus can be sited together outside of the core collection. For example, we have been clustering individual *Carpinus* specimens at a few nodes on Peters Hill.

The Arboretum is divided into 71 horticultural zones, each of which is assigned to one of seven horticulturists responsible for the daily care of the collections within. Continuing into fall, field selection of the specific planting location for each specimen involves the Manager of Horticulture, Curator of Living Collections, and the horticulturist assigned to that zone. Each planting location is marked with a wooden stake and is labeled with the taxon and accession number to be planted. With the majority of planting scheduled for the following spring, horticulturists will follow up before the ground freezes and turn the soil in place to further mark the planting location, because stakes can easily be lost over winter. This step also provides an opportunity for soil amendments to be added as needed and makes for easier digging in the spring as the freeze and thaw of the season loosens the turned soil.

The planting locations of the qualifiers (individual plants assigned identification letters A, B, C, etc.) of accession 637-2010, a Yunnan red-

KYLE PORT

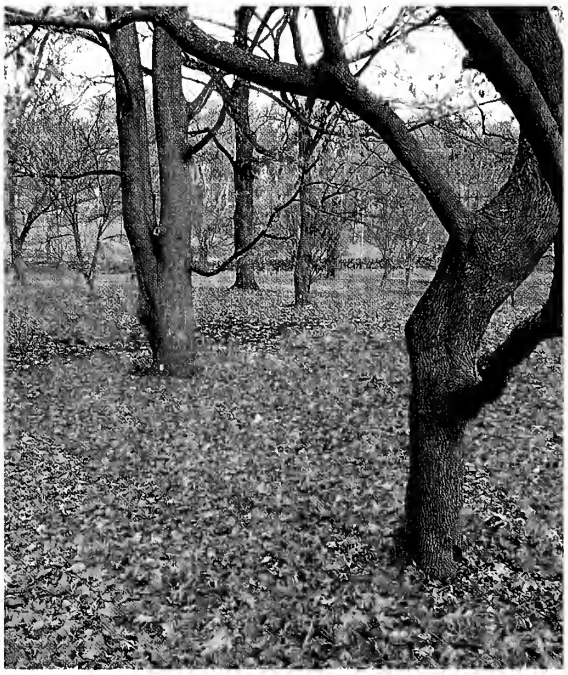
A flag and wooden stake mark a newly selected planting site for a mountain maple (*Acer spicatum*, accession 270-2010-B) grown from seeds collected by Arboretum staff in New York's Adirondack Mountains.

Gaining Ground

The Campaign for the Living Collections is under way and seeds from both near and far are sprouting in the Dana Greenhouses. As Manager of Horticulture, I can't help but feel a bit of anxious excitement as I await the challenge of growing new taxa from around the world. As stewards of the Campaign we face many questions including "Where will we find the space and how can we prepare the grounds now to receive new material?" As a horticulture team, we are viewing the grounds through an opportunistic lens—what is the value of each specimen to the collection, how can we better utilize the various environmental conditions we find across our landscape, how can we benefit from issues that affect the health of our collections, what areas need additional attention, and how can we gain "new" ground?

Although not necessarily novel questions for collections managers to be considering, these concepts are at the forefront of our decision making across the landscape:

ANDREW GAPINSKI



Addition through subtraction

Not every specimen in our collections holds the same value, and making tough decisions to deaccession and remove otherwise healthy plants is not easy, but for the building of any museum collection what is taken away can be just as important as what is added. We seek to utilize our limited resources, including space and staff time, in the most effective way to achieve the Arboretum mission. The decision-making process for the continued stewardship of every accession considers many factors, including total opportunity costs, and is ultimately guided by our Living Collections Policy (Arnold Arboretum 2016).

The deaccessioning and removal in 2015 of these four cultivars of Norway maple (*Acer platanoides*), which had low collections value, freed up valuable acreage in the heart of the Maple (*Acer*) Collection for new high priority taxa. In the opening created by the removals, a purpleblow maple (*Acer truncatum*, 629-2010-A), wild-collected in Shaanxi, China, during the September 2010 North America-China Plant Exploration Consortium (NACPEC) expedition, was planted.

Reclaiming areas of deferred maintenance

Of top priority is the reclaiming of areas in which maintenance was deferred at some point. The Horticulture staff is undertaking an aggressive cleanup effort in collections areas that have been reabsorbed into adjacent natural lands and succumbed to invasive weeds.

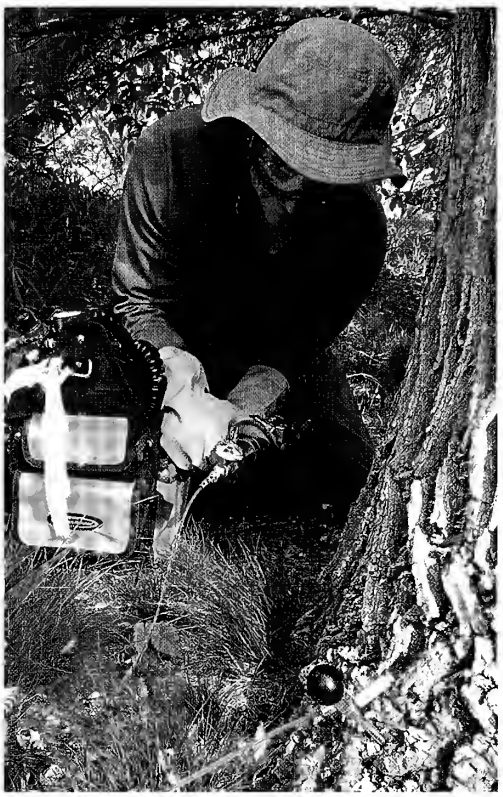
Over the past several decades, the southwest edge of the Hickory (*Carya*) Collection (seen here) has been slowly reclaimed by the adjacent Central Woodland—this area represents over an acre of valuable territory that will be available for collections expansion once it is cleared.

ANDREW GAPINSKI

With loss comes opportunity: making lemonade out of lemons

Our collections of trees, shrubs, and vines face continuous and ever-changing biotic and abiotic influences. When faced with events beyond our control, triaging the situation to prioritize and safeguard the most valuable holdings and finding opportunity in the loss is of utmost importance.

The emerald ash borer (EAB), introduced to the United States from Asia via wood packaging material, has decimated ash (*Fraxinus* spp.) populations across central and eastern North America since its discovery in Michigan in 2002. Through the establishment of an early detection program in partnership with the Massachusetts Department of Resource Conservation, the Arboretum was the first detector of EAB in the City of Boston. A triage approach to evaluate the 146 accessioned ash trees in the permanent collections was undertaken. Fifty-one individuals were determined to be of low value, not warranting long-term preservation efforts. Of these, fifteen were immediately removed because of poor health, and the remaining thirty-six trees are being utilized for further EAB monitoring efforts. The remaining 95 high-value accessions are part of a preservation program that includes prophylactic treatments and clonal propagation efforts. Branch sections (including buds) from a select number of lineages were also sent to the USDA-ARS National Laboratory for Genetic Resources Preservation for potential long-term storage via cryopreservation. The photograph shows Arboretum Horticulturist Scott Grimshaw treating a high-value ash specimen.



ANDREW GAPINSKI

ANDREW GAPINSKI

Exploring the potential of environmental niches

Across the Arboretum, differences in environmental conditions from soil moisture to annual minimum temperature exist and are key considerations when selecting locations for species requiring particular niches. We are taking an aggressive approach to clean up these areas in preparation for harboring new accessions to come.

The group project for the 2016 Isabella Welles Hunnewell Interns was to advance the development of the "The Rockery," an area with exposed rock outcroppings along Valley Road (seen here, Arboretum Horticulturist Greg LaPlume removes excess soil from the site). Taking advantage of the natural geology of the site, the Arboretum seeks to develop an environment that supports species adapted to rocky mineral soils, with characteristically low nutrient and organic matter levels, such as those found in scree type habitats. Prickly-pear cactus (*Opuntia humifusa*), several ephedra (*Ephedra*) species, regal lily (*Lilium regale*), and a number of other species on the Campaign for the Living Collections list of desiderata are potential candidates for cultivation in such an environment.

bud (*Cercis glabra*) collected by Michael Dosmann, Curator of Living Collections, on the September 2010 North America-China Plant Exploration Consortium (NACPEC) expedition to Shaanxi, China, serves as an example of the basic thought process for site selection. Having attempted to grow the species at the Arboretum several other times without success, the limited history of its cultivation here made planting decisions more difficult. Particularly in cases in which hardiness of the species is questionable, such as *C. glabra*, we use knowledge of the Arboretum's long studied and utilized microclimates to give us the best chance of success (Dosmann 2015). With the rolling topography, cold air drains down from the tops of the Arboretum's highest points including Bussey, Hemlock, and Peters Hills to the valleys below. In a typical year, these "hot spots" of the higher elevations experience minimum temperatures representative of a Zone 7 (average annual minimum temperatures 0 to 10°F [-17.8 to -12.2°C]), with Zone 6 (-10 to 0°F [-23.3 to -17.8°C]) conditions being most prevalent throughout the grounds.

With six individuals of 637-2010 ready for the planting in the spring of 2015, what was the planting approach? Three were planted that spring: one (637-2010-A) in the microclimate of the Explorers Garden, located along Chinese Path on the south side of Bussey Hill, and the two others (B and C) among its relatives in the Legume Collection. The three remaining (D, E, and F) were held back in the greenhouses as reserves in case hardiness turned out to be an issue. The winter of 2015–2016 would turn out to be a true test of hardiness, with a season low of -14.5°F (-25.8°C; Zone 5) recorded in the Bradley Rosaceous Collection—the lowest temperature recorded at the Arboretum in 57 years. Spring 2016 came and observations were made; the Explorers Garden specimen leafed out fully with no dieback and the Legume Collection plants experienced only moderate branch dieback of 1 to 2 feet (30.5 to 61.0 centimeters). Success! With hardiness a non-issue, the three remaining plants were sited and planted in the landscape surrounding the Arboretum's Weld Hill Research Building for the species' ornamental value, its botanical and taxonomic interest, and the exploration story it brings to the newly developing Weld Hill landscape. The Weld Hill planting also is separated from its previously planted siblings by nearly a mile. That distance is a key part of the idea of internal back-up.

Planting Season

As spring approaches, we pay close attention to the thawing soils and moisture conditions and begin the transplanting process as soon as the timing is right. In preparation, planting lists and locations are reviewed, and a final walk-through of the nurseries is performed to document and adjust plans based on damage that may have occurred to plants over the winter. For example, following the record breaking snowfall—110.6 inches (280.9 centimeters) measured at Boston's Logan Airport—during the winter of 2014–2015, significant damage in the nurseries occurred as the snow melted and refroze during the spring thaw. Many young trees with low branches were pulled apart with the shifting snow and ice that covered them. Evaluations completed the

(continues on page 12)

WILLIAM (NED) FRIEDMAN

Flowers of a Yunnan redbud specimen (*Cercis glabra*, 637-2010-D) that was planted in the Weld Hill Research building landscape.

A Focus on Soil Health

Jenna Zukswert, Living Collections Fellow

In order for the nearly 400 taxa we intend to collect in the Campaign for the Living Collections to have a lasting legacy here at the Arboretum, we seek to provide specimens with the most favorable habitat possible. In preparation for the arrival of these new taxa, the horticulture department is investigating all aspects of plant health care and landscape management practices to ensure we are providing the highest of horticultural standards that will give these new accessions the greatest chance of success. Evaluation of the current conditions of our soils and the development and implementation of strategies to improve soil health across the Arboretum is a high priority.

Awareness of the importance of soils, especially in relation to plant health, has been increasing; this was recently reflected in the United Nations-designated International Year of Soils in 2015. We as a global society are now more aware of how precious soil is, and also how often this resource is mismanaged. In addition to serving as a substantial terrestrial carbon sink, storing carbon that would otherwise be released into the atmosphere and further contribute to climate change (Dungait et al. 2012), soil provides important services that promote plant health, such as nutrient supply, water regulation, and physical support for roots (United States Department of Agriculture 2016). Therefore, proper stewardship of our soils will enhance the health of our valued Living Collections.

The first step in caring for our soils is to fully understand their current state. In the late 1990s and early 2000s, an intensive program of soil assessment and management at the Arboretum identified highly acidic and nutrient deficient soils, which were at the time contributing to substantial tree decline in certain areas. In the years that followed, liming and nutrient applications were made, and some plant recovery was noted. Through staffing changes over the past decade, work on soils health waned, with only isolated issues addressed as plant decline was observed and investigated. With the onset of the Campaign, the Arboretum has renewed its commitment to understanding and managing the factors that affect soil health across our landscape.

In 2015, with the help of that year's Isabella Welles Hunnewell Interns, Arboretum-wide soils testing that measured an assortment of nutrients and chemical characteristics was completed, as were analyses related to microbial processes. Initial recommendations for remediation were prescribed and executed. These soil testing data were recently mapped; the Geographic Information Systems (GIS) layer housing these data makes it possible to visualize all of the soil characteristics measured in the samples throughout the landscape. Having these data displayed spatially reveals landscape-wide patterns in soil health that we might otherwise overlook when referring only to a spreadsheet. We have also started to map the location of amendments that we apply to the soil; we hope that by continuing to measure and map soil characteristics and management efforts we can detect trends in soil health over time and determine the effectiveness of various management actions. We can use this new knowledge to adjust our practices and make more informed management decisions in the future.

In addition to looking at these data ourselves, the formation is underway of a Soils Advisory Committee composed of soil science experts who can help us to further interpret these data and inform our management plans. Members of this committee eontribute expertise from a wide range of topics in soil science and management, including bedrock geology, forest soil ecology, composting, and agricultural cover cropping. This committee will help connect us to academic research at Harvard University and beyond, enabling us to consider new ideas and to address with evidence the questions we have in our attempts to provide the best substrate for our expanding collections.

JMZ, 8/12/2016, THE ARNOLD ARBORETUM OF HARVARD UNIVERSITY

We are also evaluating our compost and mulch operations and are investigating the potential value of cover crops in our parklike setting. This fall, for example, we are testing the feasibility of growing tillage radish (*Raphanus sativus*) in the landscape as a no-till method for reducing the soil compaction that has resulted from increased foot traffic and equipment. Tillage radish is an agricultural cover crop known for its long taproot that "drills" through the soil, reducing compaction in a natural way; this taproot can grow as long as 6 feet (1.8 meters), and the first 12 to 20 inches (30.5 to 50.8 centimeters) can have a diameter up to 2 inches (5.1 centimeters) (United States Department of Agriculture 2012). When planted in fall, the radishes are winterkilled and decompose, thereby producing large cavities in the soil and releasing nutrients for surrounding plants to take up (United States Department of Agriculture, 2012). If you have been to the Arboretum since mid-August, you may have noticed four 20- by 20-foot (6.1-meter) fenced plots in our landscape. In each of these plots we are testing four sowing methods (broadcast seeding, broadcast seeding after aerating the soil, slice seeding, and slice seeding after aerating the soil), with and without a leaf compost cover, to see if we are able to grow this cover crop in an urban, partially shaded setting and, if so, which of these eight methods works best. If successful, we may integrate tillage radish into our management. We intend to continue exploring options and testing them in the landscape, learning from our trials to develop best management practices.

Managing the health of our soils to provide the best growing conditions for the over 2,000 diverse taxa that we cultivate from temperate biomes across the world is an essential component to the Arboretum's Plant Health Care program. We hope that our adaptive management approaches will help us develop well-informed ways to steward the next nearly 400 taxa to join our Living Collections and improve the habitats of our current collections, as well.

NANCY ROSE

This tillage radish testing plot is in the Linden (*Tilia*) Collection.

(continued from page 8)

previous fall comparing siblings were revisited and adjustments were made in ranking based on their overall condition.

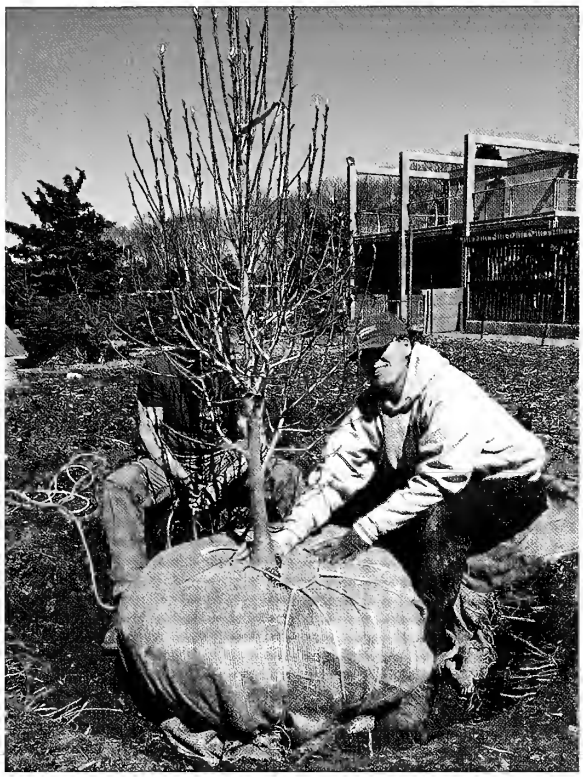
Once all is checked, lists referred to as "planting bulletins," which include accession numbers, names, and current nursery and final planting locations, are systemically issued to Living Collections Managers once final checks are complete and species' transplanting priority is established. The issuing of a bulletin first triggers the Manager of Plant Records to initiate important database updates and in turn create permanent labels for each plant being transplanted. Before plants leave the production facility, permanent labels are attached and double checked against temporary nursery labels to avoid mix-ups. When those tasks are done, horticulturists are given the green light to start the digging process. Ideally the goal is to complete transplanting before the plants break bud. Taxa such as birch (*Betula* spp.) and apple (*Malus* spp.) that leaf out early are the first priority of the digging season and thus will be listed on early bulletins. Others such as ash (*Fraxinus* spp.) and oaks (*Quercus* spp.) tend to break dormancy later and can remain in the nursery longer. Containerized plants are the last to be planted as root loss tends to be less severe.

The transplanting method known as "balled-and-burlapped," or B&B, starts with digging soil out from around the trunk of the plant. As a general rule, the ball radius should be 1 foot (30.5 centimeters) per 1 inch (2.5 centimeters) of trunk diameter. For example, a tree with a 1.5-inch (3.8 centimeter) trunk diameter would have a ball that is 3 feet (91.4 centimeters) across. When digging, larger roots are cut with pruners to avoid tearing, and imperfections in the root system are noted and addressed as needed. Once the ball has been defined and the majority of soil excavated, burlap sheets are placed over the ball and twine is used to hold the ball tightly together to prevent the ball from falling apart and drying out during transplant. When complete, B&B plants are lifted out of the holes and taken to their final planting locations as soon as possible.

KYLE PORT

Arboretum Horticulturist Scott Grimshaw checks planting information for a balled-and-burlapped specimen ready to be moved into the collections.

Once on site, the planting hole is dug paying close attention to the height of the ball to avoid making the hole too deep. The root flare, the transition zone between trunk and root system, should be at or slightly above the existing grade and never be covered with soil or mulch since it is a key zone of gas exchange for the plant. Covering the root flare can also lead to the development of a secondary root system and the occurrence of girdling roots. With burlap and twine intact, the ball is placed in the planting hole and final adjustments to planting depth are made, and the tree is viewed from all angles to ensure that the plant is straight. The majority, if not all, of the burlap and twine is then cut away from the ball and the planting hole is backfilled with the excavated soil. A 3- to 4-inch (7.6- to 10.2-centimeter) layer of mulch is applied, making sure not to cover the root flare or trunk, and plants are watered thoroughly to hydrate roots and ensure good soil-to-root contact from



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Arboretum Horticulturists Scott Grimshaw and Rachel Brinkman lace twine around the burlap covered root ball of a *Magnolia amoena* (accession 385-2012-A) in preparation for moving it out of the west nursery to its new home along Chinese Path in the Explorers Garden.

KYLE PORT

Arboretum Horticulturists Mark Walkama and Wes Kalloch plant a specimen of black cherry (*Prunus serotina*, 602-2008-B), carefully removing twine and burlap from the root ball before replacing excavated soil.

the start. New plantings are provided with regular watering during their first year of establishment and also in subsequent years when drought conditions occur.

Once the transplanting of all accessions on a particular bulletin is complete, the Manager of Plant Records is notified and each plant is visited to collect accurate GPS coordinates. In addition, all temporary marking materials (nursery labels, flagging tape) are removed and permanent labels are repositioned as needed.

Caring for the Curated Landscape

Although much planning and many resources have gone into all phases of collections development from the

ANDREW GAPINSKI

Watering is key to successful establishment of newly installed accessions. The Arboretum deploys both hand-watering and automated irrigation systems such as this one being installed in the renovated planting area in front of the Hunnewell Building by Horticulturist Greg LaPlume.

point of acquisition to establishment on the grounds, the work to preserve and steward these holdings both curatorially and horticulturally has just begun. The Arboretum's curatorial team maps, labels, and regularly inventories and evaluates all accessions, noting such observations as growth, health, damage, and various other metrics. Horticulturally, we seek to keep specimens vigorous and thriving through regular aesthetic and corrective pruning, reduction of weed competition, soil health management, and the evaluation, prioritization, and mitigation of various plant stressors, from pest and disease pressure to drought. With the goal being to maintain the germplasm represented by our collections into perpetuity, plant production staff continue to play a key role in preserving important lineages through the collection of vegetative propagation materials, such as cuttings and scions for grafting, from existing accessions. A lineage may be repropagated because of the decline of a specimen or to create clones for distribution to other institutions around the world. As we complete our second year of expeditions for the Campaign for the Living Collections, with new lineages and taxa growing in the greenhouses, we anxiously await transplanting the first of the Campaign material into the Living Collections and the challenges and opportunities that will follow.

ANDREW GAPINSKI

Goats from a local "goatscaping" company have been deployed to clear weedy underbrush and invasives such as buckthorn and Oriental bittersweet from sections of the Arboretum.

References

Arnold Arboretum. Living Collections Policy. http://www.arboretum.harvard.edu/plants/collections-management/living-collections-policy/. Accessed September 20, 2016.

Dosmann, M. S. 2015. The History of Minimum Temperatures at the Arnold Arboretum: Variation in Time and Space. *Arnoldia* 72(4): 2–11.

Dungait, J. A. J., D. W. Hopkins, A. S. Gregory, and A. P. Whitmore. 2012. Soil organic matter turnover is governed by accessibility not recalcitrance. *Global Change Biology* 18: 1781–1796.

Friedman et al. 2016. Developing an Exemplary Collection: A Vision for the Next Century at the Arnold Arboretum of Harvard University. *Arnoldia* 73(3): 2–18.

Koller, G. K. 1989. Landscape Curation: Maintaining the Living Collections *Arnoldia* 49(1): 65–72

United States Department of Agriculture. 2012. Oilseed Radish: *Raphanus sativus* L. Plant Guide from the USDA Natural Resource Conservation Service. Retrieved 1 August 2016 from: http://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/arpmcpg11828.pdf

United States Department of Agriculture. 2016. Soil Health. Retrieved 18 August 2016 from: http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/

Andrew Gapinski is Manager of Horticulture at the Arnold Arboretum.

Towards Broader Adaptability of North American Deciduous Azaleas

Alexander Q. Susko, James M. Bradeen, and Stan C. Hokanson

North American deciduous azaleas have long been adored by horticulturists. These plants, which belong to the genus *Rhododendron* sect. [section] *Pentanthera,* comprise 15 species distributed from Texas to Florida, extending northwards to southern Maine, and with one species occurring in mountainous areas of Oregon and California. These species display a wide range of flower color, from pure white to deep orange, pink, and many shades in between, providing tremendous spring and summer interest in the garden. Quickly recognized for their horticultural merit, North American deciduous azaleas piqued the interest of plant collectors upon their discovery and continue to be widely lauded by gardeners today. This has led to a proliferation of cultivars and interspecific hybrids that provide a beautiful floral display every year both in gardens and in the wild (Azalea Society of America 2016).

WILLIAM (NED) FRIEDMAN

As a common name, "rhododendron" usually refers to large evergreen shrubs whose flowers have ten stamens, such as this elepidote cultivar 'Album Grandiflorum' (accession 22810-A) growing in the Arnold Arboretum's Rhododendron Dell.

Over 240 unique accessions of *Rhododendron* sect. *Pentanthera* exist at the Arnold Arboretum including many interspecific hybrids, various cultivars, and 12 of the 15 deciduous azalea species native to North America (Table 1). The accessions at the Arnold Arboretum have origins in a wide range of environments and could contain many useful adaptations to common abiotic (non-living) stressors. This collection thus represents a valuable asset to woody plant researchers who seek to understand the adaptive potential of these plants to better benefit gardeners and ecosystems alike.

Those who have spent any time researching azalea species or cultivars quickly discover a confusing naming system. Azaleas are actually a now informal designation within the genus *Rhododendron,* a large genus of 1,024 species in the heath family (Ericaceae) with a distribution spanning across the northern hemisphere (American Rhododendron Society 2015). Horticulturists and plant enthusiasts commonly split the genus *Rhododendron* into two informal groups, "rhododendrons" and "azaleas," based on appearance. Rhododendrons are typically considered to be large evergreen shrubs with large, leathery, elepidote (without scales) leaves, or smaller evergreen shrubs with lepidote (with scales) leaves. Rhododendrons are also differentiated from azaleas in flower morphology by the presence of 10 or more stamens (Azalea Society of America 2016). Azaleas, in contrast, are usually considered to be smaller, sometimes deciduous shrubs with pubescent leaves and five to six stamens, though these morphological characteristics can be quite varied within species (Azalea Society of America 2016). The word azalea is derived from the Greek *azaleos* meaning "growing in dry soil." This name reflected the cliffside and mountain habitats of *Rhododendron luteum* (yellow azalea), a European species (Lee et al. 1953). However, this is a misleading name because azaleas are generally intolerant of drought and are most commonly found in moist or

The Linnaean system classifies organisms into increasingly narrow groups until reaching the individual species level. Classification (to the section level) for the North American deciduous azaleas is shown here (US-GRIN 2016).

Kingdom ..... **Plantae**
Order..... **Ericales**
Family..... **Ericaceae**
Genus ..... ***Rhododendron***
Subgenus..... ***Hymenanthes***
Section ..... ***Pentanthera***

DANNY SCHISSLER

Azaleas typically have five stamens that are often strongly exserted, as seen on this Alabama azalea (*Rhododendron alabamense,* 137-2005-E).

Table 1: North American deciduous azaleas at the Arnold Arboretum

Species	Distribution	Representative Accession	Flowering Details
Rhododendron alabamense	AL, FL, GA, MS, TN	137-2005	Blooms April-May. Mostly white flowers, some pink coloration.
R. arborescens	AL, GA, KY, MD, MS, NC, NY, PA, SC, TN, VA, WV	464-81	Blooms June-August. White, fragrant
R. atlanticum	DE, GA, MD, NC, NJ, PA, SC, VA	108-2007	Blooms April-May; June in northern gardens. White/pink, very fragrant.
R. austrinum	AL, FL, GA, MS	1403-85	Blooms March-April in wild, later in northern gardens. Yellow/orange, fragrant.
R. calendulaceum	AL, CT, GA, KY, MD, MS, NC, NY, OH, PA, SC, TN, VA, WV	109-2007	Blooms May-June. Variable color, from pink/orange/red-orange depending on source.
R. canescens	AL, AR, DE, FL, GA, KY, LA, MD, MS, NC, SC, TN, TX	468-81	Blooms March-April; May in northern gardens. Pink/white.
R. occidentale	CA, OR	21743 (hybrid)	
R. periclymenoides	AL, CT, GA, IL, KY, MA, MD, NC, NH, NY, OH, PA, RI, SC, VA, VT, WV	111-2007	Blooms April-May. Varying shades of pink.
R. prinophyllum	AL, AR, CT, GA, IL, KY, MA, MD, ME, MO, NC, NH, NY, OH, OK, PA, RI, TX, VA, VT, WV	805-86	Blooms May. Pink.
R. prunifolium	AL, GA	815-90	Late blooming, July-September. Vivid orange/red.
R. vaseyi	NC	1438-85	Blooms April-May. Varying shades of pink. Vulnerable in wild.
R. viscosum	AL, AR, CT, DE, GA, LA, MA, MD, ME, MO, MS, NC, NH, NJ, NY, OK, PA, RI, SC, TX, VA, VT, WV	112-2007	May-August. White/pink, depending on germplasm source. Fragrant.

AL=Alabama, AR=Arkansas, CA=California, CT=Connecticut, DE=Delaware, FL=Florida, GA=Georgia, IL=Illinois, KY=Kentucky, LA=Louisiana, MA=Massachusetts, MD=Maryland, ME=Maine, MO=Missouri, MS=Mississippi, NC=North Carolina, NH=New Hampshire, NJ=New Jersey, NY=New York, OH=Ohio, OK=Oklahoma, OR=Oregon, PA=Pennsylvania, RI=Rhode Island, SC=South Carolina, TN=Tennessee, TX=Texas, VA=Virginia, VT=Vermont, WV=West Virginia

mesic forest sites (Hume 1948). Considered a distinct genus (*Azalea*) until the mid-twentieth century, azaleas were moved into the genus *Rhododendron* after Sleumer's taxonomy was published in 1949 (Chamberlain et al. 1996).

Such taxonomies—the relationships of species based on morphological traits and, increasingly, genetic variation—are complex and frequently revised in a large genus like *Rhododendron* as new species are discovered. Traditional morphology-based taxonomy uses leaf, bud, floral, and other physical traits to determine relationships between species. However, this kind of physical classification can confuse convergent evolution (evolution of similar adaptations independently across varying taxa) with species similarity, leading to incorrect conclusions about species relationships. Modern molecular-based taxonomy uses differences in DNA sequence to group species based on the likelihood of previously shared ancestry. Since this is based on the timespan back to the most recent common ancestor, the classifications will not be confused by convergent evolution of morphological traits. In the genus *Rhododendron*, subsequent molecular phylogenies that group species based on genetic variation have shown no distinction between species commonly known as azaleas and rhododendrons (Goetsch et al. 2005). This has led to the assimilation of the North American deciduous azaleas as a section within the broader subgenus *Hymenanthes*, which includes many large-leafed evergreen *Rhododendron* species. Nonetheless, "azalea" and "rhododendron" remain important horticultural terms for marketing and identification purposes.

Rhododendron in the Garden

The earliest recorded cultivation of plants in the genus *Rhododendron* began in the fifteenth century in Japan and involved a cultivar group now known as the Satsuki azaleas, derived from the former *Tsutsusi*, or subgenus of evergreen azaleas (Callaham 2006). At the time, only the rich and privileged classes in Japan were allowed to grow and possess azaleas as they were deemed "too beautiful" for commoners (Callaham 2006). Early botanical explorers such as Robert Fortune in Asia and John Tradescant in colonial North America first brought *Rhododendron* to prominence through their plant collecting activities in the eighteenth and nineteenth centuries (Cox et al. 1997). They discovered diverse flower color, leaf morphology, and plant habit across the *Rhododendron* species they encountered. Soon after these plants appeared in European gardens, plantsmen began creating interspecific hybrids. The great diversity in flower colors, fragrance, plant size,

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Swamp azalea (*Rhododendron viscosum*) has a very wide native range and variable growth habit. Flowers are typically white, as seen on this tagged plant (left) growing near the Fourche la Fave River in the Ouachita National Forest near Y City, Arkansas, but pink flowers also occur, as on this plant (right) found in another population within the Ouachita National Forest, this one near Eagleton, Arkansas

The Ghent Hybrid Azaleas

KYLE FORT

The brightly colored flowers of Ghent hybrid azalea cultivar 'Reine des Rouges' (accession 623-61-A) show a resemblance to those of flame azalea (*R. calendulaceum*), one of the parent species originally used in hybridizing the Ghent azaleas.

The Ghent hybrid azaleas resulted from crosses between the European native azalea *R. luteum* (yellow azalea) and a number of North American species including *R. calendulaceum* (flame azalea), *R. periclymenoides* (pinxterbloom azalea), and *R. viscosum* (swamp azalea) (Dirr 1998). Initial crosses were made in Ghent, Belgium, starting around 1820, additional hybridization occurred in England, and many Ghent hybrid cultivars were introduced, primarily from Belgium, in the following decades. Although the parentage is quite mixed, these hybrids are often grouped together under the name *R.* × *gandavense*. They are notable for their often fragrant flowers that come in a wide range of colors. The Ghent hybrids lost popularity as other hybrid azaleas were introduced, but 22 Ghent cultivars can still be seen in the Arnold Arboretum collections.

leaf shape, and leaf pubescence (indumentum) resulting from these efforts led to expanded horticultural interest in rhododendrons and azaleas in the early twentieth century (Hume 1948). Throughout the twentieth century, hobbyists played a major role in the proliferation of new cultivars (Galle 1974). *Rhododendron* cultivation today spreads across temperate regions of the world, and there are over 28,000 named cultivars in existence (American Rhododendron Society 2016).

Deciduous azaleas in sect. *Pentanthera* are represented by one species each in Europe, Asia, and western North America and 14 accepted species in eastern North America (Towe 2004; Zhou et al. 2008). Deciduous azaleas constitute the largest group of *Rhododendron* species in North America. Because it holds such a large number of species (compared to other parts of the world), the southeastern United States is considered a major center of diversity for deciduous azaleas (Hume 1953). The great amount of phenotypic variation for flower color, fragrance, and cold hardiness among deciduous azaleas has long generated interest for using North American species in breeding. John Bannister, an English botanist, recorded the first deciduous azalea in North America, *Rhododendron viscosum* (swamp azalea), in Virginia in 1690 (Galle 1974). Seeds from the newly discovered deciduous azalea species were sent back to Europe where plants were grown for observation beginning in 1734 by the American botanist John Bartram. It was not until 1825 that the first recorded and popular interspecific hybrids were produced using North American deciduous azaleas (Hume 1953) (see textbox above).

Although they grow well within their native ranges, lack of cold hardiness and/or intolerance of high soil pH are major limiting factors to cultivation of these azaleas across much of North America. Relatively few *Rhododendron* species are native to continental climates, typified by extreme temperature variations throughout the year and characteristic of many regions within the United States. This is reflected in the culti-

Research staff member Margaret Gearhart stands next to the original 'Northern Lights', a cold-hardy deciduous azalea cultivar, in June 1979 at the Minnesota Landscape Arboretum.

vation history of *Rhododendron* species, which, until fairly recently, were only commonly grown and propagated in the mild and humid climates of Japan, Europe, and the eastern and western coasts of North America. For woody plant breeders in the midwestern United States, developing cultivars for their tolerance to continental climates is of paramount importance for the horticultural success of deciduous azaleas.

Fortunately, despite originating from milder climates, individual genotypes from many North American native azalea species have been identified that are exceptionally hardy under extreme temperature variation (Widrlechner 1982). North American deciduous azalea germplasm has undergone relatively little systematic evaluation and had received little breeding focus until the twentieth century, when diversified landscape needs led nursery growers to seek hardier *Rhododendron* germplasm (Hokanson 2010). For example, suburbanization in the United States following World War II led to an increased need for landscaping plants to beautify new developments (Whitehand and Larkham 1992). During the middle of the twentieth century, few ornamental plants adapted to the upper midwestern United States existed (UMN Fruit Breeding Farm 1954). Later, University Agricultural Experiment Stations in states like Minnesota began funding breeding programs for ornamental plants to develop and introduce promising cultivars for landscape use (Widrlechner 1982). Many ornamental shrubs were trialed at the time on the grounds of the newly founded Minnesota Landscape Arboretum, including several deciduous azalea species and interspecific hybrids developed previously in Europe. After years of parental and seedling testing, plants from crosses made in 1957 between mollis azaleas (*R.* × *kosteranum*),

which are a group of Asian hybrid deciduous azaleas, and the American species *R. prinophyllum* proved to be hardy to at least -35°C (-31°F) (Johnson and Snyder 1966). One seedling from this breeding population later became the cultivar 'Northern Lights' and was released in 1978 as part of the Northern Lights Series, the first flowering azaleas bred for midwestern climates (Pellett and Vos 1978). The University of Minnesota woody landscape plant breeding program has maintained the longest standing breeding program for deciduous azaleas in North America, and continues to actively release cultivars under the Northern Lights Series today (Widrlechner 1982; Hokanson 2010; Hokanson et al. 2015).

Identifying Adaptive Genetic Variation

Though certain stress tolerances (cold hardiness in particular) of azaleas within the University of Minnesota breeding program are well documented, understanding of trait variation for other abiotic stresses in natural *Rhododendron* sect. *Pentanthera* populations remains limited. Tolerance to abiotic stressors such as winter cold, summer heat, soil pH, and soil salinity are necessary for successful plant growth both in natural and cultivated settings. Abiotic stress tolerance in woody species like deciduous azaleas can arise genetically through human-mediated or natural selection. However, a lack of understanding about the nature of adaptive genetic variation for such traits is not unique to azaleas; a knowledge gap is common across woody plants and impedes understanding of their maximum adaptation in both horticultural and ecological contexts. Genetic variation, or variation in the DNA sequences between individuals in a species, is often a major factor in influencing the adaptation of an individual to an environment. In situations when individuals possessing certain patterns of genetic variation reproduce more successfully under an environmental stress, genetic variation is

NANCY ROSE

An azalea breeding trial bed at the University of Minnesota Horticultural Research Center includes introduced cultivars 'Lemon Lights' (left) and 'Northern Hi-Lights' (foreground) as well as numbered selections.

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Open longleaf pine (*Pinus palustris*) forest is a typical habitat for *Rhododendron viscosum* subpopulations in the Apalachicola National Forest near Tallahassee, Florida.

considered to be adaptive. Adaptive genetic variation and associated traits are inherited by offspring; identifying such traits is an important (but time consuming) part of breeding all plants. The development of the Northern Lights Series is a prime example: it took 21 years from evaluating initial parents, making crosses, and field testing the seedlings before a reliably cold hardy cultivar was introduced. This is largely due to the biological constraints of breeding woody perennial species, including long juvenile periods (time prior to sexual maturity of the plant) that slow the breeding process. This also complicates efforts to understand the genetics behind important traits, further hindering the discovery of potentially adaptive genetic variation. It is imperative to understand such genetic variation in breeding populations if horticultural breeders wish to sustain the development of new, adapted cultivars.

New research technologies present opportunities to more efficiently identify adaptive genetic variation for abiotic stress tolerance in populations of North American deciduous azaleas with important implications for cultivar development. Linking genomic sequence and environmental data, an emerging approach known as landscape genomics, makes it possible to identify genetic variation in plant populations that depend on an environmental factor (Rellstab et al. 2015). It is through this framework that genetic variation is declared

as potentially adaptive. Although some follow-up experiments are necessary to confirm the adaptive nature of this genetic variation discovered using this approach, this advancement gives scientists and breeders a new way to quickly screen diverse wild germplasm to identify populations that display unique adaptations to the environment.

Collections at the Arnold Arboretum and our program's prior sampling of wild populations of swamp azalea constitute an ideal source of plants to help answer these types of research questions. Most importantly, plants in this collection are linked to detailed information about their collection locations that allow for relationships between genetic and environmental variation to be investigated. North American deciduous azalea germplasm at the Arnold Arboretum is currently being used to test these landscape genomic approaches by obtaining environmental data from the origin points of the accessions and performing genetic sequencing on those accessions. The goal is to identify potentially adaptive DNA variation in North American deciduous azaleas that could benefit future breeding efforts by identifying promising species or populations as parents for future cultivar development. For example, patterns of genetic variation might be detected when looking at a set of individual azaleas originating from environments with varying degrees of average winter minimum temperatures. If an association is detected between patterns in the genetic variation and average winter minimum temperature, it is possible that the genetic variation confers an adaptive advantage in those

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Rhododendron austrinum **(orange azalea; accession 1403-85) is native primarily to the Florida panhandle and adjacent regions in Mississippi, Alabama, and Georgia. It bears fragrant yellow and orange flowers.**

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Rhododendron vaseyi **(pinkshell azalea; accession 657-70) is rare in the wild, with only a few known populations, all in North Carolina. The Arnold Arboretum has a number of conservation accessions of this beautiful pink-flowered azalea.**

KYLE PORT

Rhododendron prunifolium **(plumleaf azalea) is a late-season (July to September) bloomer, bearing flowers in shades of red and orange. The flowers of Arnold Arboretum accession 815-90-J, seen here, are an especially vibrant cherry red.**

WILLIAM (NED) FRIEDMAN

Rhododendron calendulaceum **(flame azalea; accession 109-2007-J) is notable for its brightly colored flowers that range from yellow to orange to bright red. This species is native to the Appalachian Mountains ranging from New York to Georgia.**

NANCY ROSE

The flowers of *Rhododendron periclymenoides* (pinxterbloom azalea; accession 3237-C) range from white to pink to purplish pink. It grows in mesic forests and wetlands from New Hampshire and Vermont to Alabama.

KYLE PORT

Rhododendron atlanticum **(coastal or dwarf azalea; accession 108-2007-A) is native to coastal regions in the Mid-Atlantic and Southeast. Its white to light pink flowers are sweetly fragrant.**

NANCY ROSE

Rhododendron prinophyllum **(roseshell azalea) has a wide native range from Maine to Georgia and Texas. Its flowers may be light to deep pink.**

azalea populations. While existing deciduous azalea germplasm has been well characterized for cold hardiness within the University of Minnesota breeding program, many other sources of tolerance to abiotic stressors (e.g., heat, temperature variability, drought) remain to be identified within this group of plants.

Such variation is of great interest to breeders seeking to improve stress tolerance through breeding. The approaches introduced above could be extended in the future towards informing conservation efforts that leverage the adaptive potential of populations. For the existing deciduous germplasm at the Arnold Arboretum, this research will characterize the collection for its adaptive potential to common environmental stressors. Such efforts could greatly inform future collection and conservation efforts for these species should any generate breeding or conservation interest in the future. Ultimately, we hope that this approach will further enable the cultivation of these North American horticultural gems in as many landscapes as possible.

Literature Cited

American Rhododendron Society. http://www.rhododendron.org/. Last accessed January 2016.

Azalea Society of America. http://azaleas.org/. Last accessed January 2016.

Callaham, R. Z. 2006. *Satsuki Azaleas for Bonsai and Azalea Enthusiasts*. Passumpsic, Vermont: Stone Lantern Publishing.

Chamberlain, D., R. Hyam, G. Argent, G. Fairweather, and K. S. Walter. 1996. *The genus* Rhododendron: *its classification and synonymy*. Edinburgh, Scotland: Royal Botanic Garden Edinburgh.

Cox, P. A. and K. N. Cox. 1997. *The Encyclopedia of Rhododendron Species*. Perth, Scotland: Glendoick Publishing.

Dirr, M. A. 1998. *Manual of Woody Landscape Plants* (5th ed.). Champaign, Illinois: Stipes Publishing LLC.

Galle, F. C. 1974. *Azaleas*. Birmingham, Alabama: Oxmoor House, Inc..

Goetsch, L., A. J. Eckert, B. D. Hall, and S. B. Hoot. 2005. The molecular systematics of *Rhododendron* (Ericaceae): a phylogeny based upon RPB2 gene sequences. *Systematic Botany* 30:616–626.

Hokanson, S. C. 2010. "Lights" in the land of 10,000 lakes. In: *Rhododendrons, camellias and magnolias*. London: Royal Horticultural Society.

Hokanson, S. C., S. T. McNamara, N. Rose, K. Zuzek, and H. Pellett. 2015. 'UMNAZ 493' and 'UMNAZ 502'; Two new cold hardy deciduous azalea selections from the University of Minnesota. *HortScience* 50(9)S:053 (Abstr.).

Hume, H. H. 1948. *Azaleas: Kinds and Culture*. New York: The MacMillan Company.

Hume, H. H. 1953. *Azaleas and Camellias* (Revised). New York: The MacMillan Company.

Johnson, A. G. and L. C. Snyder. 1966. Breeding azaleas for Minnesota. *Quarterly Bulletin of the American Rhododendron Society* 20:163–165.

Lee, F. P., F. O. Coe, B. Y. Morrison, M. Perkins, and F. Weiss. 1953. *The Azalea Handbook*. Baltimore: Monumental Publishing Company.

Pellet, H. and F. Vos. 1978. Northern Lights. Minnesota Agricultural Experiment Station, Miscellaneous Report #155.

Rellstab, C., F. Gugerli, A. J. Eckert, A. M. Hancock, and R. Holderegger. 2015. A practical guide to environmental association analysis in landscape genomics. *Molecular Ecology* 24(17): 4348–4370.

Towe, C. L. 2004. *American Azaleas*. Portland, Oregon: Timber Press.

United States National Plant Germplasm System (GRIN), https://npgsweb.ars-grin.gov/gringlobal. Last accessed June 2016.

University of Minnesota Fruit Breeding Farm. 1954. Report of the Fruit Breeding Farm Visitors Committee. *Minnesota Horticulturist*, 82(9):143.

Whitehand, J. W. R. and P. J. Larkham. 1992. *Urban Landscapes: International Perspectives*. Hove, East Sussex, United Kingdom: Psychology Press.

Widrlechner, M. 1982. Studies on the Breeding Potential and Genetics of Hybrid Azalea, *Rhododendron* × *Kosterianum* Schneider × *Rhododendron Prinophyllum* (Small) Millias. St. Paul, Minnesota: University of Minnesota Doctoral Thesis.

Zhou, W., T. Gibbons, L. Goetsch, B. Hall, T. Ranney, and R. Miller. 2008. *Rhododendron colemanii*: A New Species of Deciduous Azalea (*Rhododendron* section *Pentanthera*; Ericaceae) from the Coastal Plain of Alabama and Georgia. *Journal American Rhododendron Society* 62(2): 72–78.

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In *Urban Forests: A Natural History of Trees and People in the American Cityscape,* author Jill Jonnes presents stories from the early days of the urban tree movement on through the challenges that face urban forests today. Excerpted here is Chapter Seven from the book.

"A Poem Lovely as a Tree": Cherishing Memorial and Historic Trees

A tree planting in honor of dead marines. In memory of the gallant marines who had "gone west," mothers of the marines marked Mother's Day in New York City by planting memorial trees in honor of the sons who gave their lives to their country in World War I. The trees were placed on the mall in Central Park with impressive ceremonies. *(With permission from American Forests.)*

When the brutal trench warfare of World War I came to an official end on Armistice Day, November 11, 1918, the grieving nation sought suitable ways to honor its almost shocking number of dead. All told, 117,000 young Americans had died in the Great War. As a way to pay homage to these lost lives, the American Forestry Association proposed planting trees to create a new kind of living memorial. As *American Forestry: An Illustrated Magazine About Forestry and Kindred Subjects*, argued: "The trees will be, in their very greenness and robust strength, reminders of the youths who gave their vigor to win the big war. There will be no gloom about them."

American Forestry board member David Houston, Wilson's secretary of agriculture, wrote in March of 1919 to the governors of every state: "We shall seek many ways to perpetuate the memory of those who made the great sacrifice. It has been happily suggested that we do this by adorning with young trees, each named for a fallen soldier, our waysides, our yards and our pleasure places. This can be done on Arbor Day. . . . Such an observation of the day will give it a meaning more profound, a purpose more exalted, than it ever had before."

Officials at American Forestry were stunned by the fervent grassroots response to their idea of memorial trees: "Never before in [our] history," they confessed, had they received "so great a number of inquiries in regard to tree care and tree planting." By the spring of 1920 Arbor Day memorial plantings were sweeping the nation, as families, friends, and officials sought to assuage their sorrow and honor the dead with community tree planting on an unprecedented scale. In Middleton, Delaware, a huge throng, including uniformed soldiers, turned out for a ceremony as the high school students followed the prescribed American Forestry program: The students began by singing "The Planting Song" to the tune of "America," which began: "Joy for the sturdy trees / Fanned by each fragrant

breeze, / Lovely they stand." School superintendent Wilbur H. Jump followed with a brief tribute.

Then a student stepped forward to recite "Trees," a poem written by Joyce Kilmer, who had died in France. Next fourteen children each declaimed two lines of Helen O. Hoyt's "What the Trees Teach," the first beginning with "I am taught by the Oak to be rugged and strong / In defense of the right, in defiance of wrong" and the last concluding with "The firm-rooted Cedars, like sentries of old, / show that virtues deep-rooted may also be gold."

The high school students then helped plant three young trees. The Reverend F. H. Moore dedicated "the linden, to J. J. Hoffecker, Jr., of Company B, 9th Infantry, who was killed in battle near Soissons; the maple, to Rupert M. Burstan, of the marines, who died of pneumonia six weeks after reaching France; the catalpa, to David Manlove, who fought in several battles, went over the top safely—then, after the armistice was signed, was killed by an exploding shell while engaged in reconstruction work." Then Dr. Moore and "a number of ladies went to the negro school where a maple was planted, dedicated to the memory of Jeremiah Jackson, the only negro boy from Middleton who died in the service."

Each month *American Forestry* featured page after page of black-and-white photos showing crowds of children, uniformed soldiers, top-hatted dignitaries, and local citizens in suits and straw hats watching as a small child or a mayor or a governor's daughter shoveled dirt onto a memorial tree, while all around American flags marked these solemn observances of lost lives. "Trees are being planted everywhere," exulted the magazine, "in honor of the men of the war. Those men of war carried the message of freedom and now the trees will carry the message of the men through the coming generations. . . . [And] the trees will mark the remaking of the cities just as those men marked the remaking of the world."

The American Forestry Association's helpful Arbor Day program booklet launched Joyce Kilmer's "Trees" to new status as one of America's best-loved poems. When Kilmer had enlisted in 1917 in New York's Sixty-ninth Infantry Regiment, he was a staffer at the *New York Times Magazine* as well as a sought-after lecturer and poetry editor at *Current Literature* and the *Literary Digest*. After Kilmer was killed by sniper fire on the western front on July 30, 1918, at the age of thirty-one, Charles Willis Thompson, a *New*

York Times colleague, wrote, "The German bullet that slew Joyce Kilmer at the Ourcq slew a brilliant promise."

Kilmer, a 1908 graduate of Columbia University, first published "Trees" in the August 1913 issue of *Poetry* magazine. Listed in *Who's Who* by the age of twenty-five, he was viewed by many as the leading Roman Catholic poet of his generation. He was married to Aline Murray, another well-regarded poet, and together they had five young children. While Kilmer had published four books of poems, his work—including "Trees"—though critically acclaimed, was not well known to the broader public until the *New York Times* first published "Trees" on December 26, 1918, in an article titled "Urge Memorial Trees" that mentioned Sergeant Kilmer's tenure on the paper's staff and *American Forestry*'s use of his "little poem" in its memorial trees literature.

In coming years, "Trees" would become not only the most famous such arboreal ode in the English language but also one of the most cherished and recognized of all American poems. Throughout America, citizens of every age were soon reciting, hearing, and reading its twelve lines of iambic pentameter:

> I think that I shall never see
> A poem lovely as a tree.
> A tree whose hungry mouth is prest
> Against the world's sweet flowing breast.
> A tree that looks at God all day
> And lifts her leafy arms to pray:
> A tree that may in Summer wear
> A nest of robins in her hair;
> Upon whose bosom snow has lain;
> Who intimately lives with rain.
> Poems are made by fools like me,
> But only God can make a tree.

Its first two lines were especially indelible, and in the ensuing decades American schoolchildren by the millions learned the verses by heart. In 1926 the New York City Board of Aldermen voted to name what had been Concourse Plaza Park, at 161st Street and the Grand Concourse in the Bronx, Joyce Kilmer Park.

In 1920 American Forestry Association president Charles Lathrop Pack, heir to a lumber fortune, proposed a far more ambitious vision of memorial tree plantings: "Roads of Remembrance," mile after mile of street trees that would shade city avenues, the nation's many new motorways, or the historic Lincoln and Jefferson Highways. In Washington, D.C., the American Legion whirled into action, planting 507 young Norway maples to honor the local war dead. As the *Washington Herald* reported on May 31, the Legion trees ran for "almost three miles, on both sides of Sixteenth street, from the north line to Webster street to Alaska avenue, the long line of sturdy saplings stand as an army in double file, looking to the north where stands their leader, the beautiful maple dedicated to Edward D. Adams, the first of the comrades to fall." At the foot of each young tree, the Legion embedded a bronze plaque.

On April 30, 1921, new First Lady Florence Harding, as ever fashionable in bobbed hair, brimmed dark hat with white plumed feathers, and patterned long coat, arrived at American Forestry headquarters at 1214 Sixteenth Street to lend presidential glamour to a memorial tree ceremony. She planted a tiny tree from the Hardings' home state of Ohio in a lilliputian Road of Remembrance fronting American Forestry's yellow brick offices. After wielding a sturdy trowel to ceremonially dig a few clods of dirt, Mrs. Harding presented the tool to her hosts. Thus the First Lady Trowel began its long career (which continues to this day), lending presidential luster to tree plantings far and wide.

Whether Mrs. Harding loved trees or was just being politically astute has been lost to history, but several weeks after her appearance on Sixteenth Street she joined American Forestry's board. President Warren G. Harding duly endorsed the Roads of Remembrance, telling the *Chicago Tribune*, "It would be not only the testimony of our sentiments, but a means to beautify the country which these heroes have so well served," noting that tree-lined byways were "one of the useful and beautiful ideas which our soldiers brought back from France." Not long afterward the First Couple attended a ceremony in New York's Central Park, where the president was photographed shoveling dirt onto a large-caliper tree honoring the fallen soldiers. That year he also planted a southern magnolia at the east entrance to the White House, memorializing the tens of thousands of American horses who perished in the Great War.

On the fiftieth anniversary of Arbor Day in 1922, President Harding designated April 22 as the official golden anniversary. Tree lovers had come a long way since 1882 in Cincinnati, when, *American Forestry* acknowledged, "to be a 'tree enthusiast' was to be a 'crank' . . . in the same category with those persons who worked for women's suffrage, prohibition, [and] believed in flying machines." Now, however, with the entire nation united around these living memorials, "We are just awakening to the possibilities of tree planting. The trees are monuments with a meaning, for they live gloriously just as did those for whom they are planted. The glory is the thing to tell the world."

In the fall of 1922 the *Bulletin of the Arnold Arboretum* weighed in on the issue of using trees as memorials, which it recognized had become a popular movement, "judging by the number of letters which come to the Arboretum on the subject. . . . Clearly the essential thing in a memorial tree is its ability to live long." The arboretum (presumably reflecting Sargent's opinion) had its own vision of such monuments: "If memorials are to be erected for soldiers and other men in the form of trees, the Redwood-forest offers the best opportunity in the beauty and permanency which can be found anywhere in the world." As ever, the Arboretum's *Bulletin* complained about the lack of real knowledge about trees and the consequent bungled plantings. "There is nothing more laudable than to plant a tree," averred Wilson, ". . . provided the right kind of tree is planted."

With Arbor Day so firmly established and Roads of Remembrance planted or planned in almost every state, the tree lovers at the American Forestry Association added yet another dimension to Arbor Day—the celebration of individual historic trees. The American Forestry Association so liked this idea that it established a nationwide arboreal Hall of Fame. "Zest is given to Arbor Day tree planting," declared the *New York Times* as the holiday neared in the spring of 1926, "by the fact that famous trees of long ago still flourish and engage popular interest, especially in Washington, where there are more historic trees than in any other city in the world. Visitors may still behold Washington's elm, Lincoln's European hornbeam, the tree spared by Senator Simon Cameron of Pennsylvania, [and] the oak from the tomb of Confucius."

When it came to designating trees with an illustrious enough pedigree to qualify for *American Forestry*'s Hall of Fame, those with a George

Washington provenance trumped all others. The Washington Elm at the U.S. Capitol rose in "majestic symmetry, the greatest in dimension of all the historic elms" on the Capitol grounds, even though it was uncertain whether the father of our country had actually planted the elm in front of the east entrance to the Senate Wing or just used it as his outdoor office when supervising the Capitol's construction. Erle Kauffman, author of *Trees of Washington: The Man, the City* (1932), opted for the latter: "The story goes that the noon repast was often laid beneath the branches of this elm and that the First President would sit in their shade and talk with the builders." An opposing view was taken in 1902 by the *Washington Post*, which reported that "the elm that once stood on Capitol Hill and which George Washington is said to have planted was cut down under order of the landscape architect Frederick Law Olmsted, in 1878, but Superintendent [William R.] Smith secured the roots and has since raised eight trees from them."

Kauffman had made it his mission to track down every famous elm, oak, horse chestnut, and willow where Washington had sheltered, tied his horse, held meetings, or eaten breakfast, from Valley Forge to Charleston to Cambridge. Of all these none was more famous than the Cambridge Elm, "a mighty symbol of the dawn of the Republic" that Kauffman believed to be "undoubtedly dearer to the hearts of Americans than any other historic tree."

It was under this spreading elm on July 3, 1775, that General George Washington had reportedly assumed command of the Continental Army. "Artists have painted it," wrote Kauffman, "poets have sung its praise, and historians have recorded its association with the great Continental soldier and patriot." And yet when roads needed to be widened near Harvard Square at Garden Street and Mason, local leaders thought nothing of confining this living monument to an isolated island of soil, fenced in against the traffic swirling all around, the earth above its far-flung roots paved over, depriving them of water and air.

Predictably, the Cambridge Elm began to die, and city authorities sent forth crews to minister to the revered tree. "More and more dead branches were cut off," wrote one observer, "the wounds smeared with tar, the hollows filled with cement, the remaining limbs braced with iron bands and rods, until it became a truly pitiable object. Finally, on October 26, 1923, the whole wretched ruin was accidently pulled over by workmen trying to

remove another dead branch, and it crashed against the iron railing surrounding it. Examination showed that the trunk was hopelessly rotted below the ground, a mere mass of punk: the wonder was that it had stood so long." The carcass was cut into a thousand pieces and sent forth like so many holy relics to all the states, legislatures, and fraternal organizations. The following year, on Washington's birthday, an offspring of the tree was planted, but it did not survive.

Today, almost a century later, the Cambridge Elm is still remembered in its former habitat. But only the cognoscenti will know to peer under the wheels of the passing vehicles on Garden Street to catch a glimpse of the large manhole cover–like plaque embedded in the road, all that remains to mark the fabled tree.

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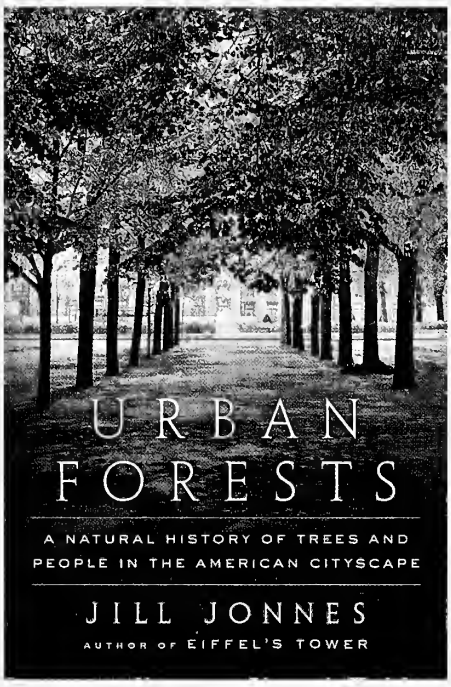

Gray's Bird Cherry (*Prunus grayana*): A Fitting Tribute to Asa Gray

Michael S. Dosmann

If you've ever noticed the similarity between North American and Asian species of *Liriodendron*, *Hamamelis*, or *Stewartia*, then you've recognized the same biogeographic phenomenon that botanists have for well over a century (for an overview of disjunct floras see: Yih, D. 2012. The Eastern Asian–Eastern North American Floristic Disjunction. *Arnoldia* 69(3): 14–22). One of the first to recognize the similarity between species native to eastern North America (ENA) and eastern Asia (EA), specifically Japan, was Harvard botany professor Asa Gray, who first compared the two floras in 1840 while reviewing Siebold and Zuccarini's *Flora Japonica*. Fascinatingly, much of Gray's own evolution of thought related to biogeography was nurtured by his extensive correspondence with Charles Darwin.

Gray's work recognized "identical species" that co-occurred in ENA and EA, and in an 1859 analysis he referred to a Japanese bird cherry as either *Prunus virginiana* (of North America) or possibly *P. padus* (a Eurasian species), though his inclination was that it was *P. virginiana*. Dutch botanist Friedrich Miquel described this bird cherry as *P. padus* var. *japonica* in 1865, but it was Russian botanist Carl Maximowicz who, in 1883, named it as a separate species, *P. grayana*, commemorating Asa Gray. *Prunus grayana* along with *P. virginiana*, *P. serotina*, and *P. padus* form a group of deciduous, racemose-flowering *Prunus* species that have a compelling evolutionary and geographic history that extends from eastern Asia to eastern North America and northern Eurasia. How fitting a specific epithet!

I was first drawn to Gray's bird cherry in the spring of 2001 while ogling spectacular floral displays in the Arboretum's Living Collections. The 2- to 4-inch (5- to 10-centimeter) -long terminal racemes of densely packed white flowers (each about 1/3 inch [7 to 8 millimeters] across) have leafy bases and lack peduncles: the lowermost flower emerges directly from a leaf axil. The abundant flowers typically appear in early to mid-May, turning the entire canopy into a dazzling green and white display that lasts about a week or two. The fruits mature from green to bright red and eventually a dark purple by mid-August.

The elliptic leaves, up to 4 inches (10 centimeters) long, become intensely yellow gold in the autumn, while the short petioles and midveins often turn bright red—quite a striking contrast. Mature trees are rounded to upright and can grow nearly 50 feet (about 15 meters) tall. Although uncommon in cultivation, *P. grayana* offers wonderful spring and autumn ornamental interest. Arboretum specimens have been free of major disease or pest issues. It grows at the Morton Arboretum, near Chicago, confirming USDA Zone 5 cold hardiness, and also survives the oppressive heat and humidity at Philadelphia's Morris Arboretum and the United States National Arboretum in Washington, D.C. I have never noticed naturalized seedlings, but since birds eat the fruit and may disperse seeds, I recommend careful invasiveness evaluation before major production and introduction into the trade.

Prunus grayana is native to Japan, where it is common in mesic forests from Hokkaido to the southern islands of Shikoku and Kyushu, and also occurs in mainland China from Zhejiang westward to Yunnan. The Arboretum currently has eight living specimens, all from Japan. The oldest (16694-A) was collected by E. H. Wilson in 1914 on Mount Hayachine in northeast Honshu. It grows near Forest Hills Gate, stands 35.4 feet (10.8 meters) in height, and has a diameter of 30.3 inches (77 centimeters) at 2 feet (0.6 meters) above the ground. Our tallest tree, at 42.3 feet (12.9 meters), is 1698-77-C, which grows nearby with three others (1191-77-A and B, and 1698-77-B). All were collected on Hokkaido by then Arboretum staff members Richard Weaver and Steven Spongberg during their 1977 expedition. They also made an additional collection (1777-77) from northern Honshu, with specimens A and C now growing on Bussey Hill and specimen D on Peters Hill. So, this autumn (or during bloom next spring), take a tour of our collection of Gray's bird cherries and think about Asa Gray's laudable contributions to botany—especially his notice of the North American-Asian floral connection.

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