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Front cover: The paperbark maple *(Acer griseum),* AA # 12488-A, growing near the Bradley Garden of Rosaceous Plants, photographed by Peter Del Tredici.

Inside front cover: Nothing says summer at the Arnold Arboretum like a flowering golden-rain tree *(Koelreuteria paniculata),* photographed by Peter Del Tredici.

Inside back cover: The paperbark maple *(Acer griseum),* AA # 12488-B, growing along Chinese Path below the summit of Bussey Hill, photographed by Peter Del Tredici.

Back cover: Visitors enjoying the cherry trees growing at Mt. Takao, Japan, photographed by Mayumi Shigeta, of The University of Tokyo.

‘Vardar Valley’ Boxwood and Its Balkan Brothers

Peter Del Tredici

In 1934, I visited Rumania, Bulgaria, and Yugoslavia under the joint auspices of Harvard University and the United States Department of Agriculture, choosing by preference the sun-baked areas of the northwestern Balkans, which have cold, dry winters like ours [St. Louis]. I attempted to collect seeds and cuttings of four interesting evergreens, holly, ivy, yew, and box, on the theory that, even though they looked more or less identical with these same species in northern Europe, they must be different on the inside.

—Edgar Anderson, 1945

With these words, the former director of the Missouri Botanical Garden and one-time Arnold Arboretum staff member, Edgar Anderson described his memorable trip across eastern Europe in search of reliably hardy, broadleaved evergreens. At the time, it may have appeared as just another Arboretum collecting expedition to a distant corner of the globe. But looking back on it—seventy-three years later—we know it was a special trip that resulted in the introduction of a horticulturally important strain of the common or English boxwood, *Buxus sempervirens,* collected from wild plants growing along the Treska River just outside the city of Skopje, the capitol of Macedonia.

In 1957—some twenty-three years after the fact—the first of Anderson’s boxwood selections was named ‘Vardar Valley’ because of its outstanding winter hardiness and mounded growth form. As this cultivar spread slowly through the nursery trade during the 1970s and 80s, it became apparent that ‘Vardar Valley’ was resistant to virtually all pests and disease—including the dreaded boxwood decline—that were damaging or killing common boxwood across eastern North America. The recognition of this resistance, together with its hardiness and compact habit, caused an explosive increase in the landscape use of ‘Vardar Valley’, beginning in the 1990s and continuing through today.

Edgar Anderson, the Man

Before proceeding further with the story of *Buxus* ‘Vardar Valley’, it would be appropriate to take a look at the man who discovered this important cultivar. Edgar Anderson was born in Forestville, New York in 1897, and moved to East Lansing, Michigan as a child. He attended Michigan Agricultural College (now Michigan State University), where his father was a professor of dairy husbandry, and graduated in 1918. Anderson received his doctorate from the Bussey Institution of Harvard University in 1922, where he studied the tobacco genus, *Nicotiana,* under the direction of Dr. Edward M. East. The Bussey was located adjacent to the Arnold Arboretum and provided Anderson with an opportunity to familiarize himself with the collections and get to know various staff members. While at the Bussey, Edgar met Dorothy Moore, a laboratory assistant working for East while finishing up her master’s degree in botany from Wellesley College. The two were married in 1923.

Following his graduation from Harvard in 1922, Anderson went to work for the Missouri Botanical Garden, and in 1929 was awarded a National Research Fellowship for study in England with a focus on genetics under the guidance of J. B. S. Haldane. He also studied cytology with C. D. Darlington at the John Innes Horticultural Institute, and statistics with

The original plant of Buxus sempervirens *'Vardar Valley,' AA 352-35-E, was 23.3 feet wide by 8.3 feet tall (7 m x 2.5 m) in December, 2006.*

R. A. Fisher at the Rothampstead Field Station. Anderson returned to the Missouri Botanical Garden in 1930 and, a year later, accepted an appointment as arborist at the Arnold Arboretum where he worked until the fall of 1935. The primary responsibilities of Anderson's position were care of the living collections and furthering the Arboretum's relations with the public. In his biographical sketch of Anderson, John Finan notes that the four years he spent at the Arnold Arboretum were frustrating because of "the large number of speaking and other public service obligations at the Arboretum did not allow him to pursue his research interests. Indeed, the press of duties became so great that, as Dorothy Anderson's diary records describe, he suffered severe exhaustion in the spring of 1934. He went with his family to England in July, 1934 and he spent August and September on a collecting trip to the Balkans." Anderson resigned his position in the summer of 1935 and returned to the Missouri Botanical Garden, where he spent the remainder of his botanical career.

Today, Anderson is remembered primarily for his groundbreaking work on the role that hybridization plays in the evolution of plants, summarized in his book *Introgressive Hybridization,* published in 1949. He was also interested in the history of domesticated plants

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Edgar Anderson, "Arnold Arboretum Arborist 1931."

and in 1952 published a popular book on the subject, *Plants, Man and Life,* which is still in print. Anderson was appointed director of the Missouri Botanical Garden in 1954, but resigned in 1957 to go back to the teaching and research that he so dearly loved. During his lifetime Anderson was awarded many honors, including membership in the American Academy of Arts and Sciences and the National Academy of Sciences, and the Darwin-Wallace Medal of the Linnaean Society. He died in St. Louis in 1969 at the age of seventy-two. Writing in 1972, his good friend, G. Ledyard Stebbins of the University of California, Davis, described Anderson's well-known humanitarian side with the following words:

> I cannot conclude without referring to Edgar Anderson's great faith in mankind, which let him to adopt and follow zealously the Quaker religion and way of life. He accepted family tragedies calmly and resolutely. His inner conflict with himself was never wholly resolved, but he never wavered in his belief that he could make life better for others by his kindness toward them, and his ability to share with them his extraordinary perception of the wonders of plant life, and what plants could mean to people.

The Balkan Expedition

Anderson's trip to the Balkans during the summer of 1934 is not usually mentioned in his list of scientific accomplishments, but it was Anderson's most important foray into the field of ornamental horticulture, and 'Vardar Valley' its most significant result. Indeed, the only other ornamentals—besides *Buxus*—that Anderson collected on the trip, which are still commercially grown, are two cultivars of Baltic Ivy (*Hedera helix* var. *baltica*) 'MBG Rumania' and 'MBG Bulgaria.' Anderson was not successful in his attempt to introduce a winter-hardy butcher's broom (*Ruscus* spp.), cherry laurel (*Prunus laurocerasus* var. *shipkaiensis*), or English holly *(Ilex aquifolium).* Several specimens collected from the trip, however, are still growing on the grounds of the Arnold Arboretum: including three accessions of European yew (*Taxus baccata,* AA #935-34, 370-35 and 371-35), one wild lilac (*Syringa vulgaris,* AA #949-34), and one wild pear (*Pyrus elaeagrifolia,* AA #948-34).

The story of how Anderson came to collect Balkan boxwood is best told in his own words, from an article he wrote for *The Boxwood Bulletin* in 1963:

> Boxwoods are not evenly distributed all over Europe; there is a northern area where they are found and then another separate area at the south. At the Royal Botanic Garden at Kew and at the Botanical Gardens in Belgrade by consultation and study in the herbarium I found that the northernmost extension of this southern strain was just outside of Skopelie [Skopje] in the valley of the Vardar River, in the Macedonian edge of Yugoslavia. The government gave me a courier to travel with me and help in buying tickets, reporting to the police, carrying luggage and generally serving as a companion. He was a White Russian and spoke almost no English but he spoke fluent German and we communicated in that language.
>
> Our directions had been to go to a monastery in the outskirts of Skopelie and that there we would find boxwood in quantity. My memory

HARVARD MAP ARCHIVES

A German Army map from 1937 showing the Treska Gorge and the Treska River. The white arrow indicates the location of the Monastery of St. Andreja near where Anderson collected 'Vardar Valley.' The region has changed considerable since Anderson's time, due to the construction of a masonry dam near the Monastery. The coordinates for the Treska Gorge are 41° 58′ N and 21° 18′ E.

is that we took some sort of conveyance out to the bridge over either the Vardar or one of its tributaries and then proceeded afoot along the pathway which led to the unpretentious little whitewashed monastery. [*Author's note: This is most likely the Monastary of Sveti Andreja on the banks of the Treska River, which flows into the Vardar River southwest of Skopje.*] The river bed, broad and gravelly, was at one side and the mountains from which the stream rose loomed ahead, dry and rocky with some shrubs on the lower slopes and here and there an occasional battered tree. The records of the monastery showed that up to a few hundred years ago the mountain was largely covered with a beechwood forest, from which the monastery had drawn a substantial part of its revenue. Over-cutting and over-grazing had destroyed the forest. Heavy erosion had done the rest and much of the mountain was down to the bare rock. Goats, which were still everywhere, were the worst offenders and when we came to the acres and acres of boxwood they too were nibbled, sometimes almost down to the ground; seldom or never were they over shoulder high. While the boxwoods grew in great abundance there were other characteristic evergreen shrubs in with them; big bushy thyme and rosemarys I remember in particular.

At the time of our visit the seeds were already ripe and had been scattered by the browsing

Anderson photos #17415 with the following caption: "Yugoslavia, Skoplje [sic], Treska Gorge. Buxus sempervirens *habitat. Photos. by Edgar Anderson, Sept. 19, 1934. Locality where herbarium specimen #133 was collected." In the picture on the left, note the boxwood growing along the edge of the road and up the steep slope of the gorge. In the picture on the right, note the Treska River flowing at the base of the Treska Gorge and the boxwood dominating the slopes.*

goats. We got down on our hands and knees and picked up the shiny black sees (a little smaller than apple seeds) from underneath the bushes. It was slow work but we eventually got a hundred or so. We also took cuttings to send back airmail to my collaborators in England and made herbarium specimens of the boxwoods and other shrubs. The bushes had been so heavily grazed it was difficult to tell anything about their growth habit but from the stubs that were left it was easy to see that there was much more variation from bush to bush than in the boxwoods which grew wild (or apparently so) at Box Hill in the south of England. They varied conspicuously in leaf size and in leaf shape and in the amount of bluish bloom on the leaves.

In the Arnold Arboretum Archives I unearthed several of the photographs Anderson took while on his Balkan trip, including several taken on September 19 of location #133 in the Treska Gorge area, and of boxwoods that were growing there. These photos are particularly noteworthy because this is where Anderson collected the plant that would eventually become the cultivar 'Vardar Valley' (AA #352-35).

I was elated at the thought that I might have discovered a photograph of the original 'Vardar Valley' growing in the wilds of Macedonia. But the joy was quashed after I located an undated, typewritten manuscript that Anderson wrote, probably in mid to late 1935, "Report on Balkan Expedition to the Arnold Arboretum." It lists all of his collections, including *Buxus sempervirens* #133, which he describes as consisting of seeds from two plants (given AA numbers 789-34 and 818-34), and cuttings from two plants, (given AA numbers 352-35 and 353-35). The report clearly indicates that Anderson used #133 to designate a collection location rather than in reference to a specific, individual plant. The truth of this supposition was confirmed when I obtained a high resolution scan of Anderson's original *Buxus sempervirens* herbarium specimen #133 from the Harvard University Herbaria, which showed a plant with long, narrow leaves as opposed to the distinctly rounded leaves that are typical of 'Vardar Valley'. Lynn Batdorf, boxwood curator at the U. S. National Arboretum and registrar for the genus *Buxus,* examined the scan and reported that "the leaves of herbarium specimen #133 are elliptic to oblong with an obtuse apex, while the leaves of 'Vardar Valley' are larger, far more ovate shaped with an acute apex."

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Anderson photos #17416 with the following caption: "Yugoslavia, Skoplje, Treska Gorge. Buxus sempervirens. *Photos. by Edgar Anderson, 1934. Herbarium specimen #133."*

The Publication of 'Vardar Valley'

Anderson collected cuttings from four different boxwood plants during the course of his Balkans expedition: two from cultivated plants in Bucharest, Romania and two from wild plants at location #133 outside Skopje. Anderson sent the plants and cuttings directly to the John Innes Horticultural Institute in London rather than to

Buxus sempervires accessions received by the Arnold Arboretum from Anderson's 1934 Balkans Expedition:

350-35 = "Buxus sempervirens #1 Bucharest E. Anderson. (from the John Innes Hort Inst., Mostyn Rd., London SW. 19) April 1, 1935. 20 cutts April 2, 1935. 18 boxed Dec. 3, 1935." [According to Anderson's undated report, these cuttings were collected from a cultivated plant. One specimen was planted on the AA grounds in 1950; it was removed in July, 1982.]

351-35 = "Buxus sempervirens #2 E. Anderson. Bucharest, Rumania April 1, 1935. 66 cutts April 2, 1935. 58 boxed Dec. 3, 1935." [According to Anderson's undated report to the Arnold Arboretum, these cuttings were collected from a cultivated plant. Two specimens of #351-35 were planted on the AA grounds in 1950; plant A was removed in April 1981; the name of plant B was changed to *Buxus sempervirens suffruticosa* by Donald Wyman on Oct. 25, 1956, and on Sept. 24, 1960 it was "stolen by vandals". In 1984, this clone was assigned the cultivar name 'Edgar Anderson' by Mary Gamble in *The Boxwood Bulletin* 24: 41–53.]

352-35 = "Buxus sempervirens. Treska Gorge, Skoplje #133. E. Anderson, April 1, 1935. 44 cutts April 2, 1935. (42). 40 boxed Dec. 3, 1935." [This accession was named 'Vardar Valley' by Donald Wyman.]

353-35 = "Buxus sempervirens, E. Anderson no label, April 1, 1935; 58 cutts April 2, 1935. (52) 50 boxed Dec. 3, 1935." [According to Anderson's undated report to the Arnold Arboretum, these cuttings were part of collection #133 at Treska Gorge. An unsigned note at the bottom of the accession card reads: "Do not name this clone. It is not as good as 'Inglis', and has a few browned leaves 4/27/66. On this date it is 6' tall, 7' across. Foliage lighter green than the much lower 'Varder Valley.'" According to Arboretum records, one specimen was planted on the grounds in 1950, and was removed in November, 1982. A cutting of this plant at the National Arboretum was given the cultivar name 'Scupi' in 1998 and registered in 2000.]

789-34: "Buxus sempervirens. seed #133 E. Anderson. Treska Gorge, Skoplje, Yugo-Slavia. Oct 5, 1934. germ Dec. 27, 1934. 25 boxed Dec. 27, 1934." [According to Arboretum records, one specimen was planted on the grounds in 1950, and was reported missing in 1986. One plant from this seed lot at the National Arboretum was given the cultivar name 'Treska Gorge' in 1998 and registered in 2000.]

818-34: "Buxus sempervirens. seed #133 E. Anderson. Treska Gorge, Skoplje. Oct 30, 1934. germ June 20, 1935. 7 potted July 16, 1936." [According to Arboretum records, none of these seedlings were planted on the grounds or distributed.]

the Arnold Arboretum for two reasons: first, the stopover would cut down on the length of time the fragile material would spend in transit; and second, Anderson knew people at the John Innes Institute from the time he spent there in 1929. In one of the letters he wrote from Yugoslavia to Oakes Ames,[1] the supervisor of the Arnold Arboretum, Anderson listed the material he sent to the Innes Institute for propagation: "Cutting and plants of the following sent to London: *Hedera helix*—5 localities; *Taxus baccata*—1 locality; *Prunus lauro-cerasus shipkaiensis*—2 localities; *Buxus*—1 locality; *Ruscus*—2 localities."

The staff of the John Innes Horticultural Institute successfully rooted all four of Anderson's *Buxus* selections, and sent them on to the Arnold Arboretum, where they arrived on April 1, 1935, and were accessioned under numbers 350-35 through 353-35 [see box this page]. The Arboretum's propagator took a second generation of cuttings from the Innes Institute plants on April 2, most of which rooted and were potted up on December 3, 1935. At some point during the early 1940s, a number of these rooted cuttings were planted out on the Arboretum grounds amidst its other boxwood accessions.

Around this same time, in November, 1942, one plant each of the four cutting-grown selections and one seedling from accession number AA 789-34 were distributed to the geneticist Orland E. White,[2] Director of the Blandy Research Farm of the University of Virginia in Boyce, Virginia and to Henry Hohman, owner of Kingsville Nursery in Kingsville, Maryland. While other individuals and institutions undoubtedly received rooted cuttings of Anderson's boxwoods at a later date, it is likely that White and Hohman were the first to receive them because they were friends of Anderson's and both had special interests in boxwood.

In 1957, Donald Wyman, who had been appointed Arnold Arboretum horticulturist in late 1935 to replace Anderson,

A high resolution scan of Anderson's original herbarium specimen for Buxus sempervirens *#133 housed at the Harvard University Herbaria in Cambridge and incorrectly annotated as the cultivar 'Vardar Valley'.*

formally named one of his predecessor's boxwoods 'Vardar Valley.' In an article in *Arnoldia,* Wyman explained why the plant he selected was special:

> Eight plants were grown to size over a period of many years. Several of these were sent outside the Arboretum for trial elsewhere. Cuttings were sent to at least one commercial nursery which, in turn, rooted them and propagated more, selling the resulting plants [this was probably Henry Hohman]. Enthusiastic responses have come from several of these sources so that now it is thought wise to name this plant *Buxus sempervirens* 'Vardar Valley' and to start propagating it for a wide distribution. . . . Cuttings, rooted in 1935, have grown into plants that are now four feet across, with a fairly uniform flat top, but only two feet high. This habit is of outstanding importance, for it is low enough to be covered or partially covered by snow in winter, or else it is an easy matter to protect the plant in other ways when necessary. It is unlike other varieties of *Buxus sempervirens* in having this low, flat-topped shape. Apparently, it is as hardy as any clone we have yet tried. In January of 1957, the temperature dropped to -23° F at Weston, and although there was some snow on the ground, the top of the plant was not covered nor was it injured. A large plant in the Arboretum has not shown any marked winter injury. Reports from others in Cleveland show that it has withstood temperatures of -20° F there, and we know that it had withstood similar temperatures in Boston. The foliage is a glossy, dark green, similar to that of the species, while new young foliage is first bluish green.

An Interesting Postscript

The story of 'Vardar Valley' is a worthy subject in its own right, but what really peaked my interest was a letter that Anderson wrote from the Balkans to Professor Oakes Ames, then supervisor of the Arboretum. I was reading through the archival material at the behest of my friend from Longwood Gardens, Dr. Tomasz Anisko, who was planning a trip to Skopje in the summer of 2007, and had asked me to help locate any of Anderson's original collecting books in the Arboretum Archives. The books weren't there, but the letters were. One letter in particular caught my attention; it was written on September 3, 1934, while Anderson was at the mouth of the Danube River in Salina-Tuscea, Romania, describing his earlier travels: "At Cluj my companion, Erhart Muller started back for the Harvard Medical School. He has been very helpful in many ways, gathering seeds, labeling packages, building up my German, and has greatly reduced traveling expenses since he always paid his half of cab and boat fare. I celebrated his departure by going to bed with an acute attack of diarrhea."

What stunned me about this passage was that I actually know Erhart Muller and that he is well and living in the town of Harvard, Massachusetts, about thirty miles west of Boston. I first met him in 1972, when I was living in Harvard and working at the Harvard Forest in Petersham, Massachusetts. I knew that Erhart had traveled with Anderson on his Balkan trip, but somehow failed to appreciate the full significance of this fact when he told me about it thirty years ago. It wasn't until his name popped out at me from a letter written in 1934 that the proverbial light bulb went on. Maybe Erhart had been with Anderson when he collected 'Vardar Valley' was my first thought. But the date of the letter in which he is mentioned, September 3, clearly indicates that he went home before Anderson collected the 'Vardar Valley' cuttings on September 19. So, in much the same way that I was foiled in my attempt to turn up either a photograph or herbarium specimen of 'Vardar Valley', I was thwarted in my attempt to locate a living witness to its collection.

AUTHOR PHOTOGRAPH

A portrait of Erhart Muller, December, 2006.

Nevertheless, I decided to pay Erhart a visit to see what he might remember about Anderson and their trip together. The answer is, as it turns out, not very much. Erhart was born in 1909—his father had immigrated to the United States from Barmen, Germany and his mother was a New Yorker of German descent. He grew up in the New York City area, spent a year at boarding school in Germany after World War I, and attended Harvard College where he studied anthropology. One highlight of his college days made newspaper headlines in April, 1929, when a small biplane he was traveling in was forced to make an emergency landing on Memorial Drive, a major roadway along the Charles River in Cambridge. Later, after graduation from Harvard in 1932, Erhart spent the summer in Montenegro with one of his professors, documenting the physiognomy of people living in the highlands.

Erhart first met Anderson—or Andy as he called him—in 1933, at the Keewaydin boy's camp on Lake Temagami in Ontario, Canada, famous then, as now, for its wilderness canoe trips. Erhard had been a camper there during a previous year and had returned for another summer to help out in the "running of the thing." Anderson was there to lead groups of campers on canoe trips. The two became friends and remained in contact after they both returned to the Boston area. Erhart remembers visiting Anderson at the Arboretum, not so much to

PHOTOGRAPHS AND LETTERS FROM THE ARCHIVES OF THE ARNOLD ARBORETUM

Anderson's photo #17432 taken on September 2, 1934 at the Letea Forest Reserve in Valcov, Romania, at the delta of the Danube River. In a letter to Oakes Ames on September 3, 1934, Anderson described the scene: "The last two days have been spent on the ultimate delta of the Danube, hot in summer, cold in winter; a vast swampy region with a very low rainfall. One does not know whether to refer to it as a dusty swamp or a swampy desert. Among the ancient sand ridges there are long strips of a most peculiar forest. The topography reminds one strongly of the Lake Michigan sand dunes. Like them it has been made a natural reservation and is in charge of the department of forestry. . . . The great plant of the delta is Phragmites. It builds the land and like the palms of the tropics is used for everything. The young growth is forage, the dried canes are fuel, housing, roofing, fences, sticks, rafts!"

Balkan Boxwood, the "K-series"

Anderson left the Arnold Arboretum at the end of the summer in 1935 and returned to the Missouri Botanical Garden, taking his interest in Balkan boxwood with him. Writing in *The Boxwood Bulletin* in 1963, he describes how he, ". . . got in touch by mail with the acquaintances I had made in the Yugoslav forest service[3] and imported a pound or so of boxwood seed which was raised at the Gray Summit Arboretum of the Missouri Botanical Garden."

AUTHOR PHOTOGRAPH

Buxus sempervirens # *131-64 (K-24) at the Arnold.*

Horticultural selections from Anderson's second importation of Balkan boxwood have come to be know as the "K-series" boxwood, as a means of distinguishing them from the earlier selections distributed by the Arnold Arboretum. The history of the K-series boxwood has been painstakingly pieced together by Mary Gamble in her articles in *The Boxwood Bulletin* published in 1975 and 1984. As she recounts the story, Paul A. Kohl, floriculturist at the Missouri Botanical Garden for forty years, told her that a boxwood seed arrived in September, 1936 from Anderson's contact in the Yugoslavian Forest Service. The seed, which had most likely been collected earlier that summer, was propagated in two locations, at the main garden in St. Louis by Kohl, and at Gray Summit Arboretum (now the Shaw Nature Reserve), about 35 miles from St. Louis, by Martin Bagby. Eventually, seedlings from both locations were brought together in a special boxwood nursery at Gray Summit.

In June, 1954 Anderson distributed cuttings from a number of these Balkan plants to the National Arboretum with cultivar names reflecting their Yugoslavian origin: 'Agram,' 'Nish,' 'Petch,' and 'Ipek,' all being ancient names for famous cities in the region. In 1955, following this initial cultivar selection and distribution, Mr. Clarence Barbré, a retired chemist and avid horticulturist from Webster Groves, Missouri, selected 155 of the Balkan seedlings at Gray Summit for further horticultural trial. These selections were assigned numbers preceded by the letter "K", which designated the Kingsville Nursery run by Henry Hohman, to whom the unrooted cuttings were sent for propagation and distribution.

Hohman rooted the cuttings and in 1957 and 1958 sent sets of plants under their original K-numbers to the University of Washington Arboretum in Seattle, the United States National Arboretum in Washington, DC, the Blandy Experimental Farm in Boyce, Virginia, and Longwood Gardens in Kennett Square, Pennsylvania. According to the latest research (2004) by Lynn Batdorf, the National Arboretum has fifty of the original plants; the Blandy Farm has twenty-nine; the Washington Park Arboretum has six; Longwood Gardens has twenty; and the Missouri Botanical Garden, including the Shaw Nature Reserve, has thirty-five.

The Arnold Arboretum received unrooted cuttings of 64 of the K-series boxwoods from the National Arboretum on January 29, 1964 (AA # 83-64 through 146-64), and still has three living plants from this distribution: #131-64 (= K-24), a conical plant, currently 11.7 feet wide by 13.3 feet tall; #113-64 (= K-33), a tall plant, 13.3 feet wide by 21.7 feet tall; and #116-64 (= K-75), a low-growing plant resembling 'Vardar Valley', 16.7 feet wide by 7.3 feet tall.

talk about plants, but to get some guidance from him about what he should do with his life. Probably because of Erhart's past experience in Montenegro and his ability to speak German, Anderson invited him to go on the Arboretum's expedition to the Balkans, planned for the summer of 1934. Erhart's memories of that trip are vague, but he remembered well one of the botanists they met, a Professor Stoyanoff from the University of Sofia in Bulgaria:

> He was probably the chief botanist there because he was the one who went botanizing with the king, Boris. And I was very much impressed with him. He seemed more aristocratic in demeanor. We went down by bus. The thing that impressed me tremendously was what a gentleman he was. A woman getting on the bus with quite a bit of luggage and so forth, he didn't try to press in ahead of her or anything. He treated her as though she has as much right to be there as he did—that sort of thing. I remember particularly later when we got to the monastery of Rila, and one of the monks there was really quite spruced up, I don't know what to say, but, he had long curly hair and that sort of thing. And I made the comment that it looks as though he had curled the hair, and this botanist, I think his name was Stoyanoff, said in response to my comment, "It is not impossible."

Indeed, Professor Stoyanoff's response could well be used to describe the serendipitous circumstances surrounding the discovery and propagation of *Buxus* 'Vardar Valley'.

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Endnotes

[1] Ames had been one of Anderson's botany professors at the Bussey Institution and was appointed Supervisor of the Arboretum in 1927 following the death of its founding director, C. S. Sargent. I suspect that it was Ames who persuaded Anderson to work at the Arnold Arboretum in 1930 and that Ames's retirement in 1935 may have been a factor in his decision to leave. Anderson's 1952 book, "Plants, Man and Life" is dedicated to Oakes Ames, Orland White, and Carl Sauer.

[2] Like Anderson, Orland White was one of Dr. East's graduate students, who earned his D.Sc. degree from the Bussey Institution in 1913.

[3] For clues as to who this person might be, I turned to Anderson's undated "Report on Balkan Expedition to The Arnold Arboretum." In this document he mentions only one person who worked for the Yugoslavian Forest Service: "Herr Ing. Ohm, Forest Service, Skoplje [sic]. This forester, stationed at present in Skoplje is the best botanist actually located in the neighborhood, though he is liable to transfer at any time. He has an herbarium of his own and has a very real interest in botanical problems. Most of the foresters whom I met are more interested in hunting wild boars than in botanical problems allied to their work."

Peter Del Tredici is Senior Research Scientist at the Arnold Arboretum and a Lecturer in the Department of Landscape Architecture at the Harvard Graduate School of Design. Edgar Anderson is one of his botanical heroes.

Climate Change and Cherry Tree Blossom Festivals in Japan

Richard Primack and Hiroyoshi Higuchi

Climate change is already having an influence on plants throughout the world, with warming trends creating conditions that cause many plant species to extend to cooler zones on mountain slopes or farther north of their original ranges. Plants are leafing out earlier in the spring and holding leaves longer in the autumn, creating an extended growing season. Of all of the characteristics of plants that relate to global warming, the timing of flowering is the one for which there are the greatest number of observations. These data demonstrate that plants are now flowering earlier than they did a few decades ago, and that changes are mainly a product of temperature increase, rather than a result of other aspects of the weather. Although observations of flowering time tell a convincing story of the impacts

PHOTO COURTESY OF HIROYOSHI HIGUCHI

People enjoying the cherry blossom festival in Ueono Park, a popular spot in the center of Tokyo.

A well-organized cherry blossom party being celebrated by a group of business people at Yasukuni, a park in the center of Tokyo.

of global warming, the record extends back a mere 150 years, at most. The studies are predominantly from Europe, with a scattering of more recent studies from the United States, and many of these studies of climate change are from cities where additional warming is associated with urbanization. Scientists working on long-term climate change need additional studies from elsewhere in the world and conducted over a longer period of time. Such studies could provide evidence that the earlier flowering time—observed in Europe and the United States—is caused by a warming trend, a truly global phenomenon extending beyond the historical weather record of the 19th and 20th centuries.

Kyoto Cherries as Indicators of Climate Change

A unique data set that can potentially supply these insights is the record of annual cherry blossom festivals in Japan. Cherry blossom festivals, or *Hanami,* are a special feature of Japanese life that really has no equivalent in other countries. During modern festivals, all ages spend time outdoors, enjoying the beauty of the cherry blossoms by day and by night, with their family, friends, and workmates. Festival activities include eating seasonal foods, such as bamboo shoots, rice cakes with red beans, and wild vegetables, playing games, listening to musical instruments, and singing. More enthusiastic pursuits include dancing and drinking sake—Japan's special rice wine—and beer. The festivals have been the subject of numerous poems and songs and have been depicted in paintings, pottery, and textiles for hundreds of years. Because of their great popularity and cultural significance, local governments, meteorologists, botanists, and newspapers have recorded the flowering times of cherry blossom times for an extraordinarily long time. In Kyoto, a beautiful ancient city on the main island of Honshu, the cherry blossom

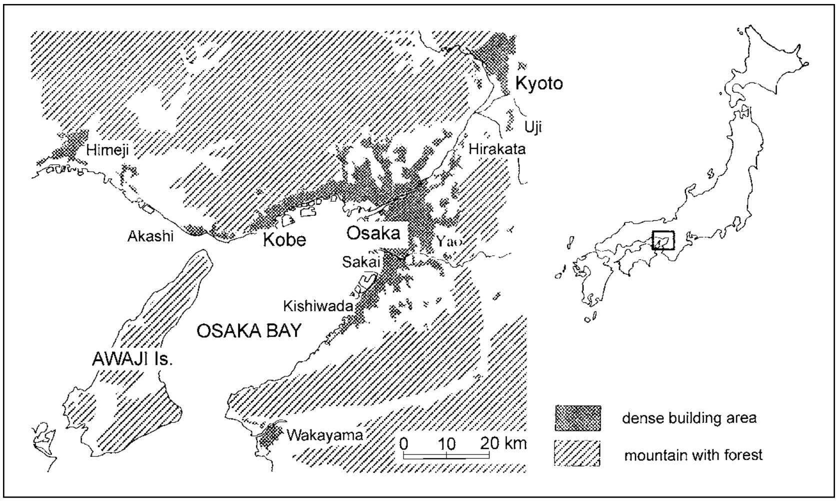
People boating in the moat surrounding the Imperial Palace in Tokyo, when the cherry trees are in full flower.

festivals have been part of court life for over one thousand years. The diaries of court officers often include mention of the festival dates, a peculiarity of the region's history that allows modern scientists to track the influence of a changing climate on flowering times.

Kyoto became the capital city of Japan in 784 A.D., and was the focus of a rich court life for several hundred years, a time known as the Heian Period. Cherry trees were prominently planted in the gardens of aristocratic residences, and cherries were an important imperial symbol. During the flowering period, people made special trips to visit particular sites around Kyoto to view cherry trees planted in attractive settings, such as temple gardens, and imperial parties went on excursions of up to several days into the surrounding Arashiyama hills to enjoy the cherry blossoms at their peak.

While double-flowered cherries and unusual cultivars were sought for the gardens of the nobility, ancient cherry blossom festivals focused on the blossoming of wild cherry trees, known in English as the Japanese mountain cherry and in Japanese as the *yama-zakura.* Scientifically this species is known as *Prunus serrulata* var. *spontanea,* or less commonly as *Prunus jamasakura.* It is typically found in the foothills of central Japan, often in secondary forests. In contrast with many other species of cherries, the mountain cherry is long-lived and easily raised from seed. Its white five-petaled flowers, about 1 to 1½ inches (5 to 8 cm) across, help with identification, and the species is more readily recognized because the young leaves are brownish-red to red in color, presenting a striking contrast with the green leaves of most other cherries.

The mountain cherry trees are still found in abundance around Kyoto and have been planted extensively in gardens. The hills of Arashiyama are especially noted for them. Paintings from



COURTESY OF DR. YASUKUKI AONO, 1998

The location of Kyoto and Osaka in Japan. The urban area of Kyoto is densely shaded.

Kyoto depict boatmen paddling small boats in the nearby Oigama River, with their passengers observing the flowering trees on the riverbanks nearby and the hills above. And the Arashiyama Hills have featured prominently in Japanese literature, most notably as the occasional 17th century residence of the great Haiku poet Matsuo Basho.

For over eighty years, Japanese scientists have been examining court records and diaries from Kyoto to extract information on when the cherry blossom festivals have been celebrated in Kyoto. The date of the celebrations are determined several days before peak flowering by observations of the flower buds, and may be adjusted some days earlier if the weather is unusually warm or later if the weather is unusually cold. The past dates of the festival thus indicate when the Japanese mountain cherries were in full flower and provide an estimate of the temperature in that year. The earliest of these studies, published in 1939 and 1969, were carried out by meteorologists primarily interested in using this data to reconstruct past climate and to predict the timing of the modern cherry blossom festivals based on climate variables. The researchers were able to find fairly abundant records for the 15th and 16th centuries, with less complete records extending back to the 11th century, and forward to the present.

Studies by Aono and Omoto

In the 1990s, the agricultural meteorologist Dr. Yasuyuki Aono of the Osaka Prefecture University, along with his colleague Yukio Omoto, began to search all available court records and diaries, with the goal of having a complete set of cherry blossom festival dates for Kyoto. These documents were stored in libraries, archives, and museums, primarily in Kyoto, Nara, and other historical centers of Japan. The documents were hand written in ancient Japanese script on paper and parchment. Over many years, Dr. Aono taught himself to read these documents, and he gradually converted them to modern Japanese characters. In addition, the dates on the documents corresponded to the Japanese calendar and had to be converted to the Western calendar. His lifetime goal of analyzing ancient and modern climate data has filled his modest office with boxes of photocopies of court records, old books, and computers.

During fifteen years of dedicated searching, Dr. Aono was able to greatly increase the number of years for which there were dates of the Kyoto cherry blossom festivals, with many additional dates going back to the 11th century. From 1401 to the present time, a 605 year time span, there are now records of the festivals for most years. For the period 1476 to 1553, there is a record for every single year.

The cumulative flowering record shows a six week range in flowering dates from as early as late March to as late as early May. The extreme flowering dates are scattered throughout this time period. There are, however, periods of decades with earlier than average flowering and decades with later than average flowering. Many of the flowering records from the 12th and 13th centuries are noticeably earlier than average, along with the decades before and after 1600. In contrast, the period from the mid-1600s to the early 1800s is characterized by later than average flowering. After approximately 1830, the flowering times become progressively earlier. By the 1980s and early 1990s, average flowering times had become earlier than at any time previously during the entire flowering record of over one thousand years.

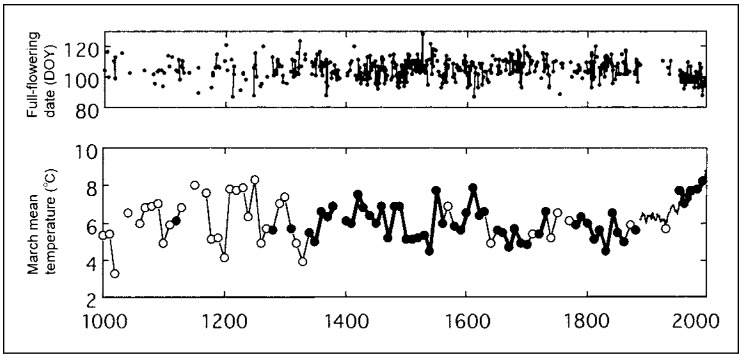
Using these old records and more modern temperature data, Dr. Aono's goal was to develop a model that could predict the modern flowering time of cherry trees from temperature data, then use this model to predict past spring temperatures from past flowering dates. The modern values used for calibrating the model come from the Arashiyama Hills, the same site where ancient court officials went for their parties. He and Omoto published the results of their work in the *Journal of Agricultural Meteorology* in 1994, a journal appropriate to his background in agricultural meteorology, and his appointment in a College of Agriculture within his university. Using a complicated equation, he was able to show that estimates of flowering time of the Japanese mountain cherry could be made using just the temperature in the months before the cherry trees flowered. These estimates using temperatures corresponded closely with the actual flowering times of

ARRANGED BY DR. YASUYUKI AONO, WITH PERMISSION FROM THE KYOTO UNIVERSITY LIBRARY

Old court diaries and records let us know the past dates of the cherry blossom festivals in Kyoto. This diary of Tokistune Hiramatsu, a well-known court figure of the Edo era, provides the following entry on April 14, 1644: "In Seiryoden Palace, Kyoto, we enjoyed watching cherry blossoms and took sake provided by the emperor." The translation of the highlighted sentence is shown in red. The black entry is the date, according to the Japanese calendar.

cherry trees in Kyoto during the last few decades.

With this equation and past dates of cherry blossom festivals, Dr. Aono was then able to estimate March temperatures in Kyoto going back to the 11th century. Obviously the accuracy of the estimates depends on the number of years for which data exist, with the greatest certainty available for the middle and later periods of this one thousand year span. The calculations show that during the 11th through the 13th centuries, average temperatures were at their warmest averages, often as high as 8° C , as indicated by early dates of the cherry blossom festival. There were occasionally very cold years, as indicated by late flowering years, but on the whole this was the warmest average period. From 1400 to the mid 1500s, temperatures were variable, but they appear to have declined slightly on average. Certain decades, both before and after 1600, were noticeably warmer. In the following centuries, temperatures generally declined to 6° C, with particularly low temperatures in the periods from 1690 to the 1710s, and from 1810 to the 1830s.



COURTESY OF DR. YASUYUKI AONO AND YUKIO OMOTO, 1994

Upper figure. Known dates of the cherry blossom festival (full flowering of P. jamasakura*) in Kyoto from the 11th century to the present time. April 1 is the 91st day of the year (in years without a Leap Year); May 1 is the 122nd day of the year. In recent decades, flowering times have become earlier than in the past.*

Lower figure. Estimated March mean temperature in each decade, as calculated from flowering dates. Means calculated from 5 or more years are shown as solid dots. Decades with less than 5 years of data are shown as open circles. While temperatures have varied over this period, recent decades have been warmer on average than any time during the past 1000 years.

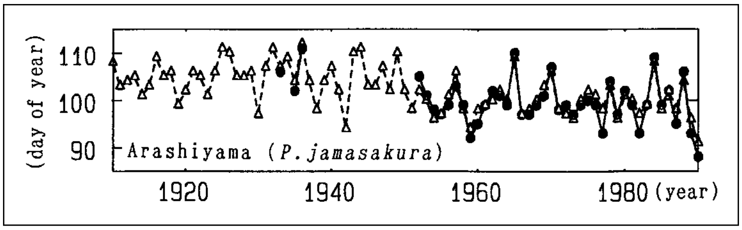
And by using estimates made from the cherry blossom records, over the past 170 years, Dr. Aono saw a general rise in temperature in the Kyoto area of 3.4° C. The estimated temperature increase during this period corresponds well to the increase in temperature recorded from regular meteorological records, and is attributed, primarily to the warming associated with the urbanization of the Kyoto area, and secondarily with the general global climate warming of Japan. If we assume that Kyoto has experienced the average global increase of 0.6° C , then the remaining 2.8° C is due to urbanization.

Dr. Aono has been active in tracking down ever more obscure historical records to fill in the remaining gaps in the records of Kyoto's cherry blossom festival times. He has located records going back even further in time, back to the early 9th century, and many scientists around the world are awaiting the published results of his new work.

Cherry Tree Flowering Affected by Urbanization

As mentioned above, cherry tree flowering times have been strongly influenced by the urban heat island effect, the warming that comes from the added heating caused by removing trees and replacing them with roads, parking lots, buildings and other aspects of a human-dominated landscape. In studies of the impact of global warming, it is important to separate the effects of localized warming caused by urbanization from the more general aspects of warming caused by global climate change. Cherry trees can be used to separate these effects because they are planted at many locations—in cities, suburban areas, and more remote rural locations. It is again Drs. Aono and Omoto who lead the way in this research.

The most widely planted cherry species since the late 19th century, and therefore the most useful for climate change research covering the past one hundred years, is Somei-yoshino (*Prunus* x *yedoensis*), also known in the nursery trade as the Yoshino cherry. This cherry is almost certainly a hybrid between the Edo-higan cherry (*P. pendula* f. *ascendens*) and the Oshima cherry (*P. serrulata* var. *speciosa*). The somei-yoshino is the most striking of the cultivated cherries with a profusion of white to pink, five-petaled flowers that appear on the branches before the leaves are produced. The 1½ inch (4 cm) wide flowers are produced in umbels of three to four flowers. This hybrid began to be widely planted in the late 19th century, and is now commonly cultivated in Japan. In the view of many Japanese, the Somei-yoshino is the most beautiful cherry tree, and it has replaced the yama-zakura as the focus of the cherry blossom festival. This is the same cherry tree that is planted in Washington, DC, and enjoyed by Americans during the flowering season. Its flowering behavior is similar to the Japanese mountain cherry, so the results from the two species are comparable.



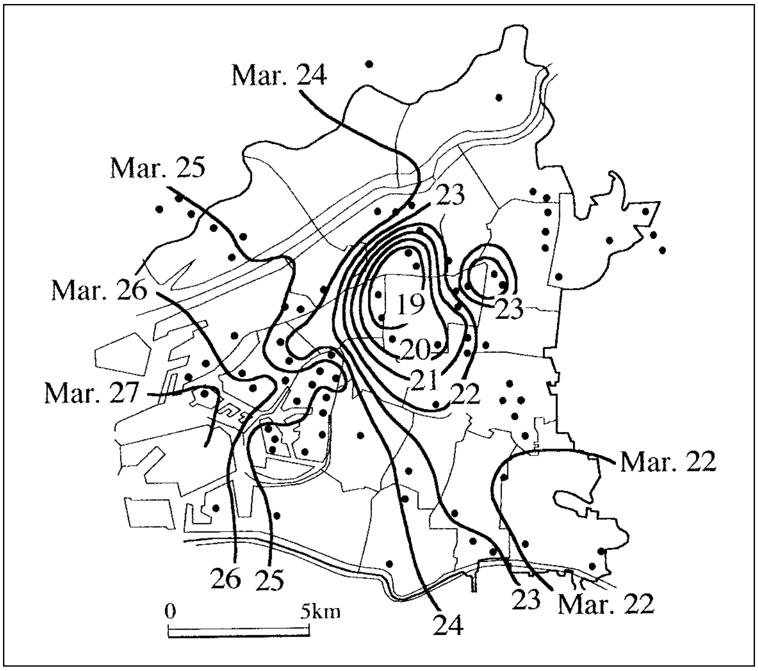
The flowering dates of mountain cherry trees (P. jamasakura) *on the Arashiyama Hills outside of Kyoto have been getting earlier over the past 90 years; the different symbols represent different types of observations of flowering dates. Courtesy of Dr. Yasuyuki Aono and Yukio Omoto, 1994.*

Due to the abundant records of cherry blossom festival records at numerous locations in Japan, it is possible to use the flowering dates

PHOTO COURTESY OF HIROYOSHI HIGUCHI

A cherry tree in flower in the built-up center of Osaka, the second largest city in Japan.

of the Somei-yoshino to measure how many days earlier plants flower as a result of the urban heat island effect. At locations near Kyoto, Osaka and Tokyo, urban, suburban, and rural locations had similar times of cherry blossom festivals in the 1950s. This indicates that urban, suburban, and rural areas still had essentially the same temperatures in the spring. Over the next 50 years, however, urban, suburban, and rural sites at each of these cities gradually began to diverge in flowering times, with urban areas flowering earlier than nearby rural and suburban areas. By the 1980s, the warmer temperatures in the city had shifted the flowering of cherry trees by eight days earlier in central Tokyo in comparison with nearby rural areas, and four to five days earlier in central Kyoto and Osaka than in their nearby rural areas.



Cherry trees were monitored for their flowering times in 1989 at numerous locations in Osaka, shown as black dots in this map. Isoclines are produced by a computer program to show the geographic pattern of flowering. Trees flower earliest on March 19 in the center of the city and progressively later at greater distances from the center. The latest flowering is along the coast to the west of the city, due to the moderating influence of the sea. A city park to the northeast of the city center also creates a small area of later flowering.

The temperature effects of urbanization on flowering times for Osaka City have been mapped in detail. In 1989, the first flowering times of somei-yoshino cherries were recorded at around eighty locations in Osaka City. First flowering was recorded starting on March 19 at locations in the city center. Flowering was recorded at successively later dates at distances farther from the city center. At around seven kilometers from the city center, plants were starting to flower as late as March 22 to March 27, as much as eight days later than in the city center. The latest dates were found along the bay to the west where the cooling influences of the water may have caused a further reduction in temperature, slowing flowering. Cherry trees in a city park just northeast of the city center also have a delayed flowering, indicating a local cooling effect. Based on models that relate temperature to flowering times, Drs. Aono and Omoto were able to show that these earlier flowering times in the center of Osaka City correspond to a temperature increase of 1 to 1.5° C.

Conclusion

The dates of cherry tree festivals in Japan have emerged as one of the most important sources of information on the impacts of climate change on plants. The data set is exceptionally detailed, and extends back in time more than any other known data set on plant flowering times. Because cherry trees have such great cultural importance in Japan, the results of this climate change research have been widely appreciated and publicized, both in Japan and among the international scientific community. Even the cherry trees in Washington, DC, donated by the Japanese government, are responding to higher urban temperatures by flowering one week earlier than in the past, providing an example of the biological impacts of climate change right on the doorstep of the American government.

People and Cherries in Japan: The Shinagawa Family

The Japanese people often mark events in their lives by corresponding events in the natural world, and one of the most significant events on the Japanese calendar is the time of the cherry blossom festival. Mr. Fujiro Shinagawa, a well known psychologist and author of books on raising healthy children, often associates himself with the cherry blossom festival. He was born in Okayama Prefecture in western Honshu on April 15, 1916, a day on which the cherry blossom festival was being celebrated. As a child, the trees were always in flower on his birthday, and he considered himself a child of the cherry blossom. Living in Tokyo as an adult, however, the cherry blossom festival gradually moved forward in time and was celebrated before his birthday; in some years, the cherry trees had finished flowering by his birthday.

His twin daughters, Hiromi and Yoshimi, growing up in Tokyo from 1955 to 1965, associated cherry blossom festivals with their school opening ceremony—always held on April 8, an exciting day, when students, parents and teachers joined at the school for special activities. On that day, the cherry trees in the schoolyard were always covered in blossoms, creating a joyous start to the school year, and in some years, April 8 was even the day of the cherry blossom festival, creating a double holiday. But in the 1990s, when Hiromi sent her own son to school in Tokyo, the cherry blossom festivals were often held before April 8, and in some years the trees no longer had any flowers by that date. Hiromi felt that something joyous and beautiful was missing from her son's school ceremony without the profusion of cherry blossoms. But for her son, the earlier flowering time of cherry trees seemed normal.

At the retirement community in the western suburbs of Tokyo, where Mr. and Mrs. Shinagawa now live, the annual cherry blossom festival remains an important event. On this day, the staff put chairs and tables in the parking lot of their building, and serve a special meal under the gorgeous flowers of the cherry trees. Now, however, the date is typically at the end of March, two to three weeks earlier than in 1916, when Mr. Shinagawa, the cherry blossom child, was born.

PHOTO COURTESY OF HIROMI KOBORI

Mr. and Mrs. Shinagawa and their grandson enjoying a cherry blossom festival on April 5, 1992.

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The Future of Research at the Arnold Arboretum

Robert E. Cook

In this article, the director of the Arboretum examines the role of research in botanical gardens, and the singular circumstances that position the Arboretum to become a center for the scientific study of plants. In this context, he discusses plans for a future research program on the biodiversity, genomics and developmental biology of plants.

I recently came across the title of an opinion piece that I thought I should read. "What genes make a tree a tree?" was published in the May, 2005 issue of *Trends in Plant Science* by Andrew T. Groover. A decade ago I would have passed over this title without notice. But the Arnold Arboretum has recently put forward a plan to make a major investment in molecular and genomic approaches to research on the biology of woody plants and this research will call upon the resources of our living, herbarium and library collections. It will also cost a lot of money. Because the Arnold Arboretum receives no funds from the University (we are financially self-sufficient, depending almost entirely on past and present philanthropy), a large invest-


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The oak collection at the Arnold Arboretum in late spring.

ment in research presents a major financial challenge to the institution. Let me discuss collections-related research in more general terms first, and then return to those genes that make a tree a tree.

Over the past couple of decades, directors of many botanic gardens and arboreta, especially those associated with colleges and universities, have wrestled with the question of the role that research should play in their institution's mission. In part this reflects the historical roots of botanical collections gathered and curated as a basis for advancing knowledge of the botanical world and as an important foundation for economic advancement and commerce through the development of new plants. At modern research universities, the substantial budget allocations once enjoyed by botanical collections have increasingly come under scrutiny by the administration as the research use of those collections, particularly living collections, has shrunk in importance. Likewise, the availability of external research funds from federal agencies to support the use of living collections (to say nothing of their upkeep) is non-existent. In many public gardens and arboreta, the purposes of the living collections have expanded to include educational and horticultural display values which have surpassed any research use the collections may have once served. This leaves the fiscally conscientious director to ask: how important a role should research play in the mission of the organization?

Supporting a Research Function

For many institutions whose mission is fundamentally educational, supporting a research dimension confers great interest and legitimacy in the eyes of the institution's supporters. The investment required may be modest and the rigor of the research can be high if pursued systematically. The research can bolster the primary mission to educate and increase scientific literacy. But major research investments require a realistic assessment of what will be the cost of achieving long-term, high quality results as judged by publication in peer-reviewed journals. Most institutions are not well positioned to make such open-ended investments.

Since research comes in many flavors, very different financial implications accompany the initiation of a research program. In the simplest case, an institution may create a formal monitoring protocol designed to provide environmental and horticultural data with which to improve the care of collections whose primary functions are aesthetic and educational. Gathered systematically over longer periods of time, such data may also yield valuable insights into local trends related to larger environmen-

The proposed research facility on Weld Hill as designed by KlingStubbins Architects.

tal variables such as climate and soil chemistry. Depending upon the scope of the measured variables, and the quality and duration of the monitoring records, this can yield publishable information that constitutes valuable research. The creation of such formal programs can, but need not, require expensive equipment; rather, it requires a long-term commitment to the management and evaluation of data, and its subsequent publication. These days the web can be an excellent medium for providing inexpensive access to this information.

Beyond the gathering of data for the purposes of collections management, research investments are often motivated by the desire to discover unknown aspects of the natural world, by the application of existing knowledge to the development of improved horticultural plants

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A well-laid out research collection can be enjoyed by people with little or no interest in science.

(stress tolerance, pest resistance, morphological variety, urban horticulture), or to the testing of specific hypotheses about the evolutionary history and functional biology of plant diversity. Whether an institution should invest in any or all of these types of research, and how much investment is appropriate, depend very much on the specific circumstances of that institution.

Discovery Research

Among large botanic gardens in this country that are involved in discovery research, the Missouri Botanic Garden and the New York Botanic Garden clearly stand out as leaders. Both institutions continue to mount major efforts in botanical exploration at multiple locations around the world, and this work is accompanied by significant publications in plant floristic and monographic research. The Arnold Arboretum, by virtue of its age and history, and in collaboration with other botanical institutions at Harvard University (the Gray Herbarium, the Botanical Museum, the Farlow Herbarium, the Oakes Ames Orchid Collection) maintains a modest effort in this type of research, and it will continue to do so in the future, with particular emphasis on the floras of Asia. Absolutely essential to this kind of work is the collection and maintenance of a large herbarium (over 5 million specimens at Harvard) and the related library collections (280,000 volumes, 900 current journals) without which such research would be impossible. In recent years, this type of research has been complimented at the Arboretum with molecular systematic studies utilizing its well documented living collections. Of particular interest are phylogenies that relate to our understanding of the biogeography and evolutionary history of the disjunct floras of eastern Asia and eastern North America.

Improved Horticultural Plants

The use of the living collections of a botanic garden or arboretum for the development of better plants for agricultural production, for landscape use in suburban and urban settings, and for improving basic mechanisms of stress tolerance and pest resistance has been closely tied to the land grant university system with its long history of support from the Department of Agriculture and related commercial sources. The research mission of botanical gardens within such a setting will always depend upon its relationships with various research departments (horticulture, crop physiology, plant breeding) and the idiosyncratic needs of faculty members and senior research scientists for the resources of the gardens. Directors of these gardens may feel captive to these academic sources of power and funding, and independent investment in research not defined by faculty needs and external funding sources can be politically risky. Of course, independent institutions outside the academic system of universities have much greater leeway to pursue problems of applied research of their own choosing.

Evolutionary Relationships and Functional Biology

Basic research into the evolutionary history and functional biology of plants has generally been less closely allied with botanical gardens than with academic departments of botany, biological sciences or ecology and evolution. On the face of it, the great diversity of the living collections of botanic gardens and arboreta would seem a particularly valuable resource for such research, especially for comparative experimental approaches to addressing functional and evolutionary questions about plants. Twenty-five years ago, my predecessor as director, Professor Peter Ashton, put forth a vision for the use of the living collections of the Arnold Arboretum to investigate basic questions of plant functional biology in an evolutionary context. At that time, however, Peter's vision did not find fertile soil among his faculty colleagues and he was unable to implement it.

There are a number of challenges facing a director inclined to invest in such research. Generally large questions of this nature require the development of specific hypotheses about mechanisms and controls that can only be addressed through experimental designs using molecular, genetic, and biochemical approaches. This kind of research can only be done in a highly sophisticated laboratory setting with expensive equipment and protocols. Technical support is essential and, therefore, expensive. Senior research scientists usually establish large labs consisting of multiple technicians, post-doctoral researchers, undergraduate assistants, and several graduate students working on elements of the problem at hand. The research is highly collaborative, both within the laboratory setting and among different labs located at other institutions. Funding the research requires a continual flow of money, most often provided by the federal government through grants from organizations like the National Science Foundation. This system of funding is closely tied to the peer review system that dominates both the publication of results from such research and the advancement of faculty members through traditional ladder positions within university departments.

As this implies, the director of an independent botanical garden needs to think twice before embarking upon such research investments without having in place close working relations with an academic institution that can provide access to students and faculty resources. The investment in modern research laboratory and growing facilities must be of a large scale to attract the quality of researchers able to support their research through successful, peer-reviewed grant applications. Finally, an institution will want a critical mass of such researchers, at least five or six senior scientists, each capable of supporting a laboratory staffed with up to half a dozen technicians and students. The hiring of each is usually accompanied by significant start-up requirements (laboratory equipment, laboratory assistance until the first grants are received). It is all a very expensive affair and it can't be done in incremental steps.

Investing in Research

At the Arnold Arboretum, we are prepared to make such an investment. Ironically it will be very much based on the vision of research with the living collections articulated by Professor Ashton twenty-five years ago. How can such a vision succeed today if it was not able to do so two decades ago?

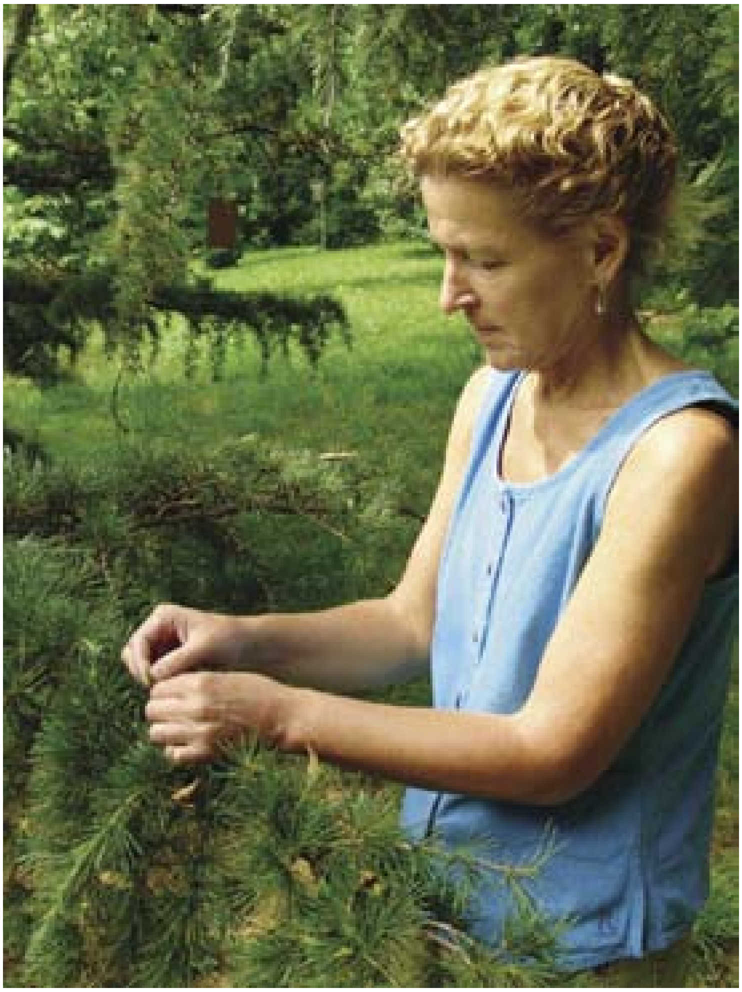
Two major advances in the biological sciences have fundamentally altered the context surrounding such a vision. First, the proliferation of molecular approaches to investigating the evolutionary history of organisms has dramatically altered our understanding of the phylogenetic relations among species. This new understanding provides a solid evolutionary foundation for the comparative study of the functional and developmental biology of closely and distantly related species. Second, with the sequencing of the human genome in the past decade, biological science has made tremendous advances in creating genetic and molecular tools for investigating basic questions about the functional and developmental biology of organisms. These tools have led to the subsequent sequencing of the genomes of the tiny herbaceous plant *Arabidopsis thaliana,* in the mustard family, and the first woody plant in the genus *Populus* as model species for the understanding of plant biology at the genetic and molecular level. Over the coming decade, the genomes of a number of other species will also be partially or fully sequenced, creating an immense opportunity for comparative studies of plant diversity.

To provide just an illustration of this, let me briefly return to the publication, "What genes make a tree a tree?" Woody stems, of course, develop from growth in the vascular cambium that is generated by meristematic stem cells whose daughters differentiate into the carbohydrate-conducting phloem and water-conducting xylem (wood). As Andrew Groover, the author of this article, points out, "trees" may be categorized at the local nursery as a group based on the presence of a woody trunk; but it is a completely artificial classification. Nearly all orders of higher plants in the Angiosperms contain tree-like species and many families have both herbaceous and woody species. Because woody growth is evolutionarily ancient and probably predates the divergence of Angiosperms and Gymnosperms, the appearance of woody taxa may be a matter of degree rather than a trait that has arisen uniquely within a single lineage. Even within a species, the expression of woody growth can depend upon environmental conditions. Not surprisingly, then, we find that woody species on remote islands have evolved rapidly from closely related, herbaceous ancestors on the mainland. Groover concludes that the genes regulating woody growth ought to be evolutionarily ancient and common to all taxa, ought to be present in a broad range of taxa including herbaceous species, and ought to be readily modifiable to express or suppress woody growth in the process of speciation or in response to changes in the environment.

With the sequencing of the genomes of the herbaceous species *Arabidopsis* and the woody species *Populus,* scientists can now determine whether woodiness in the latter species depends on genes not found in the former species. In fact, the same genes that regulate primary growth in the shoot apical meristem in *Arabidopsis* are also involved in the regulation of secondary growth in *Populus.* Thus these genes are probably present, but suppressed, in many herbaceous species. Tree forms therefore reflect differences in the expression of a similar set of genes that are present in a vast number of taxa. Woodiness—the genes that make a tree a tree—could be studied and artificially manipulated in almost any species. Groover argues that this fundamental understanding, and the genetic tools that have led to it, will usher in a revolution in approaches to increasing our knowledge of woody plants.

The Arnold's New Research Initiative

I believe that these new approaches to addressing basic research questions about the evolutionary diversification of plants through a deeper comparative understanding of their functional biology should be at the heart of the Arnold Arboretum's research mission. At the same time, I do not believe that this should necessarily serve as a model for other botanical gardens and arboreta. The Arnold is in a relatively unique position because of several important factors. First, we have an exceptionally well-documented collection of woody taxa, many of known wild origin. Second, we are part of a university able to provide a constant stream of students (if not money) and a brand identity that can be immensely helpful in recruiting the finest scientists. Finally, a long history of philanthropy has created a substantial endowment able to provide a dependable financial foundation upon which to build new programs.



JON HETMAN

Sarah Matthews collecting leaf tissue from Cedrus deodara *growing at the Arboretum.*

To staff this large investment in research, the Arboretum has created a new type of research position which we have named Sargent Fellows. We intend to recruit individuals of the highest quality as judged by their colleagues and permanent appointment will require rigorous peer review. Two Sargent Fellows are currently appointed. Sarah Matthews is an expert on the molecular biology and evolutionary history of the light sensing pigment phytochrome in plants, and Maciej Zwieniecki studies plant hydraulics, the microfluidic systems that control the long-distance movement of water, solutes and energy from roots to leaves.

In 2007, we will break ground for the construction of a $38,000,000 laboratory and greenhouse facility able to support up to eight senior researchers and their associates. This state-of-the-art facility will also serve to integrate the research efforts of our Sargent Fellows with those of faculty and students in Cambridge through common use of greenhouses, growth chambers and experimental gardens. This substantial investment will return the Arboretum to the forefront of basic research on the biology of trees. As Peter Ashton stated shortly after arriving as director in 1979, "Only if it maintains its preeminence in research and education can the Arnold Arboretum continue to develop its complementary function as a unique public amenity and an authoritative source of information on the culture of woody plants."

Robert E. Cook has been director of the Arnold Arboretum since 1989. An earlier version of this article appeared last year in *Public Garden,* vol. 21, no. 1.

The Arnold Arboretum's Living Collections: A Repository for Research

Michael S. Dosmann

As Bob Cook has expressed in the article preceding this one, the Arnold Arboretum is embarking on a dramatic programmatic expansion into research. This includes housing an expanded research staff in a modern facility sited on Weld Hill, adjacent to the Peters Hill section of the Arboretum. As the newly appointed Curator of Living Collections charged with overseeing the development and enhancement of this most precious of Arboretum assets, this new initiative has served to focus much of my energy on the dynamic interplay between living collections and scientific research. As a result, in the coming months, the Arboretum will be unveiling a new collections policy that will reaffirm its commitment to research.

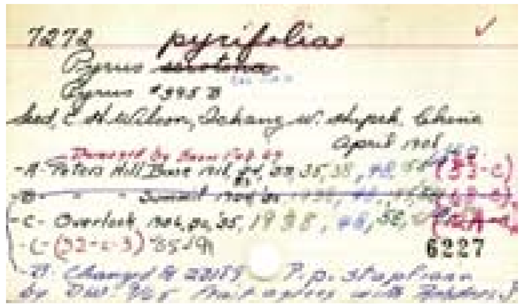
While the resurgence of a strong research agenda is heartening for the Arboretum, it does not seem to be a trend being followed by similar institutions. Over the past decade, many members of the natural history collection community, which includes a full spectrum of museums, herbaria, zoos and aquaria, have been concerned about their future. Despite their intrinsic value, some of these collections, particularly those affiliated with universities, have become fiscally endangered and are at risk of abandonment by their parent institutions. At the very core of the issue is a decline in collections-based research. Dubbed a "crisis" by those in the field, this state of affairs has prompted an array of discussions and calls-to-arms demonstrating the vital importance collections have to science and to society (Krishtalka and Humphrey, 2000; Dalton, 2003; Pekarik, 2003; Miller et al., 2004; Suarez and Tsutsui, 2004).

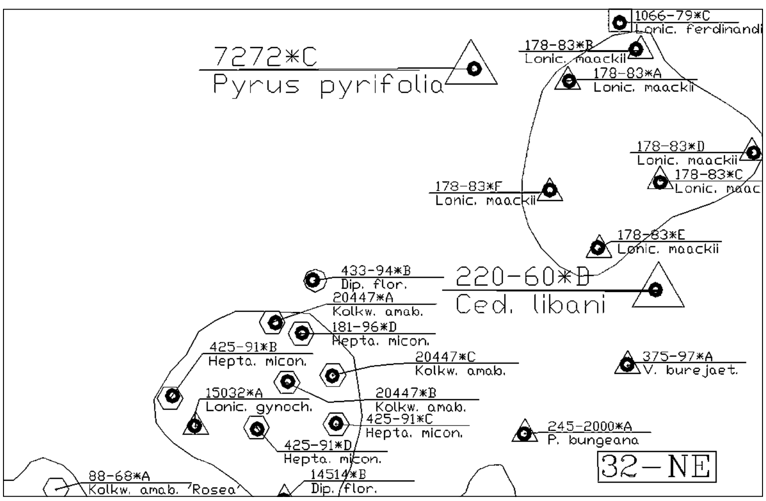
While following these dialogues, I was puzzled by the absence of botanic gardens and arboreta—long-standing members of the collection's community—from the debate. Even more surprising was the discovery that there was very little discussion within the botanic garden literature about the collections crises and its implications for research. I began to ponder a broad question: What does the future hold for collections-based research in our gardens and arboreta? What eventually came to fruition was a review, published last year in *The Botanical Review* (Dosmann, 2006), of the historical and contemporary literature related to living plant collections, the research derived from them, and strategies and tactics that gardens and arboreta can take to avert their own crisis. This article summarizes some of that work, describes the central role the living collections can play in supporting research, imparts some rationales and approaches for fostering collections-based work in the future, and frames several take-home-messages in light of the Arnold Arboretum's mission and history.

Research in the Collection: Why is it Important?

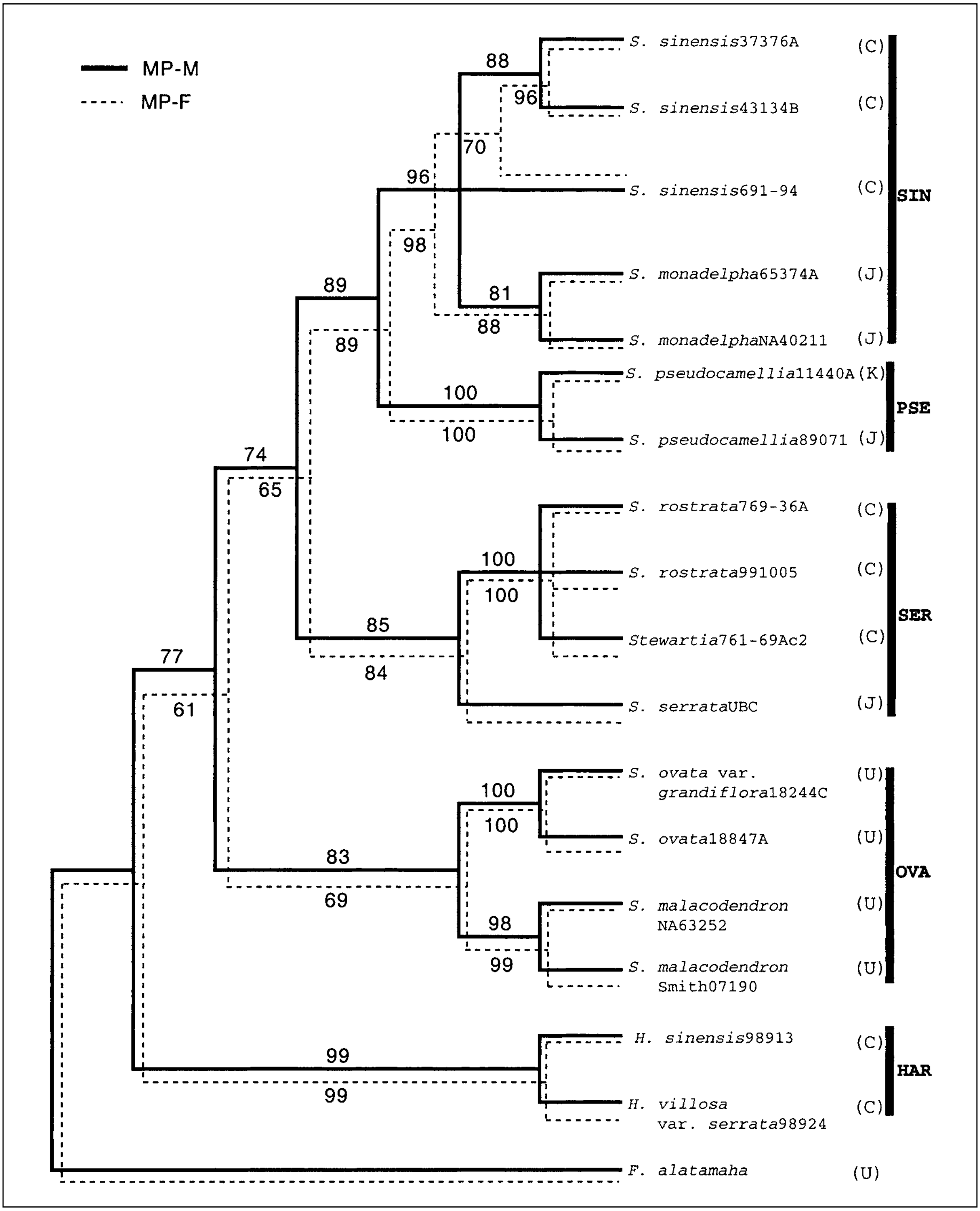
There are many reasons why research is important to botanical gardens, and I would like to highlight but a few. Because of their original missions and mandates, many instititutions are obligated to engage in research activities, even if it is only to accommodate requests for material by off-site researchers. At one time it was argued that "no institution is privileged to call itself a botanical garden unless it is doing research of some kind and to some degree" (Steere, 1969). Estimates of the number of gardens and arboreta whose collections are used in research vary considerably, from 10% (Raven, 1981) to nearly 50% (Sacchi, 1991; Watson et al., 1993), depending upon the type and nature of the institution. Regardless of the percentage, a common perception among curators is that their collections are underutilized for research (Rae, 1995). It should be noted that while research may play a central role in numerous gardens and arboreta, oftentimes that which is lauded is field-based floristics and genomics rather than collections-based and could occur in the absence of curated living collections (see Marris, 2006; Nature, 2006).

Due to trends within academia, gardens and arboreta are some of the last bastions where collections-based research can occur because of the combined presence of documented accessions and trained staff. Here at the Arboretum, with the planned construction of the new research facility and the expansion of its staff, the research potential of the collections ought to increase dramatically. Not only will the scientists have full access to the plants, but as they observe them on a daily basis, hypotheses will flow freely and experimental results will become easier to interpret. It is also important not to underestimate the off-site pool of researchers who must rely upon gardens and arboreta as a source of material. All too often, the cost





Collection documentation increases its value. This sand pear (Pyrus pyrifolia)*, AA 7272-C, growing on Bussey Hill was collected by E. H. Wilson near Ichang, Western Hubei Province in 1907 and accessioned in April of 1908. Original accession cards were used to record information until the late 1980s, when the data were transferred to a computerized database. Computer-generated maps make it easy to locate plants in the field, and accession tags that hang from the plant contain essential information. Photos by M. Dosmann.*



As illustrated in this phylogenetic tree of Stewartia *(From Li et al., 2002), living collections are frequently used by researchers studying biogeography. In this analysis, molecular data derived from documented Arboretum accessions were used to delimit relationships between Old World and New World* Stewartia *taxa.*

(both in time and dollars) of assembling collections at their own institutions is prohibitive, making places like the Arboretum a vital resource, especially for individuals working with limited budgets.

In a very practical way, research can pay a dividend for gardens and arboreta because it actually improves the management and care of their collections. Every time an accession is targeted for study, it is accessed and evaluated by a member of the curatorial staff. This increase in field-check frequency allows for timely evaluations of the plant's condition and when necessary (e.g., poor health), appropriate maintenance or vegetative repropagation can occur. At the same time, the accession records are reviewed, previous information is checked for accuracy and new information is added. This includes a notation that the accession was used in a research project, and oftentimes notes or observations the researcher may have made. These periods also provide opportunities for additional voucher herbarium specimens to be collected, if necessary. Also, one of the best ways to ensure verification is to encourage its use as a reference collection for taxonomic studies. The various additions to the records increase the collections' value and also catalyze future discovery, for those collections with a history of characterization serve as benchmarks against which future results can be compared. This has been demonstrated in other germplasm repositories where researchers prefer to characterize accessions that had been previously studied. To put it another way, a collection's value is directly linked to its "past, present, and future uses" (Widrlechner and Burke, 2003).

Research in the Collection: Making it Happen

Maximizing the potential for collections-based research requires several things, the most important of which is strong advocacy. In 1984, Judy Zuk posed an important question to the curators of botanic gardens and arboreta: "Are our collections underutilized because we have not been successful advocates, or because we are advocating a resource for which there is no widespread demand?" In light of the current collection crisis, her question is still timely. My answer to both parts of the question is a qualified yes: we must be better collection advocates, and we must work to increase their demand among a range of users.

Here at the Arnold Arboretum, collection advocacy is well-established and the historic link to scientific endeavors is strong. In fact, Ida Hay's 1995 history of the Arboretum, *Science in the Pleasure Ground,* epitomizes this connection. By declaration of the indenture signed by the trustee's of the will of Mr. James Arnold and the President and Fellows of Harvard College, the arboretum was established on the 29th of March, 1872 with a clear collections-based mandate: ". . . [to] contain, as far as is practicable, all the trees, shrubs, and herbaceous plants, either indigenous or exotic, which can be raised in the open air at the said West Roxbury." The appointment in November of the following year of Charles S. Sargent to the position of Director of the Arboretum and Arnold Professor set into motion the realization of this mission. In one of his earliest reports, Sargent (1877–78) described his research vision for the Arboretum: "In such a museum, every thing should be subservient to the collections, and the ease with which these can be reached and studied; and none of those considerations of mere landscape effect, which properly govern the laying out of ordinary public parks, should be allowed to interfere with these essential requirements of a scientific garden, however desirable such effects undoubtedly are." From day one, it was clear to Sargent what the priorities of the Arnold Arboretum should be.

As a word, *research* was not part of the printed lexicon in the early days of the Arboretum; however, as a process of *science,* it most certainly was a priority. In his many written statements, Sargent often placed research activity under the scope of *education* and the Arboretum's general goal to "increase the knowledge of trees." In his fifty year review of the Arboretum's accomplishments, written in 1922, he outlined the key components to its dramatic success: "a collection of living plants arranged for convenient examination and study . . . the distribution of surplus material obtained in the Arboretum explorations, and . . . the publication of the results of the dendrological investigations carried on in its laboratories."

As an example of planning, Sargent and Frederick Law Olmsted arranged the collection according to Bentham and Hooker's natural classification sequence outlined in *Genera Plantarum.* This not only increased its educational value but facilitated comparative studies among related plant groups (Spongberg, 1989). Less well known is the fact that the original plan also took in to account comparisons beyond the taxonomic. For many North American species, Sargent (1922) intentionally sited individual specimens in the open as well as in groves, so "that they may show their habit under different conditions." While the term did not exist at the time, this demonstration of phenotypic plasticity (the capacity of a species to adjust its morphology or physiology in response to distinct environmental conditions) was part of a larger plan for studying the interaction between plants and their environment.

The development of the living collection under scientific auspices was clearly part of the culture and its importance extolled by others in addition to Sargent. In describing the Arboretum to the broader museum community, Ernest H. Wilson wrote in 1924 that it was different from many other public arboreta, because while "[i]n many countries individuals have planted collections of trees . . . such collections lack scientific control and permanency, and sooner or later they disappear without having made any great addition to knowledge. It has been left to Harvard to establish the first garden which is exclusively a *tree museum* and which has the size and the promise of permanency necessary for success in its field."

More recently, Arboretum leadership has lauded the use of living collections in meeting research needs and goals. In his maiden report as new director, Peter Ashton wrote in 1979: "We have, perhaps, thought of the herbarium as our principal center of research, but we must not underrate the research potential offered by the living collections. . . . Opportunities exist here for basic research to bridge the traditional divisions between biology, horticulture and forestry." This mantra launched a vigorous restoration of the Arboretum's living collection, as well as a modernization of its curatorial practices (Ashton, 1989). And now, this well-documented collection of woody plants is first among several anchors as the Arboretum positions itself to achieve preeminence in studying the evolutionary history and functional biology of trees.

Beyond advocacy, gardens and arboreta must continually evaluate their collections, enhance their value, and develop them through steady acquisition—a static collection is the antithesis of a working collection. This includes shifting perspectives of what may constitute a research collection. They may be long-term and obligatory collections, like the six genera the Arboretum grows as part of the North American Plant Collections Consortium *(Acer, Carya, Fagus, Stewartia, Syringa,* and *Tsuga);* they may be short-term and discretionary collections, such as the *Crataegus* assembled for study by Sargent on Peter's Hill or plants grown for a specific experiment; or some place in between. Regardless of their position on this sliding scale, it is important to document intended use(s), priority, and commitment.

It also behooves us to broaden how we intellectually categorize our collections. Traditional types of classification (e.g., taxonomic, phytogeographic, habitat, use) have served gardens well and will continue to do so, yet other designations (e.g., conservation status, expedition, collector, cultural significance, research project, location in the garden) can also be used to maximize both their interpretive and research potential. In this regard, it is important to recognize that a single accession can fall under multiple collection categories. For example, a lone katsura tree, *Cercidiphyllum japonicum,* may occupy a place in an institution's taxonomic (Cercidiphyllaceae), geographic (Eastern Asia), conservation (threatened), ecological (disturbance-induced stem sprouting), collector (E. H. Wilson), horticultural (trees with outstanding autumn color), educational (specimens included centenary tree tour) and research (dimorphic leaf project) collections. Also, the collection may contain unaccessioned plants found in natural areas of the grounds, or may extend outside the institution's boundaries (see Box on page 35 describing the 1980 SABE collection). With

Case Study: Tracking the Fate of the 1980 SABE Living Collections

In 1980, the Arboretum participated in the Sino-American Botanical Expedition to the Shennongjia Forest District, Hubei Province, a monumental trip that not only improved scientific ties with China, but yielded a considerable amount of valuable herbarium and germplasm material (Bartholomew et al., 1983). New and notable introductions to cultivation included *Magnolia zenii, Heptacodium miconioides, Sorbus yuana,* and *Rubus lasiostylus* var. *hubeiensis.* All told, 621 germplasm collections were brought back to the United States and divided into equal shares among the four participating institutions (The Arnold Arboretum, The US National Arboretum, the University of California Botanical Garden at Berkeley, and the Cary Arboretum, which at the time was affiliated with the New York Botanical Garden). There was some sharing of excess germplasm by the individual institutions, including a distribution of nearly the entire Cary Arboretum's lot during the 1983 American Association of Botanical Gardens and Arboreta meeting, however no system had been in place to document what material was distributed and to whom it was distributed.

In 2000, Peter Del Tredici and I began to sleuth the fate of those plants collected on the trip. We pooled the Arboretum's extant holdings of SABE plants with those of the other participants and nearly 30 other institutions we suspected had SABE material, to create a master database. Upon analyzing these and other archival data, we drew some conclusions that were informative on many levels (Dosmann and Del Tredici, 2003; Dosmann and Del Tredici, 2005). At the core, we found 258 (42%) of the original collections to be alive, however what was startling was that 115 (45%) of these existed as a single accession growing in a lone garden, arboretum, or USDA research facility. The fact that nearly half of the plants in cultivation were at extreme risk of loss clearly demonstrates that the process of plant introduction is much more tenuous than generally assumed. Perhaps most importantly, we recognized that without sharing of collection information, institutions have no way of determining the uniqueness of their own collections. After putting our database on-line, we shared it with Quarryhill Botanic Garden which combined it with its own botanical inventory to create a Database of Asian Plants in Cultivation (DAPC): http://www.quarryhillbg.org/DAPC/DAPC.htm. Continuing to grow, the DAPC provides collection information on documented Asian germplasm and serves not only as a valuable resource for collection managers and curators, but provides a catalogue for researchers as they seek germplasm for study.

the aid of databases and other information systems, it is now much easier to see collections in the multiple dimensions within which they exist and appreciate their unlimited research potential.

In addition to advocating and redefining their collections, gardens must concomitantly advocate and redefine perceptions of collections-based research. As I consider the Arboretum's living collections, I see research potential across a wide swath of disciplines—far too many to list here. For certain, taxonomic and horticultural research will continue to be important areas of study, as will work in plant conservation and natural products. I also foresee the collections becoming more valuable in areas not traditionally studied using living plant collections, such as ecology and developmental biology. For these and other fields, our concept of collections-based research must be broad, spanning a scale that includes the multiple genomes residing within a given accession, genotypic responses to the abiotic environment, and interactions between plants and other organisms.

While Peter Ashton lauded the work on model systems because of their use in experi-

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The 1980 Sino-American Botanical Expedition yielded over 600 collections of seeds, cuttings and plants. SABE 1084 was a collection of but 16 seeds of Staphylea holocarpa, *and four of each were sent to the four participating institutions. However, only one seed germinated and that was one at the Arnold Arboretum: AA 59-81A. When this tree flowered, it was found to be of the pink-flowered type, and its name was changed in 1991 to* Staphylea holocarpa *var.* rosea. *Because of its rarity, the Arboretum has been attempting to vegetatively propagate this accession.*

mentation, he (1981) went on to state "There is no doubt that future research must be directed increasingly at developing the technology required to expand this dangerously slender base, and competently curated collections, particularly of living plants, will prove invaluable." As we seek to apply the lessons gleaned from *Arabidopsis thaliana* and other models to the diversity within the plant kingdom, the Arboretum's collection is well positioned because of the genetic diversity it comprises. Our accessions of documented wild origin will continue to be important in illuminating mysteries related to genetic variation, adaptation, and biogeography. We should not discount the research potential of cultivated taxa—particularly those cultivars that are aberrant forms of the botanical species—as they may find new footing in the research of the future. Just imagine the typical ornamental border: a colorful circus of cuticular waxes, pigment combinations, bizarre leaf and floral morphologies, contorted habits, atypical growth rates, and unusual tolerances to environmental stresses. These ornamental mutants, in many ways similar to those found in the contrived collections of *Arabidopsis,* could well become important research collections of tomorrow.

Ever the seer, Ashton also recognized that a living collection's research potential could never be exhausted, that there would be a constant need for its use, growth and development.

It does not require clairvoyance to realize the basic premise that new technologies and new research interests always have a way of shedding light on old, "anachronistic" collections. Many museums have found this to be true, impacting collections of mummies (Irving and Ambers, 2002), preserved pigs (Larson et al., 2005), and dried plants (Stern and Eriksson, 1996). When a new perspective is brought to a collection, discovery follows. Take for instance the paintings of Caravaggio, which have been extensively studied by artists and historians. When scrutinized by a horticulturist, these works, in unanticipated fashion, revealed a unique glimpse of the crop diversity, pests and diseases present in the late 16th and early 17th centuries of the Old World (Janick, 2004).

Living plant collections are no different, and those amassed for one reason frequently become useful for others. Countless synoptic collections assembled for taxonomic comparison have been extremely practical in the screening of natural products for medicinal use, an area of research that will become more important as natural populations of plants become threatened in the wild. Harrison Flint (1974) recommended plant collections would be ideally used to study phenology, and recently they have been—not to examine genecology as he suggested but to study climate change (Primack et al., 2004; Wolfe et al., 2005). Sometimes the unanticipated use is the result of unfortunate events, leading to the application of the adage "When life gives you lemons, make lemonade." Ongoing research at the Arboretum on the hemlock wooly adelgid includes studies on forest floor regeneration, biogeochemistry, and the identification of replacement hemlock species. When it comes to the last, it is doubtful that when E. H. Wilson collected a single plant of Chinese hemlock, *Tsuga chinensis,* in 1911, he had in mind that this accession would play a key role in understanding the behavior of the insect (Del Tredici and Kitajima, 2004).

Because one cannot predict the future, a challenge presents itself: How to prepare the Arboretum's collections for these unanticipated research needs? There are two areas where the institution can plan accordingly. The first deals with the nature of the collections and what makes them valuable. As future development of the collection ensues, it is important to target taxa (genera, species, populations, clones) that are not only unique to the Arboretum's holdings, but also have a greater than normal reseach potential. For example, future acquisitions to the six genera grown as part of the North American Plant Collections Consortium will be to specifically bolster their status as world-renown reference collections. Clearly, an accession's value is directly proportional to the information attached to it, and that which may lie in waiting. Thus, it is crucial that new additions have as much of the desired passport information related to their source as possible, and for accessions already in the collection, we

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Studying gas exchange in the field on the golden-rain tree, Koelreuteria paniculata.

must attempt to repatriate any collection information that may have been lost over the years. It is also important that collaborating researchers have ready access to all types of collections data in order to be able to select the plants best suited to their projects. Luckily, the Arboretum continues to obtain material whose origin is well documented, and as we improve our ability to track and document research usage, the accessions become more robust benchmarks for future assessment.

The second area of preparation is associated with the researchers themselves. One dilemma that living collections often face is the inability of researchers to know what gardens have to offer; conversely, gardens often do not know what researchers need (Rae, 1995). Such problems are particularly acute when researchers are located off-site, but they can also occur between and among staff members employed by the garden. As researcher pools expand into nontraditional disciplines, it is ever more important for gardens to engage these audiences directly and build the necessary relationships. The late Arboretum director, Richard Howard (1970) was an early proponent of a system where researchers outside of the garden and arboretum world could seek out and obtain research material in cultivation. Now, with the advent of the internet, access of collections to potential researchers is vastly improved, in part answering Howard's call. The Arboretum's website allows researchers to search for accessions in the living collections inventory, as well as vouchers held in the cultivated herbarium.

Beyond access to the living collections themselves, the Arboretum can provide scientists with a wealth of other things, including affiliated collections (records, archives, images, herbarium specimens), expertise, greenhouse and lab space, and even financial assistance in the form of grants and fellowships. Although the institution may be the primary provider in this relationship, there are also things that researchers can do in return for collection access. One of the most basic is following-up when the project is completed, which includes sending updates and/or reprints of any published work. I have found that while nearly all gardens and arboreta request this, it unfortunately occurs less than a third of the time. It is also important that results that did not make it into publication because of their anomalous or questionable nature be reported, particularly when the study is taxonomic in nature, as they may indicate that the name on the label is not correct. Researchers are also able to assist with the development of the living collection by donating well-documented plant material. By understanding and valuing the mutually beneficial relationship between the Arboretum and researchers, we can more ably respond to, and meet, the future needs of science.

When it comes to the collections crisis afflicting other museums, gardens and arboreta are not immune. However, with strong collection advocacy and commitments to the collections use in research, I believe the future to be bright. In fact the relevancy of gardens and arboreta will only continue to increase as they become dynamic citadels comprising living plant collections and specialized botanical expertise. As for the Arboretum specifically, it is well poised for this future because of its historic and contemporary commitments to collections and research. With the physical manifestation of a research center on site, our living collections will become more bountiful and valuable.

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The Paperbark Maple—One Hundred Years Later

Peter Del Tredici

The living collections of the Arnold Arboretum hold many important trees, but few are as significant as two of its paperbark maples *(Acer griseum)* which are celebrating their hundredth anniversary this year. Not only are these trees exquisitely beautiful, but they are also the oldest specimens of this rare Chinese species growing in North America. One of them is the well-known, low-branched individual growing on Bussey Hill along Chinese Path (see inside back cover), while the other is much taller and grows at the edge of the maple collection near the Bradley Garden of Rosaceous Plants (see front cover). Given their status as the original introduction of this highly ornamental species into North America, it is worth telling the story of how these two landmark trees came to be growing at the Arboretum.

In the fall of 1907, Ernest Henry Wilson collected at least two seedlings of paperbark maple in Hubei Province, China. In his field notebook for this trip, under the number 719, Wilson entered the following notation: "Acer griseum. tree 25–50 ft. margin of woods 4500–6000 ft. North Plants." Ten years later, in 1917, Wilson rewrote this cryptic entry in Volume III of *Plantae Wilsonianae,* edited by C. S. Sargent. The following entry appears on page 427: "Acer griseum: Western Hupeh: north of Ichang, margin of woods, alt. 1500–2000 m., 1907 (No. 719; trees 8–16 m. tall; plants only)." According to our card files, two of the *Acer griseum* seedlings that Wilson collected under number 719 in Fang Xian, in Hubei Province, were accessioned in December 1907. They were originally assigned accession number 5813-2, which was later changed to 12488, the number under which both trees are still listed today.

Among botanists, the maple family is notorious for having complex flowers, and *Acer griseum* is no exception. Technically the species is considered to be "androdioecious," which means that some individuals produce only staminate (male) flowers while others produce perfect flowers with both male and female parts. Individual "A", near the Bradley Garden, is a male specimen that produces no seed and stands some 64 feet tall (19.5 meters), with a spread of 44 feet (13.5 meters), and a diameter at breast height of 28 inches (70 centimeters) at the age of 100. Individual "B" has a more unusual form, having lost its leader some time ago. It stands only about 30 feet tall (9 meters), with a spread of 38 feet (11.5 meters), and a diameter of 37.5 inches (95 centimeters) at two feet off the ground. It produces perfect flowers and regularly produces viable seed which germinate spontaneously under the tree. This specimen was undoubtedly the source of the first generation of paperbark maples planted in North America. Indeed, the Arboretum's distribution records indicate that seedlings of *Acer griseum* were first distributed in 1927, some twenty years after its introduction from China. All together some 79 seedlings, 4 seed lots, 3 packets of scions, and 1 packet of softwood cuttings of *Acer griseum* were distributed to various plant collectors and nurserymen between 1927 and 1945, firmly establishing the species in North American gardens.

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