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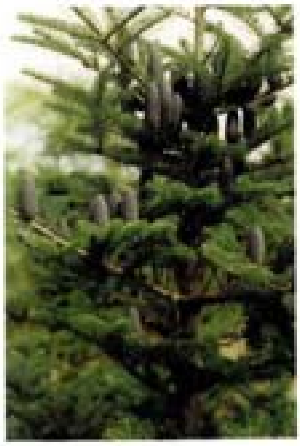
The Magazine of the Arnold Arboretum









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The Arnold Arboretum
125 Arborway
Jamaica Plain, MA 02130–3500

Karen Madsen, *Editor*
Andy Winther, *Designer*

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SARAWAK TRIBUNE

Tree climber Jugah Tagi photographed on a giant strangler fig, Ficus *sp. (Moraceae).*

The View from the Forest Canopy

Richard Primack, Melvin Goh, and Meekiong Kalu

For decades, botanists from Harvard University and elsewhere have been studying the remarkably diverse flora of the rainforests on the island of Borneo. Much of this interest was sparked by Peter Ashton, former director of the Arnold Arboretum, who has been doing research in Borneo for over forty years. Through the years, many Harvard students, undergraduate and graduate, as well as postdoctoral and staff researchers, have traveled to Borneo to look for new plant species, to hunt for plants with medicinal potential, or to determine the environmental effects of logging. Others have pursued zoological interests. Tim Laman, an Arnold Arboretum Associate, combined his knowledge of the rainforest with his photographic skills to produce a series of articles for *National Geographic,* most recently one on gliding frogs, lizards, and snakes that live in the forest canopy. Cheryl Knott and Mark Leighton of Harvard's Peabody Museum have investigated the ecology of orangutans, monkeys, hornbills, and other large mammals and birds.

Whatever the subject being investigated, a key member of all these exploration teams in Borneo's rainforest is a person known as a "tree climber." Not surprisingly, a tree climber's official job is to climb trees and collect specimens of leaves, flowers, and fruits that are then dried and mounted on herbarium sheets for use in botanical research. The best tree climbers are also experts in camp craft and forest lore. Two of the most famous tree climbers in all of Southeast Asia, both of them well known to Harvard researchers, are Jugah Tagi and Banyeng Ludong, now in their fifties and recently retired from the Sarawak Forest Department. Sarawak, which is part of Malaysia, occupies the northwest coast of Borneo.

Both Jugah and Banyeng grew up in remote longhouses, the sort of single-structure villages on stilts that are common in Borneo. After their childhood, they went to Kuching, the capital of Sarawak, seeking education and work. They both have the "burongs"—bird tattoos on their throats and star tattoos on their shoulders—that mark them as members of the rural Ibans (also known as the Sea Dayaks), but apart from that, they are very different in both appearance and personality. Jugah is short, weighing only around a hundred pounds, with an outgoing, fun-loving personality. In a group he is often the main talker, loudly telling stories in an excited, high-pitched voice. By contrast, Banyeng is barrel-chested, with a quieter, more reserved personality. He usually speaks more slowly and hesitantly, but occasionally he, too, becomes excited.

The Traditional Way of Climbing Trees

In their working years, both Jugah and Banyeng could climb virtually any tree in Sarawak's forest: few trees were too tall or too difficult for these two, who used the traditional methods they had learned from boyhood and refined while working for the Forest Department. The most common method involves an inchworm-like series of movements—grabbing a tree with the arms, raising the legs along the trunk, and gripping the trunk with their feet while extending the body another one to two feet up the trunk—movements repeated again and again until the top of the tree is reached.

When the trees were of ideal size for climbing in this way—about two feet in diameter—Banyeng and Jugah could scoot to the top in a minute or two. When the trees were smaller, or had slippery bark, they sometimes tied a rope around their ankles to increase the pressure of their feet against the trunk.

When the trunk of the targeted tree is too thick to hold onto, the traditional tree climber has to work from a smaller tree nearby. If the smaller tree is flexible enough, he might simply climb to the top branch and swing back and

Jugah Tagi demonstrates the techniques of traditional tree climbing.

forth until he can reach over, grab a branch of the larger tree, and leap across. Other situations require the use of a "penyulok," a forked pole up to thirty or thirty-five feet long to which another forked stick is tied with a vine to make a hook. For example, after climbing the smaller tree, the tree climber might haul up the penyulok into the tree using a long, rope-like rattan vine. He then extends the penyulok horizontally to hook a branch on the target tree and twists the branch until it breaks off and falls to the ground. In other cases the climber might build bridges between the two trees: after pulling up the penyulok and hooking it over a branch on the target tree, he ties the base of the penyulok to the smaller tree and crosses over it to the larger tree

As one can imagine, these maneuvers, often performed hundreds of feet above the ground, require extraordinary strength and suppleness, as well as long practice. Jugah and Banyeng never used safety equipment even when climbing trees more than 175 feet tall, relying on their own skill and confidence to avoid accidents. Today's young tree climbers, by contrast, make extensive use of tree-climbing spurs and belts and specialized rock-climbing equipment. This makes tree climbing much slower and more restrictive than the traditional methods.

But it also makes the climbing safer. Banyeng, who still does contract work with the Forest Department, comments on the danger inherent in his unusual profession: "There is always an element of fear when you are so high up, but the higher we go, the more careful we are. The few times that I have fallen it was because I wasn't careful enough, as I was not very high yet. My worst accident was near Melinau Gorge in Mulu National Park, where I not only fell out of a tree, but also rolled down a hill and got really banged up all over."

Paul Chai, at the time a Forest Department botanist and who frequently worked with visiting Harvard researchers, recalls this incident,

Constructing the hook end of a penyulok

Maneuvering the penyulok into position

and says that other members of the party thought Banyeng had probably been killed in the fall. When they dashed down the slope to find him, however, they discovered that Banyeng's main complaint was that he couldn't find his new clay pipe, which had fallen out of his mouth during his tumble down the hill.

Using the penyulok to break off flowering branches from a neighboring tree.

"Daily-Paid" Tree Climbers: Two Careers Begin

In the early 1960s, when Jugah and Banyeng first signed up with the Forest Department as daily-paid tree climbers, they hardly expected to become full-time employees, much less

G. H. S. WOOD IN A MANUAL OF DIPTEROCARP TREES OF BRUNEI STATE AND SARAWAK, SUPPLEMENT, P. S. ASHTON, 1968

A young Banyeng Ludong photographed beside the trunk of a resak batu tree, Cotylelobium malayan *(Dipterocarpaceae).*

recognized experts in their trade. Climbing trees came naturally to them; like other boys in their longhouses, they had learned tree climbing along with fishing, hunting, and farming. But both possessed unusual agility and curiosity, which made them well-suited to their future occupation.

The two men came to the profession through similar routes. In 1963, Jugah, then a young Iban from a longhouse on the Sut River, a tributary of the Kajang River, upstream of Kapit in central Sarawak. He met the well-known forester B. E. Smythies, of the Sarawak Forest Department, in Kuching, the state capital, where he had gone to look for work. Smythies' name was familiar to Jugah because a friend had worked for him in Brunei. Jugah managed to convince Smythies of his abilities and his willingness to work hard, and that was the beginning of his career.

Jugah recalls the opportunity that Smythies' offer represented: "At that time, life at our longhouse was quite difficult. I helped on the farm and occasionally took rubber and wild fruits to Kapit, the nearest town, for sale. The journey itself was difficult then—a day's paddling from the longhouse to the town and a further two-day ride back upstream. When the offer was made of a job paying RM 4.00 per day [now just over one U.S. dollar], I grabbed it, since the amount seemed very big. I had no formal education as far as plants or trees were concerned. At first, all I knew was how to climb the trees and collect whatever plant specimens were needed."

Banyeng came from a longhouse on the Merit River, a tributary of the great Rajang River. He arrived in Kuching in 1957 and spent six years in a Chinese primary school. He too met B. E. Smythies and applied for the job of daily-paid tree climber. He was soon hired, as he came highly recommended by Robb Anderson, the great authority on Southeast Asian peat swamp forests. "To get RM 4.00 a day then was quite a good pay," recalls Banyeng, now the father of four grown children. "I think that I was hired because I was very interested in the job, and I grabbed the offer, as it was not that easy to get a job without many skills."

It quickly became evident to both men that they would need to learn a great deal in order to succeed at their new profession. Jugah tells of a conversation he had with Peter Ashton, then working as a Forest Department botanist: "He asked me if I knew the names of the plants or trees we were collecting from, and when I said no, he looked at me with disbelief and chided me for my lack of knowledge. It was, according to him, a necessity for me to at least know the local names of the plants. This was one of the

J. DRANSFIELD

Banyeng holding a fruiting branch of a sabal palm, Pinanga tomentella.

skills required of tree climbers, to know the names the local communities gave to the plants.

"I knew that what he said was true and correct. I had to know the names, not only for myself but also because of what I was doing. With little education and knowledge, I realized that if I were to be good at what I do, I had to master some of the skills needed in the trade. Over the years, I learned the local names of the plants and trees. For many trees, I also learned the species and family names used by plant experts."

Outdoing Botanists at Their Own Game

Indeed, both Banyeng and Jugah are storehouses of botanical knowledge. Through years of working with local botanists and foresters, as well as with visitors from Harvard and other universities, Jugah and Banyeng have come to know the names of hundreds of tree species, and often their scientific Latin names as well. When they are not able to identify a species, they can usually recognize the family to which the tree belongs, or the species it is related to.

So proficient are they that they can often remember where they first saw a particular species, a huge help in field identification. And in contrast to most trained botanists, who must study plants carefully before venturing an identification, Banyeng and Jugah can name plants on sight with incredible speed. At Bako National Park, Jugah used to play a game with botanists, who would show him a leafy branch for five seconds and then hide it from sight. If Jugah knew the species, he would say the name instantly. To make the game more challenging, the botanists showed the branch for only three seconds or even one, and the result was the same—if Jugah knew the species, he needed only the briefest glance to recognize it. But his skills went even farther, he could be shown two or even three branches mingled together, all of different species, and still identify them instantly. In addition to being expert at field identification, both Banyeng and Jugah are repositories of knowledge about the ways villagers use each part of a tree species—for construction, medicine, rope, or food—and which animals eat the fruit, leaves, or bark.

Jugah and Banyeng eventually taught practical field identification to dozens of other Forest Department staff and visitors. Paul Chai, now working with the International Tropical Timber Organization, recalls how Jugah and Banyeng would begin by showing newcomers a leafy branch. Then, over the course of days and weeks in the field, they would reduce the learning cues to a single leaf, then part of a leaf, and finally only part of a rotten leaf. These lessons were always taught in good humor and accompanied by lots of laughter at each stage.

The Care and Feeding of Scientists

Probably the tree climbers' most important job is to keep the research scientists alive in the field, particularly when the scientists are visiting Borneo for the first time. Between the two of them, Jugah and Banyeng have saved the lives of numerous inexperienced biologists, including one of the authors, Richard Primack.

Primack recalls a Harvard-sponsored expedition in 1981 to Mulu National Park, at that time still a wild and remote area, when Jugah saved

RICHARD PRIMACK

Jugah helping to identify branches at Bako National Park

him from a serious accident or death: "On one of the evenings, while Jugah was setting up a camp on the side of Mt. Mulu, I crossed a shallow, rock-filled stream to a little island, about a hundred feet long by fifteen feet wide, on which were growing some unusual shrubs and vines that I wanted to collect. I noted that above me the mountain was draped in black rain clouds, but I didn't give it much thought. As I was collecting plants, I saw Jugah gesturing at me urgently, but I couldn't hear what he was shouting due to the rising roar of the stream. From the look on his face I could see that something was terribly wrong.

"Deciding I had better see what Jugah wanted, I was preparing to cross the twenty-foot stream to where he was standing when I saw that most of the rocks were now covered by the surging stream. As I watched, the water was getting visibly higher! Suddenly, I realized that a flash flood was coming. I struggled to the middle of the stream but couldn't keep my footing in the strong, knee-high current that covered the slippery rocks below. I was fighting just to keep standing in the rush of oncoming water. Just then, Jugah dashed into the stream and hauled me out onto the bank, despite the fact that I outweighed him by sixty pounds. Within the next few minutes, the water level in the stream rose another two feet, covering the little island and the place where I had been innocently wandering about only minutes before."

Another life-threatening incident involved an American biologist who had come to collect snakes on the Sarawak coast with Jugah and other members of the Forest Department. "He was quite inexperienced in catching snakes, as it turned out," Jugah recounts. "A boat dropped us off in the afternoon in the Santubong area. We were planning to collect snakes at night, with the boat picking us up the next morning. The American told us that he was interested in collecting king cobras and other poisonous snakes. I told him that these were very dangerous snakes and that he should let me catch them for him, or he should at least wear gloves. Before long we caught sight of a poisonous snake near some bushes. Saying he didn't need our help, he brushed us aside. Despite our warnings, he insisted that he was capable of catching the snake himself with his bare hands. As he reached for the snake, it bit his hand, and as he struggled to grab its head, it bit him a second time.

"Finally, hearing our screams, he flung the snake into the forest. He asked us how serious the bite was. I told him, 'You are going to die unless you go right to the Kuching Hospital,' and he then asked me what was the fastest way to the hospital. There was no road to the coast then; we had reached the place by boat but it was not due to pick us up until the next day. By then, he would have been long dead from the snake's poison! Luckily for him, we managed to find a fisherman who had just returned from his fishing trip and was willing to take us back to Kuching. But the fisherman was asking RM 50.00 to ferry us to Kuching, which seemed very high. The American didn't seem too pleased about the high price and asked me what I thought of the situation.

"'It's quite simple,' I told him. 'Either you pay him or we wait for our boat tomorrow. Only by then we will be carrying your dead body with us.' Upon hearing that, he made no further fuss, and we arrived in Kuching just in time to get treatment for the bites." Jugah laughs as he finishes: "The American left Sarawak without going out snake-collecting again."

Another crucial role played by tree climbers is that of supplementing their expeditions' limited supply of tinned meats with fresh meat. Jugah and Banyeng are highly skilled fishermen and hunters and often welcomed the opportunity to use these skills while on field trips. In the early days, any animal could be shot for food, but awareness of the need for conservation later resulted in restrictions against hunting monkeys, hornbills, and other endangered wildlife. This often meant that the tree climbers faced conflicting demands: the need to follow the new restrictions on the one hand, and the need to supply food for expedition members on the other.

Fortunately, even if the hunting wasn't good, there were always fish to be caught. Mountain streams often produced a large supply of small fish, albeit full of bones. Any pole with a bit of string, a fishhook or a bent nail, and a small berry or insect as bait would suffice for fishing gear. Lee Hua Seng, associate director of the Forest Department and a frequent visitor to the forest, recalls that Banyeng had a special talent for catching freshwater carp using a fishing rod fashioned from the midrib of a palm frond, with a grasshopper tied to its end for bait.

Richard Primack also recalls one memorable evening in 1986 when he was working with a student, Pamela Hall, and Forest Department staff at the remote Bukit Mersing Protected Forest, way upriver and a long walk into the forest. One night everybody was sleeping in the streamside camp except Jugah, who was out hunting. When a gunshot echoed through the forest, everyone woke up. About twenty minutes later, Jugah emerged from the dark forest carrying a dead porcupine the size of a basketball. The men heaped up the campfire with wood and threw the porcupine on it to burn off the quills. The experience of sitting around a huge fire at eleven o'clock at night on a remote Borneo mountain, with clouds of burning porcupine smoke rising in the air and sparks flying from the crackling quills, will definitely not be forgotten soon.

Tree climbers are also responsible for setting up camps in remote locations, making sure the camps are safe, functional, and if possible, comfortable. The basic camp consists of a framework of poles over which tarps are stretched to keep out the rain. Simple cots covered with mosquito netting serve as beds. Often, the tree climbers are asked to improvise special structures, such as a writing desk and chair for a scientist, or a temporary shelter of palm leaves when a sudden rain shower erupts.

Banyeng and Jugah learned that their knowledge of camp craft was not always heeded, however. Banyeng often worked with Peter Ashton, and Banyeng recalls that while Ashton was brilliant as an administrator and biologist, he sometimes chose not to listen to advice. "During one of our collecting expeditions along the Baram River he insisted on pitching his tent along a riverbed despite repeated warnings from us. The rainwater that fed the stream eventually rushed down the slope later that evening and washed away his tent, leaving him cursing and fuming over the situation," Banyeng remembers, laughing.

Today there are still tree climbers in the Forest Department collecting tree branches for botanical projects and also gathering fruits and seeds for various replanting projects. But these young tree climbers, with their special climbing shoes, belts, and ropes cannot easily move around in the forest because their equipment is so heavy and cumbersome. Climbing with the new gear is slow and tiring in comparison with the speed with which the young Jugah and Banyeng bounded up trees with no equipment at all. Those days are over for the tree climbers, the Forest Department, and the visiting researchers, but the vivid memories remain.

Richard Primack is a professor of plant ecology at Boston University and was recently a Bullard Fellow in the Harvard University Herbaria Melvin Goh is a reporter for the *Sarawak Tribune* Meekiong Kalu is a research officer for the Sarawak Biodiversity Centre.

Survival of the Most Adaptable

Peter Del Tredici

Botanic gardens and arboreta are great places for the adventurous gardener to explore for plants and new ways to use them. Tucked into out-of-the-way, often untidy corners one can find plants that are refreshingly different from those offered by the trendy horticultural industry or seen in our monotonous suburban landscapes. Often these plants have been underutilized because they cannot meet the demands of a horticultural marketplace that requires rapid turnover. Botanic gardens, by contrast, are islands of stability where plants can grow and develop at their own pace. This is especially important in the case of trees, which can be very slow to develop, often taking fifteen to twenty years to produce flowers or cones.

A brief summary of how plants become part of botanic garden collections will illustrate the value of these collections for the gardener interested in expanding his or her horticultural options. To begin with, the source of the plants is an important part of the process. Botanic gardens, particularly those with a research mission, go to great lengths to obtain plant material that has been collected in the wild and documented with herbarium specimens. This expensive and time-consuming documentation ensures for future generations that our plants are properly identified. And that represents only the beginning of the plant documentation, which consumes a significant portion of the Arboretum's living collections budget.

In contrast, there is no way to know for certain that a plant in a nursery is what the label says it is. Indeed, most nurseries raise their plants from very small seedlings or cuttings that they purchase, and they use the identifications that come with them. If the seeds were collected from the wild (and correctly identified), the seedlings will be true to type. If the source nursery made an identification mistake, however, the error will spread throughout the industry.

After seeds have been collected in the wild and received at the greenhouse, they are chilled or scarified before being sown. When and if they germinate, the resulting seedlings are potted up. Once they reach an appropriate size in the nursery, which differs widely from garden to garden, they are labeled and planted out in permanent locations where it is hoped they will flourish. The plants are watered and weeded during their first year or two on the grounds, but after that they are generally left to develop in their own good time, under conditions that might be called "benign neglect." The whole process, from seed to being planted out on the grounds, is long, taking three to five years for shrubs and five to seven for trees.

The purpose of this article is to highlight some noteworthy plants that have made it through the cultivation process at the Arnold Arboretum but are still not common in the landscapes and gardens of the Northeast. Some of them can be considered new, having only recently become available commercially, while others are not currently available through nurseries even though they have been growing on the Arboretum grounds for over a hundred years. The latter group includes plants that have always been ignored by the nursery industry, and others that may have been popular in the past but have fallen out of favor and are now essentially forgotten.

Most of the plants on the list are adaptable to a wide range of environmental conditions, growing well in either full sun or partial shade, and on wet or dry sites. All of them have performed well on the Arboretum's well-drained, acidic soils, and most have few, if any, pest or disease problems. Keep in mind, however, that this characterization is based on a small sample size and may not hold true if the plants become widely planted. It should also be noted that the USDA hardiness zone ratings, as well as the sizes of the plants, are meant as guidelines rather than as absolute judgments.

While most of the plants have multiseason interest, I have organized the list around their primary season of interest. The list is heavily weighted toward species rather than cultivars, for two reasons: first, many of the plants have not yet undergone intensive horticultural selection in either nurseries or landscapes, so no cultivars are available; and second, the primary criterion for selection was ecological adaptability, which is best treated as an attribute of the species as a whole rather than of a particular cultivar.

Selecting plants with broad adaptability may be the best approach to one of the gardener's primary goals: choosing the right plant for the right place. Unfortunately, highly adaptable species can also be highly invasive; the trick is to identify species that are adaptable but not invasive. The amur cork tree *(Phellodendron amurense)* is an example of a species that has the potential to become an invasive if it becomes widely planted in the Northeast. It is an unfortunate conundrum that every plant, including *Stewartia pseudocamellia* and *Acer palmatum*, has the potential to become invasive when growing conditions allow its seedlings to get established.

My reasons for assembling this list go well beyond an interest in seeing greater variety in our local landscapes. Our physical environment is changing rapidly—in large part because of human activities—and there is an urgent need to identify plant species that can thrive alongside people and the pollution we inevitably create. The plants listed below have performed reliably under a variety of environmental conditions with minimal maintenance and little supplemental irrigation; they can therefore be considered "pre-adapted" to flourish under the erratic weather extremes that global warming appears to have in store for us. I hope this eclectic sample of ornamentals will not only encourage horticultural experimentation, but also get more people thinking in practical terms about the impending changes in our environment.

SPRING

Aristolochia manschuriensis (Manchurian dutchman's pipe): zone 4 (?). This rarely seen vine produces three-quarter-inch-long yellow flowers early in spring before the foliage emerges, making it much showier than the American species, *A. macrophylla*, whose flowers are hidden under fully expanded leaves. While the two species are similar in growth rate and habit, the leaves of the Manchurian species are somewhat larger and a duller green than those of the American species.

Chionanthus retusus (Chinese fringetree): zone 5. Chinese fringetree is more tree-like than its straggly American cousin, *C. virginicus*. In May or June, the whole plant is covered by small, white flowers, followed by a large crop of blue-purple fruit in fall. When planted in an open situation, Chinese fringetree will develop into an elegant specimen about thirty feet in height with a similar spread. It has a broad distribution in Asia, where it shows considerable variation in hardiness, leaf shape, and growth form. At least two distinct ecotypes are available from commercial nurseries in the United States,

Chionanthus retusus

one adapted to warm, dry climates like that of southern California and the other better suited to cold, moist climates like that of New England.

Corylopsis spicata (Japanese winterhazel): zone 5. All winterhazels produce beautiful, soft-yellow flowers in early spring and perform best in moist soil under light shade. Japanese winterhazel, together with fragrant winterhazel *(C. glabrescens)*, is the hardiest species of the genus. It can reach six to ten feet in height with an equal spread and works well as a mass planting. The soft yellow color of its flowers offers an attractive antidote to the bright yellow forsythia that bloom at about the same time.

Corylopsis spicata

Fothergilla major 'Mt. Airy': zone 5. The 'Mt. Airy' cultivar is more vigorous and floriferous than the species. It spreads rapidly from underground stems and tolerates a wide range of conditions. It grows to about five or six feet in height and produces fall color in a gorgeous blend of yellow, orange, and scarlet.

Magnolia x 'Wada's Memory': zone 4. This hybrid of the willowleaf *(M. salicifolia)* and kobus *(M. kobus)* magnolias grows to be about thirty feet tall and only ten feet wide, producing large, pendant, white flowers in early spring. The combination of upright, conical habit and drooping flowers is very striking. Like both its parents, 'Wada's Memory' does best in full sun and moist soil.

Prunus cyclamina (cyclamen cherry): zone 6 (5?). A native of central China, cyclamen cherry grows to thirty feet in height with an equal spread. It produces prolific clusters of small, rose-pink flowers in early spring, and in fall its foliage turns a beautiful orange-red. Compared to other cherries cultivated at the Arnold Arboretum, cyclamen cherry is free of pests and disease.

Rhododendron calendulaceum (flame azalea): zone 5. This azalea is one of the best-adapted to the Northeast. It blooms in late May to early June, producing yellow, orange, or red flowers. It grows equally well in sun and shade and is tolerant of drought and, compared to other azaleas, of soils with high pHs. Inferior hybrids and cultivars have largely displaced the flame azalea in contemporary landscapes, but its hardiness and lack of susceptibility to powdery mildew have led to a resurgence of interest, especially for naturalistic plantings.

Syringa x *chinensis* 'Lilac Sunday': zone 3. This cultivar of the persian lilac, selected at the Arnold Arboretum, is a large, spreading shrub that can grow to be ten to fifteen feet tall and equally wide, producing foot-long racemes of light purple flowers in mid-May. In general, persian lilac is more heat tolerant and disease resistant than the common lilac *(Syringa vulgaris)*; it also produces a smaller, more delicate foliage, creating a lacy appearance.

Weigela subsessilis (Korean weigela): zone 5. This multistemmed shrub from Korea grows to be about six feet tall and six feet wide. In May it produces three-inch-long flowers that change

Syringa x chinensis *'Lilac Sunday'*

Aesculus parviflora (bottlebrush buckeye): zone 4. This large, July-blooming buckeye is native to the southeastern United States. Its spectacular flower spikes can reach up to twelve inches in length. It is decidedly shrubby in habit, forming large clumps from underground suckers and layers. Unlike most buckeyes, it is totally free of leaf scorch, so its foliage looks good throughout the summer and fall. Because it grows equally well in sun or shade, the bottlebrush buckeye is perfect for sites where the woodland meets the garden's edge—especially since its win-

gradually from pale yellow to lavender, creating an interesting, multicolored effect. The plant deserves further testing under both nursery and landscape conditions.

Xanthocerus sorbifolium (yellowhorn): zone 4 (3?). An upright shrub or small tree from China, yellowhorn grows to fifteen feet in height with a somewhat gawky growth habit. It produces showy white flowers on six- to ten-inch-long racemes in late spring. Yellowhorn is tolerant of full sun and of dry soils with high pHs; together with its ability to spread from root suckers, this makes it potentially useful for highway embankments and other difficult sites.

SUMMER

Actinidia kolomikta (kolomikta kiwi): zone 4. This unusual vine from northeast Asia normally produces irregularly variegated leaf tips of white and pink in spring and summer, making it look as though someone had splashed paint on its leaves. It should be sited so that its dramatic foliage can be viewed from above (e.g., below a deck). If left to its own devices, the kolomikta kiwi can spread into adjacent trees and damage them, a problem that can be avoided by training it to a trellis or periodically pruning it.

Aesculus parviflora

Aesculus parviflora

Hydrangea paniculata *'Praecox'*

ter habit can be gawky when cultivated as a specimen in the open.

Cercidiphyllum japonicum ''Morioka Weeping': zone 4. This spectacular katsura cultivar originated in Morioka City, Iwate Prefecture, Japan, and was introduced into North America by the Arnold Arboretum in 1981 under the name *Cercidiphyllum magnificum* 'Pendulum'. 'Morioka Weeping' can be distinguished from other weeping katsuras by its ability to form a central leader without staking. It produces strongly pendant branches with a growth form reminiscent of weeping beech, and it should be planted near water for fastest growth and best effect. Twenty-year-old plants of 'Morioka Weeping' are now over thirty feet tall and ten feet wide.

Hydrangea paniculata 'Praecox' (early hydrangea): zone 3. Early hydrangea forms a large shrub growing to about ten feet in height and the same in width. It begins to flower in midsummer, continuing for about six weeks, with sterile flowers that gradually turn from white to red to papery brown. In appearance, it is more "natural" than the old-fashioned peegee hydrangea (*H. paniculata* 'Grandiflora'), but it is every bit as hardy and flexible in its soil and moisture requirements. The cultivar 'Tardiva' is similar to 'Praecox', but blooms about a month later.

Hydrangea quercifolia (oakleaf hydrangea): zone 5. The horticultural merits of this outstanding shrub, a native of the Southeast, have finally been recognized. It grows well in either sun or shade, and is tolerant of dry soils. It produces beautiful blossoms in July and stunning burgundy-red fall color; in fact, even if the plant never flowered, it would be worth growing for its bold foliage. This species and all of its cultivars well deserve the popularity they are now enjoying.

Liriodendron tulipifera x *chinense* (Chinese-American tulip tree): zone 5(?). One plant of this cross has been growing at the Arboretum since 1981; it is now over thirty feet tall and fifteen feet wide. Its foliage is bronzy colored in spring, and its flowers, though somewhat smaller than

Quercus phellos

those of the American species, have more orange in their petals. This hybrid tulip tree was developed at the University of North Carolina in 1978 and should be tested in landscape situations. The specimen at the Arboretum has been given the cultivar name 'Chapel Hill'.

Quercus phellos (willow oak): zone 5b. Although commonly planted as a street or park tree in the South, willow oak in underutilized in the Northeast. When raised from seed collected in the northern part of its range (e.g., central New Jersey), it is perfectly hardy into southern New England. It grows to about sixty feet and maintains a strong central leader well up into the crown. Its small, narrow leaves cast a light shade that allows grass to prosper underneath it, and, as an added bonus, are easy to clean up in the fall. Willow oak is late to leaf out in the spring, but it makes up for its slow start by growing continuously throughout the heat of summer.

Rhododendron arborescens (sweet azalea): zone 4. Sweet azalea is native to moist habitats throughout the mountains of the Southeast. In late June and July it produces extremely fragrant white flowers that are highlighted by bright red anther filaments. Since its glossy green foliage is generally undamaged by insects or fungi, it remains attractive throughout the growing season. Sweet azalea can grow to about six feet in height and spreads laterally by underground stems, making it an ideal choice for naturalistic landscapes.

Xanthorhiza simplicissima (yellowroot): zone 3. This woody groundcover grows to be about two feet tall, spreading vigorously by underground stems and performing well in both wet and dry soils and in sun or shade. Its adaptability and persistence make yellowroot a good choice for low-maintenance landscapes. It was used more commonly in the past than it currently is.

FALL

Acer pseudosieboldianum (Korean maple): zone 4. This medium-sized understory tree from northeast Asia produces spectacular fall color ranging from orange to scarlet in late October. The species is similar in general appearance to the Japanese maple *(A. palmatum)*, but it is more upright in habit—growing to be about thirty feet tall and fifteen feet wide—and more cold hardy. It deserves wider testing under landscape conditions, particularly in zones 4 and 5, where Japanese maple can have problems.

Acer triflorum (twisted-bark maple): zone 5 (4?). This mid-sized tree from northeast China can grow to forty feet in New England. Like its near relative the paperbark maple *(A. griseum)*, it produces trifoliate leaves. Its most striking features include late fall color that ranges from bright red to orange, and its whitish-tan, shredding bark in winter. *A triflorum* performs reliably under a wide range of conditions and appears to be hardier than *A. griseum*.

Enkianthus perulatus (white enkianthus): zone 5. White enkianthus is a slow-growing deciduous shrub from Japan that eventually grows to six feet in height with a similar spread. In spring it produces small, white flowers, and in fall its fine-textured foliage turns rich burgundy to flaming scarlet, brighter than any other plant cultivated at the Arnold Arboretum, where specimens of *E. perulatus* have been growing in full sun and dry soil for over a hundred years.

Enkianthus perulatus

Euonymus carnosus (glossy euonymus): zone 6 (5?). This small deciduous tree from China can grow to about twenty feet in height. At the Arnold Arboretum, glossy euonymus has been free of pests and disease for nearly twenty years. Its shiny, dark green foliage turns a striking burgundy red in late fall, quite unlike that of any other euonymus cultivated at the Arboretum.

Heptacodium miconioides (seven-son flower): zone 5. This tall deciduous shrub or small tree, introduced from China in 1980, can grow to be about twenty feet tall and fifteen feet wide. *Heptacodium* produces six-inch-long panicles of small, white flowers in late summer, followed rapidly by a beautiful display of showy, rose-magenta seeds in early autumn. It is tolerant of clay soils, road salt, and full sun, making it a good choice for roadside plantings. Its white, exfoliating bark is spectacular in winter, especially when trained to develop a single stem.

Koelreuteria paniculata 'Rose Lantern' ('Rose Lantern' golden raintree): zone 5. This deciduous, round-headed tree grows from thirty- to forty-feet tall with an equal spread. It produces striking yellow flowers in showy panicles in late August or early September, almost a month later than is typical of the species. The fruit capsules are an attractive light pink, eventually turning paper-brown. 'Rose Lantern' grows well in full sun and dry soil, making it suitable for streets and parking lots. This clone has been widely distributed under the cultivar name 'September'.

Lindera obtusiloba (Japanese spicebush): zone 5b. This deciduous, wide-spreading shrub grows to about fifteen feet in height with an equal spread. Its leathery, distinctively lobed leaves are extremely handsome and turn a bright, chrome yellow for a full two weeks in late fall—indeed, in terms of fall color, Japanese spicebush is one of the Arboretum's most reliable performers. It is a complete mystery why one seldom sees this plant in New England landscapes.

WINTER

Ilex pendunculosa (longstalk holly): zone 5. This Japanese species, which can grow to be fifteen feet tall and ten feet wide, is one of the hardiest of the upright hollies. Its attractive red fruit and delicately creased, glossy foliage make it an excellent choice for northern gardens, either as an informal hedge or as a specimen. Like most hollies, it grows best in light shade and moist, well-drained soil.

Magnolia virginiana var. *australis* (evergreen sweetbay): zone 5b. This slender, upright tree grows to be thirty feet tall and ten to fifteen feet wide, with a strong central trunk. The evergreen sweetbay has narrow leaves and deliciously fragrant, two-inch-wide flowers in June and July. A native of the Southeast, it is botanically and

Magnolia virginiana *var* australis

horticulturally distinct from the shrubby, deciduous sweetbay that grows in the Northeast (var. *virginiana*), but not quite as hardy.

Stewartia sinensis (Chinese stewartia): zone 6 (5?). This species is an understory tree from China that can grow to thirty or forty feet in height. In summer it produces small, white flowers (one-and-a-half-inch in diameter). With its smooth bark, white to tan in color and resembling alabaster, Chinese stewartia is every bit as beautiful as the more commonly planted Korean stewartia, *S. pseudocamellia.* It needs moist, well-drained soil and performs well in either full sun or light shade.

CONIFERS

Abies koreana (Korean fir): zone 5. This relatively small fir, around twenty to thirty feet tall and ten feet wide at maturity, produces highly ornamental purple-blue cones at a young age. Like most true firs, this Korean species requires full sun, but unlike other species it flourishes at sea level and is tolerant of a variety of soil conditions. This is one of the few firs suitable for use in small residential landscapes.

Calocedrus decurrens (California incense cedar): zone 5. This tall evergreen from the mountains of California grows to be about fifty feet tall in the East. Incense cedar typically develops a narrow, almost fastigiate, growth habit that is very striking in the landscape, with foliage that stays bright green through the winter. It grows best in full sun and is tolerant of a wide range of soil conditions, including clay and extreme drought, and has no serious pest or disease problems in the East. This plant deserves to be much more widely grown than it currently is.

Abies koreana

Cedrus deodara 'Shalimar': zone 6. This hardy form of the deodar cedar was selected at the Arnold Arboretum in 1982, where it grows to about thirty feet in height. Its beautiful, blue-gray foliage and graceful, drooping branches make the deodar cedar a dramatic landscape specimen. It grows best in full sun and is very tolerant of dry soil.

Thuja plicata (western arborvitae): zone 5. Although native to northwestern North America, this species is perfectly hardy in the Northeast. In comparison to *T. occidentalis*, the eastern arborvitae, *T. plicata* is taller and looser in growth habit, forms a strong central leader, and has much better winter color. It can grow to be fifty or sixty feet tall in the East, with a spread of about twenty feet.

Calocedrus decurrens

Cedrus deodar *'Shalimar*

Tsuga chinensis (Chinese hemlock): zone 6 (5?). A tall evergreen, Chinese hemlock grows to at least fifty feet in height in the Boston area. Preliminary evidence indicates that it is resistant to the hemlock woolly adelgid, but more research is needed before the species gets a full recommendation. The oldest specimen in North America, collected in China by E. H. Wilson, has been growing at the Arnold Arboretum since 1910.

Peter Del Tredici is director of living collections at the Arnold Arboretum.

For a list of nurseries that carry these plants, contact the Arboretum's membership department by mail or by e-mail (membership@arnarb harvard.edu).

Cypress Knees: An Enduring Enigma

Christopher H. Briand

The cypresses keep their secrets from the prying investigator.
—J. E. Rogers, 1905

Baldcypresses in the Wolf River, near Memphis, Tennessee.

The function of cypress knees has long intrigued botanists. In 1819, François André Michaux wrote, "No cause can be assigned for their existence," and in 1882 Asa Gray concurred. Nevertheless, throughout the nineteenth century and continuing to the present, botanists have put forth hypotheses about the function of these peculiar formations, hypotheses that have included aeration of the root system, vegetative reproduction, mechanical support, nutrient accumulation, and carbohydrate storage. The aeration theory has been the most popular and, indeed, is presented without question in some botany texts, but in fact, no explanation has been generally accepted.[1]

The genus *Taxodium* has been present in North America since at least the Upper Cretaceous, approximately seventy million years ago, but very little is known about when knees first developed and why. Knees can be found on both varieties now extant in the United States. Baldcypress *(Taxodium distichum* var. *distichum)* is distributed along the coastal plain from southern Delaware to southern Florida, west to southeastern Texas, and inland along the Mississippi Valley as far north as southern Illinois and Indiana. Pondcypress *(Taxodium distichum* var. *imbricarium)* has a more limited distribution, with its northern limit in southeastern Virginia and its range extending south throughout Florida and west to southeast Louisiana. The two varieties are readily distinguished by their leaf morphology and the orientation of both their leaves and branchlets. While the leaves of baldcypress are needlelike and generally arranged in two rows, those of pondcypress are scalelike and radially distributed around the branchlets. Also, baldcypress branchlets are horizontally oriented, whereas pondcypress branchlets are often ascending. Where they overlap in distribution, however, there is considerable morphological intergradation.[2]

Visitors to the cypress swamps of the southeastern United States are often intrigued by the swollen bases, or buttresses, of cypresses, and by the woody conical structures—the knees—of varying size found around the base of many trees. More than anything else, the knees resemble termite mounds, but are in fact outgrowths of the shallow, horizontal roots of the cypress trees and are not caused by insect activity. Knees are formed on the upper surface of these roots by the vascular cambium, the

ROBERT H. LAMBORN, FROM GARDEN AND FOREST

The denuded roots of a baldcypress, showing the knees and underground structure.

meristematic layer that produces xylem and phloem, the tissues that transport water and nutrients through the plant. The knees are generally solid, but may become hollow over time due to rotting. In cypress plantations, knees are found on trees as young as twelve years old.[3]

Cypress knees vary greatly in size. In 1803, Andrew Ellicot observed knees as high as eight to ten feet; the tallest on record is a knee fourteen feet in height seen on a tree growing along the Suwannee River, which flows through Georgia and Florida.[4] Many researchers have agreed that it is average water depth that determines the height of knees, and one observer, Mattoon, reported that the knees on trees growing in softer soils were larger than those produced by trees growing on firmer land.[5]

In spite of much research and a plethora of hypotheses, exactly what stimulates cypresses to form knees remains, like the knees' function, unknown. In the following, I will review all these hypotheses and the present state of our knowledge about cypress knees.

The Aeration Hypothesis

Knees are most often found on the roots of trees growing in wet soil and in relatively shallow water; they are generally absent from trees growing in deeper water and only occasionally on trees growing on land that is dry year-round. In 1934, Herman Kurz and Delzie Demaree, working in Florida, suggested that knees may be caused by the root system being alternately exposed to water and air. In 1956, L. A. Whitford, a researcher working in North Carolina, came to a similar conclusion: "The formation of cypress knees seems . . . to be a response of the cambium of a root growing in poorly aerated soil or water to chance exposure to the air during the spring or early summer." Another indication that aeration may play a role in knee development emerged from research done in 1991 by Fukuji Yamamoto, who observed that the number of knees per tree declined with increasing water depth. The fact that knees have been reported on trees found on land that is dry year-round, of course, throws into question the need for periodic flooding or drying to stimulate knee formation.[6]

The need for aeration has been a favorite hypothesis for explaining the function, as well as the formation, of knees. Since all plant roots need a source of air to carry out cellular respiration, some researchers have suggested that knees are simply a form of pneumatophore, or breathing root. Pneumatophores are specialized roots that characterize many woody plants growing in poorly aerated soils, such as in swamps or in the intertidal zone; examples include *Avicennia nitida* (black mangrove), *Sonneratia alba* (mangrove apple), and *Bruguiera parviflora* (small-leafed orange mangrove). Pneumatophores grow either entirely above the level of the water, or in such a way as to be exposed only during low tide. They are characterized by the presence of lenticels (porous regions in the bark that allow gas exchange with the atmosphere) and of aerenchyma, the specialized internal tissues that transport gases through many hydrophytic plants.[7]

The first published suggestion that cypress knees may be a form of pneumatophores dates from 1848, when Montroville W. Dickenson and Andrew Brown wrote in the *American Journal of Science and Arts* that by means of knees "the roots although totally submerged, have a connection with the atmosphere." They also suggested that when the knees were inundated, the connection with the atmosphere could be maintained by the swollen base of the tree, sometimes called the "bottle buttress": "Such enlargements never fail to rise to the top of the highest water level . . ." In 1887 Nathaniel Shaler conjectured that "[the] function of the knees is in some way connected with the process of aeration of the sap . . . " with air entering the knees through newly formed bark at their apex. He also observed that trees died when the water rose high enough to inundate the knees. Two years later, in 1889, another researcher was even more categorical: "[the] location and occurrence [of knees] indicate beyond a doubt that they are for purposes of aerating the plant." In their 1934 paper, however, Kurz and Demaree stated just as categorically that it is "difficult to reconcile the aeration hypothesis with the fact that cypresses of the deeper waters are devoid of knees."[8]

Single young baldcypress with buttressed base growing in Chipman Pond, Delaware.

As early as 1890, Robert H. Lamborn, writing in *Garden and Forest*, had suggested that tests be conducted to learn whether or not knees were indeed "aerating" the trees' roots. Nevertheless, in spite of all the theorizing, little was done to test the pneumatophore hypothesis until 1952, when Paul J. Kramer and his colleagues at Duke University used modern physiological techniques to ascertain the amount of oxygen consumed by knees on living cypresses. They enclosed the knees in airtight containers sealed with a mixture of paraffin and beeswax, and used an oxygen analyzer to measure the amount of oxygen consumed over several weeks. The rate of oxygen consumption was actually lower than for other plants, leading the researchers to conclude that "the available evidence indicates that cypress knees play no important role as aerating organs."[9]

Baldcypress knees appear to march from dry land into the Wolf River, Tennessee.

Anatomical evidence presents another problem for the hypothesis that knees are a form of pneumatophore. Two studies found that knees lacked aerenchyma—the spongy tissues in true pneumatophores that transport air from the knee to the rest of the root system. In addition, lenticels—the regions of the bark that in pneumatophores allow air to be taken up from the atmosphere—are also absent from cypress knees.[10]

The Methane Emission Hypothesis

A less frequently heard theory is one presented by William M. Pulliam in 1992: "Given the possibility that cypress knees provide a conduit to the below-ground environment, it was hypothesized in the present study that knees may also show methane emissions." Methane is not toxic to plants, but neither is it of use to them.

Pulliam measured total methane emissions from trees in swamps bordering the Ogeechee River in Georgia, finding rates that averaged 0.9 milligrams per day." His tests showed that cypress knees accounted for a negligible amount of the methane emissions from the swamp—less than one percent. This methane is commonly referred to as "swamp gas." Furthermore, it is quite possible that even this miniscule amount of methane was being produced by the bacteria that are found on the outside of the knees, rather than being vented from the soil through the knees.[11]

The Vegetative Reproduction Hypothesis

Lamborn, in his 1890 review of what was known about cypress knees at that time, mentioned and then quickly discarded the idea that cypress knees were organs of vegetative reproduction: "I have . . . examined hundreds of living 'knees' in southern swamps, and found upon them no trace of bud, leaf or sprout . . ." No one has since revisited this hypothesis.

The Mechanical Support Hypothesis

Buttresses and stilt roots provide mechanical support for a number of tropical trees. It was again Lamborn, in 1890, who first proposed that knees perform the same function for cypress trees growing in wet soil: "I became convinced that the most important function of the Cypress knee is to stiffen and strengthen the root, in order that a great tree may anchor itself safely in a yielding material." Increased support, he believed, allowed cypresses to withstand strong winds such as those produced by hurricanes. Lamborn suggested that knees located on horizontal roots add stiffness and strength to the junction between the horizontal root to which the knees are attached and the vertical roots that branch off directly below the knees. In 1915, Wilbur R. Mattoon, working for the United States Forest Service, concurred with Lamborn, opining that knees were involved in "enlarging and strengthening the basal support" provided by the rest of the root system. He pointed out that deep roots growing down from the base of the knees provided considerable anchorage for the tree. Both Mattoon and Lamborn premised their hypotheses on the assumption that vertically oriented roots and knees always occur at the same location on horizontal roots, as was apparently the case in their observations. However, Clair A. Brown and Glen N. Montz found that cypresses sometimes produce knees at locations other than above downward-growing roots, and, conversely, that some downward-growing roots do not share a junction with knees on the horizontal roots. And, as with the pneumatophore theory, the absence of knees on the roots of trees growing in deeper water casts doubt on this hypothesis, since there is no reason to believe that they too wouldn't need support. The hypothesis could be tested empirically in the same way that researchers have used cables and winches to pull down trees in order to

Looping Roots vs. Knees

Cypress, as well as water tupelo *(Nyssa aquatica)*, red maple *(Acer rubrum)*, and a number of other swamp and mangrove species, also produce looping roots that somewhat resemble knees. In baldcypress, normal knees are often found at their apex. These looping roots are essentially roots that grow up out of and then back into the soil, producing an aboveground loop or fold. In water tupelo, looping roots can reach a height of 22 inches and a width of 26 inches. The function of these structures, beyond that of normal roots, is obscure. Penfound observed that aerenchyma was lacking in the looping roots of water tupelo and questioned the efficacy of these structures as pneumatophores. Knees have even been reported on pond pine *(Pinus serotina)* growing under wet conditions in Georgia. It is unclear if these resemble normal knees or looping roots.[16]

A looping root of red maple (Acer rubrum) *growing in a swamp at Adkins' Mill Pond, Maryland.*

Knees are beginning to form at the apex of the looping roots of a cultivated baldcypress.

compare the stability of buttressed versus non-buttressed tropical trees—such a test could compare trees with knees to trees that have had their knees removed—but no one has yet done so.[12]

The Nutrient Acquisition Hypothesis

Lamborn postulated that another secondary function of cypress knees, along with that of giving mechanical support, was to act as "drift catchers" that accumulate organic nutrients during periods of water movement. A hundred years later, Hans Kummer and his colleagues at Zurich made a similar supposition about looping cypress roots, which they also called knees, after studying baldcypress in a Florida cypress dome. (A cypress dome is a group of cypresses growing in a shallow depression where the largest trees are located in the center and tree height declines toward the periphery.) They found that the number of looping cypress roots present were highly correlated with the number of dead cypress trees in the dome, but not with the number of live trees. In other words, looping root density increased with an increase in the number of dead cypress stumps. They also observed that approximately 98 percent of the youngest looping roots spread over the stumps and penetrated the dead wood. Older looping roots were not generally in direct contact with decaying stumps. Direct evidence of nutrient acquisition was not obtained, however. Kummer and his colleagues suggested that further work was needed to determine if "young root loops extract nutrients from stumps . . . [or] . . . use stumps merely as vertical supports to reach air above the water table.[13]

CHRIS BRIAND

Baldcypress trees with buttresses at Trussum Pond, Delaware

The Carbohydrate Storage Hypothesis

Clair A. Brown in 1984 and again with Montz in 1986 postulated that the primary function of cypress knees is as a storage organ. They reported the presence of "granules"—presumably amyloplasts (organelles that store starch)—and confirmed the presence of starch by performing iodine tests on the cut surface of sectioned knees. Even if their hypothesis is accurate, unanswered questions remain about the function of knees. Why do cypresses need an auxiliary storage organ when growing under wet conditions, but not dry? Is it possible that cypress roots in general store starch, and that knees are simply extensions of these storage areas? Unfortunately, no comparison of the storage capacity of roots and knees has been made to test the hypothesis.[14]

After nearly two hundred years of speculation and research, the function or functions of the knees of cypresses remain unclear. Darwin referred to the origin of the flowering plants as an "abominable mystery"; it appears that the function of cypress knees is another.[15] The truth may be that cypress knees evolved in response to past environmental pressures that no longer exist, in which case their function may be lost in the depths of time. Before we accept this conclusion, however, much further research is needed on this fascinating subject.

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Christopher H. Briand is Associate Professor in the Department of Biological Sciences, Salisbury State University, Salisbury, MD 21801, and producer of the Salisbury State University Arboretum website (www.ssu edu/arboretum) Thanks are extended to William Grogan, Mark Holland, and Judith Stribling (Salisbury State University) for their assistance and suggestions, and to Joan Rye at the *American Journal of Science* (Kline Geology Laboratory, Yale University) for providing a copy of the paper by Dickeson and Brown.

Ginkgo biloba in Japan

Mariko Handa

Various theories estimate when ginkgo arrived in Japan. Some say it grew here during the Mesozoic era but then died out. Others argue that it arrived from China along with Buddhism in the sixth century. Nothing has been proven, but whenever and however it arrived, ginkgo is deeply rooted in the lives of the Japanese people, admired for its beautiful shape and its seasonal colors. Today ginkgos grow throughout Japan, along roadsides and streets, in parks and schoolyards, on shrine grounds, and in private gardens. Ginkgo serves frequently as the symbol of a region or as an object of worship, and it plays a role in many legends.

Ginkgo as a Roadside and Street Tree in Japan

According to one account, roadside trees in Japan date back to the middle of the eighth century, when fruit trees were planted along roads for the benefit of travelers. It was in the latter half of the nineteenth century, however—when Japan opened its borders and began to modernize—that trees became a part of urban landscapes.

The forerunners of modern street trees were first seen in Yokohama and in the capital, Tokyo. Willow and pine trees were planted along a street called Bashamichi in Yokohama in 1867. In 1873, black pine *(Pinus thunbergii)*, cherry *(Prunus)*, maple *(Acer)*, and other species were planted in Tokyo along Ginza Street, newly modernized by the construction of European-style brick buildings. The first major use of imported trees to line city streets occurred in 1875 when a North American native, *Robinia pseudoacacia* (black locust), was planted in Tokyo, having been grown from seeds brought back to Japan from the 1873 International Exposition in Vienna. *Ailanthus altissima* (tree-of-heaven), *Firmiana simplex* (Chinese bottle tree), and other species were also planted at that time, but because of inappropriate planting methods or insufficient care, most of these trees died.

In 1907 a replanting project was initiated along Tokyo's streets using ten species selected for fast growth and the ability to withstand urban conditions: among them, *Platanus* (plane tree), *Liriodendron tulipifera* (tulip tree), Chinese bottle tree, *Castanea* (chestnut), *Acer buergerianum* (trident maple), *Styphnolobium japonicum* (pagoda or scholar tree), *Cornus* (dogwood), *Fraxinus* (ash), and *Mallotus japonicus*. Ginkgos were chosen for the front of Tokyo's City Hall, marking the species' debut as a street tree in Japan.

Tokyo's urban tree-planting projects suffered two major setbacks during the first half of the twentieth century. In 1923, the fires following the Great Kanto Earthquake destroyed more than half the street trees, leaving only about 10,000 still standing. As part of the effort to restore the city, more than 16,000 new trees were planted by the national government and nearly 5,000 by the city of Tokyo itself. This time the principal species chosen were ginkgo, plane tree, and black locust, all of them fast maturing.

The second disaster was the bombing of Japan during World War II, which destroyed 121,162 street and roadside trees in Tokyo, or about 45 percent of the 271,168 that were standing before the war. Postwar, the government's War Recov-

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Ginkgos along Midosuji Avenue in Osaka City

ery Agency appointed a committee to design a tree restoration project. The committee suggested that local trees be used for replanting, in order to take advantage of each region's environmental conditions.

Government records trace the changes in tree species planted in the aftermath of these disasters and during the ensuing period of normality. Between 1922 and 1967, the species planted most often along roadsides and streets throughout Japan was the plane tree, with ginkgo in second place. The plane tree was preferred because it best suited the need for fast restoration: first from the 1923 earthquake, and later, from the devastation caused by the war. However, the characteristics that made it useful during the recovery periods—fast growth, vigorous sprouting capacity, and relatively big leaves—made it difficult to maintain as the city matured, and since 1982 ginkgo has been the preferred species for street and roadside planting. Ginkgo grows well in urban environments, withstanding pol-

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Ginkgos line a walk at the Tsukuba Research Center of the National Institute of Advanced Industrial Science and Technology in Tokyo

lution, cold, and even fire. Unlike the plane tree, its shape remains symmetrical, and its changing appearance more clearly marks the progress of the seasons. Similar factors explain the popularity of Japanese zelkova *(Z. serrata)* and trident maple. Evergreen camphor *(Cinnamomum camphora)* is increasingly used for its year-round foliage. And cherry trees remain Japan's overwhelming favorite among flowering trees, despite their susceptibility to disease. The mix of trees has varied by region, however. Ginkgo has been designated the prefectural tree in Tokyo, Kanagawa, and Osaka Prefectures, indicating that it is used preferentially there.

By 1991 a total of almost five million street and roadside trees were recorded in Japan—four trees for every kilometer of "ordinary" roads, which can be defined broadly as all roads and streets except expressways. A greater diversity of species were planted after the war: whereas in 1938 the top ten species in areas surveyed had accounted for 95 percent of all trees, by 1991, the top ten had fallen to 52 percent of the total, although in aggregate, the five million trees represented five hundred different species. Ginkgo, with 11.5 percent of the total, was followed in popularity by cherry (various species), Japanese zelkova, trident maple, and plane tree.

The use of trees is very different along roads managed by public corporations (primarily expressways). These trees accounted for an additional 1.7 million trees in 1991, representing about 210 species, with Japanese red pine *(Pinus densiflora)*, black pine, and cedar *(Cryptomeria japonica)* being the most commonly used, and ginkgo accounting for only one-tenth of one percent. On these wide, high-speed expressways,

COURTESY OF HIMEJI CITY

Lines of ginkgos are faced with evergreen camphor trees on Otemae Avenue, Himeji City.

large numbers of evergreens are planted to reduce traffic noise in the surrounding residential areas. Where expressways pass through undeveloped areas, such as mountain foothills, species are selected for harmony with the surrounding natural vegetation. Both these factors mean that ginkgo trees are limited to service areas along expressways.

Ginkgo in Geometrical Japanese Landscapes

Ginkgo trees in Japan have often been used in designs that incorporate Western landscaping features, among them allées. An allée of ginkgos shapes the approach to the Meiji Jingu Gaien (Meiji Memorial Gallery) in Tokyo, built in 1926; two lines of ginkgo stand on either side of the path that leads from Aoyama Street to the Gallery. To exaggerate the perspective, the trees are maintained such that their heights decrease as they approach the Gallery—an effect that is further magnified by the slight downward slope of the ground. The massive ginkgos guide the viewer's line of sight to directly focus on the Gallery. The entire complex includes 146 ginkgos, arranged in the four lines leading to the Gallery and in two additional, shorter allées that branch off to the left. The largest of the trees is now about 79 feet tall, with a trunk diameter of about nine feet; the shortest is 56 feet tall with a diameter of about six feet. The trees are pruned every four years to maintain their beautiful shape.

COURTESY OF MEIJI JINGU GAIEN

Above, double rows of ginkgos draw the eye to the Meiji Memorial Gallery, Tokyo, photographed in 1988 Below, the sculpted allée in winter 1999.

Ginkgos also form the allée in Tokyo's National Showa Memorial Park, a 450-acre park that was created in 1983 to commemorate the fiftieth anniversary of the accession of the Emperor Showa. Because the site had previously been occupied by the United States' Tachikawa military base, its condition first had to be improved. The 600 buildings on the base were removed, ponds were excavated, hills were reconstructed, and trees were planted and grasses sown to create forests and fields.

COURTESY OF NATIONAL SHOWA MEMORIAL PARK WORKS OFFICE

Geometrically pruned ginkgos in the National Showa Memorial Park, Tokyo.

From the park's Tachikawa Gate, a canal extends 255 yards to fountains at the opposite end and, on each side, four lines of ginkgo trees. The 108 ginkgos were moved to their present location from other places on the site in 1982. They are kept at 23 feet to conform with height restrictions imposed by the proximity of the Self-Defense Force Air Base.

The ginkgo allées at both these sites—the Meiji Memorial Gallery and the National Showa Memorial Park—illustrate how Western influences have been adapted to the Japanese sensibility. By using ginkgos—a species that has rarely been used in Western geometric landscapes—the landscape architect, Yoshinobu Orishimo, rendered it unique. The alleé is a form that originated in Europe, but in using ginkgos, the effect is very different. This way of combining a form, or vessel, from the West with materials, or contents, of the East is an excellent example of the way culture changes and is transmitted in Japan.

Individual Ginkgo Trees of Note

Many individual ginkgos have taken on special importance in Japan, either for historical reasons or for their place in legend or simply for their size. A giant tree is defined by Japan's Environment Agency as "a tree with a trunk diameter of 300 centimeters [117 inches, or close to 10 feet] or more at a height of approximately 130 centimeters [51 inches] above the ground." According to a survey in 1988, of the 55,798 giant trees of all kinds in Japan, 4,318 (7.7 percent) were ginkgos, taking fourth place after cedar, Japanese zelkova, and camphor.

When ginkgos grow to immense size, some of them develop distinctive shapes that are reflected in the names given to them. In the *senbon* (one-thousand) ginkgo, the central trunk is surrounded by many secondary trunks, forming a single large tree that looks like a collection of many separate

Hashigami-cho, a giant ginkgo in Aomori Prefecture, northern Honshu.


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Shibata-cho, a giant in Miyagi Prefecture, northern Honshu Camellia japonica *is flowering at its base.*

trees—therefore the name "one-thousand ginkgos." *Sakasa* (upside-down) ginkgos are so-called because their branches, especially the lower ones, appear to be upside down. The names *meoto* (husband-wife) ginkgo and *oyako* (parent-child) ginkgo refer to pairs of trees growing close together and appearing to be related. *Ohatsuki* ginkgo is a name used when flowers bloom at the margins of leaves; *ohatsuki* means "stuck to leaves." In the *chichi* (breast) ginkgo, a number of aerial roots droop down from the thick branches and trunk of the trees, becoming narrower as they near the ground. Many women pray to these sacred trees for the ability to nurse their babies.

Many trees, whether giant or not, are associated with legend and worship. A good example is the Nigatake ginkgo at Ichou Machi, Sendai City, Miyagi Prefecture. It is a female tree about 115 feet in height with a trunk diameter of about 8.2 feet at chest height; it is said to be a thousand years old. Of its many "breast columns," the largest is 63 inches in diameter. According to legend, the dying wish of Byakkouni, a wet nurse of the Emperor Shoumu (reign 724–749), was that a ginkgo be planted on her grave mound. A god is said to be enshrined at the foot of the tree. Women who cannot produce their own milk often worship there.

Another famous old ginkgo tree, called *mizufuki* (water-spray) ginkgo, stands in front of the Founder's Hall at the Nishi Hongwanji Temple in Kyoto. Its age is estimated to be 400 to 500 years old. A legend tells that when the fire that swept through Kyoto in 788 threatened

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Nigatake ginkgo at Ichou Machi, Sendai City, Miyagi Prefecture.

When the Mizufuki ginkgo showed signs of decline, a Kyoto tree doctor, Shoji Yamada, was called in to restore its vigor. First, he studied the tree externally and found spreading trunk rot and hollowing. Next, to investigate the soil layers and the distribution of the root system, soil excavations 4 feet deep and 3.2 feet wide were made at three locations under the tips of the canopy. This revealed that the soil was severely compacted by foot pressure to a depth of 4 to 6 inches, hampering the growth of feeder roots and causing asphyxiation. The measures taken to help the tree recover its vigor were:

1. Dead parts of the trunk and large branches were pruned to remove rot, taking care not to harm the tree's beautiful shape. Then, urethane resin was injected into the tree; putty was used to prevent rainwater from penetrating this repair work. Finally, an antibacterial agent was applied.
2. The soil beneath and around the tree was excavated to a depth of 20 inches—using great care not to damage the fine roots—then filled with new soil, a soil-improvement agent, and fertilizer.
3. A shallow embankment was formed and groundcovers planted to retain moisture in summer and prevent freezing in winter.
4. To protect the tree from soil compaction, a fence and curbstones were placed around the tree to keep people away from it.

By mid-April of the same year, fresh young buds had formed. The tree has recovered its vigor and appears to be in good condition.


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Mizufuki ginkgo at Nishi Hongwanji Temple, Kyoto, photographed in 2000 to spread to the Hall, this large, male ginkgo sprayed a column of water on the flames, saving the building. It is 39 feet in height with a circumference at the roots of 29 feet and a canopy of 85 feet in diameter. In 1994 the tree was losing its vigor: its branches were drying up, and the size and density of its leaves were dwindling. Fortunately, treatment carried out at that time has restored the tree to health.

Perhaps the most famous ginkgo stands in Hiroshima. When the atomic bomb was dropped on that city on August 6, 1945, some of the trees in the temple called Housenbou survived the atomic blast, although it was only one kilometer from its center. One of these survivors was a ginkgo tree that stands near the main building of the temple. The building was instantly destroyed but the ginkgo survived; fresh young buds appeared soon afterward, and new branches formed.

TAKETO NAKANO

A Hiroshima survivor stands before the Housenbou Temple, Hiroshima City.

The temple's followers were eager to rebuild the main building, but the ginkgo tree presented a problem. There was no room for it elsewhere on the temple grounds, and in any case, it would have been risky to move such a large tree, estimated to be 150 years old. Rather than cut it down, the building was modified to preserve the tree where it stood. The roof was changed to give the tree more space, and two stairways were built in the front of the building to form an inverted "U" with the ginkgo protected inside it. An opening under the stone stairs allows air to flow past the tree. This accommodation expresses the intense feelings that this ginkgo tree inspires, still living today, a precious witness to the disaster. It has a powerful impact on all who see it.

Mariko Handa is in charge of the research department of Parks and Recreation Foundation, Tokyo. This article is adapted from "*Ginkgo* Landscapes" by Dr. Handa, Yasuo Iizuka, and Nobuo Fujiwara, which appeared in the 1997 Ginkgo Biloba—*A Global Treasure.*

ARCHIVES OF THE ARNOLD ARBORETUM

Ginkgo biloba *and shrine in China, the village of* Leng che, Valley *of* the Tung *River, western Sichuan. Measured at eighty feet in height and twenty-five in circumference and photographed by E. H. Wilson, 1 August 1908.*

Arnold Arboretum Weather Station Data — 2000

	Avg. Max. Temp. (°F)	Avg. Min. Temp. (°F)	Avg. Temp. (°F)	Max. Temp. (°F)	Min. Temp. (°F)	Precipitation (in.)	Snowfall (in.)
JAN	36	17	27	65	−2	3.87	16.2
FEB	43	22	33	66	0	3.35	8.85
MAR	54	33	44	78	14	4.49	3
APRIL	57	38	48	78	24	6.88	0
MAY	72	48	60	97	35	3.16	0
JUNE	82	56	69	96	44	6.67	0
JULY	84	62	73	93	52	4.91	0
AUG	83	61	72	96	50	1.78	0
SEPT	77	52	65	93	32	4.52	0
OCT	66	43	55	84	32	3.54	0
NOV	47	34	41	66	12	4.87	0
DEC	37	18	27	66	5	5.73	0

Average Maximum Temperature	62°
Average Minimum Temperature	40°
Average Temperature	51°
Total Precipitation	53.77 inches
Total Snowfall	28.05 inches
Warmest Temperature	97° on May 8
Coldest Temperature	−2° on January 17
Date of Last Spring Frost	28° on April 15
Date of First Fall Frost	32° on September 29
Growing Season	167 days

Note: According to state climatologist R. Lautzenheiser, the year 2000 was abnormally cold and wet; compared to 1999, it was 2.2 degrees colder and more than 5 inches wetter. February, March, and April were very mild—March 2000 was one of the warmest on record—but this was offset by the unusually wet and cool June and July. June ranked eleventh for precipitation in 130 years. September through December were also below normal in temperature; the first killing frost arrived on September 29. Snowfall totaled only 28.05 inches, 13.5 inches below normal.

The consistent rains through spring, summer, and fall made 2000 a very good planting year. Trees and shrubs put on more than average growth and appeared to be recovering well from the droughts of a few years ago.

Tree climbing in the Arnold Arboretum, 1949. Heman Howard photographed arborist William Stefany near the top of a white pine.

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The Arnold Arboretum

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Sun-Loving Shrubs and Vines: A Garden of Their Own

Robert E. Cook, Director

Two thousand and one will be a year of landscape construction at the Arboretum. Five years ago we added a 15-acre wetland to our lease with the City of Boston. This spring we will initiate construction of a stonedust pedestrian pathway that will open the site to the public by connecting the Forest Hills train station with a major gateway into the grounds at South Street. New steel gates, stone pillars, and walls will be added at each end of the path. A second project will install similar steel gates at Bussey Street where it separates the Peters Hill area from the rest of the Arboretum. New land for the planting of trees will be created by removing a short stretch of existing asphalt roadway along the south edge of Bussey Brook. We will say more about these projects in a later issue.

Our largest landscape project, set to begin construction in May, will create the Sun-Loving Shrub and Vine Garden on three acres of land located northeast of our greenhouse and bonsai complex. Designed by the landscape architecture firm of Reed Hilderbrand, this new garden will allow us to greatly expand our current collection and to display up to 400 shrub species and cultivars not grown elsewhere on the grounds. In addition, an open-air pavilion with attached trellises, and an extensive system of steel vine structures will permit us to grow approximately 100 vine species as individual specimens integrated into a single horticultural space.

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A Schoolyard Arboretum

Last November teachers and students at the Nathan Hale Elementary School in Roxbury held a ceremony to dedicate their newly constructed schoolyard, which has been specially designed to include an arboretum. Twelve remarkable trees will become part of the educational experiences for both teachers and students, as they document each tree's growth and characteristics over the years.

This schoolyard renovation is part of the Boston Schoolyard Initiative (BSI), which awards grants to schools with a vision as well as a constituency capable of making significant improvements to the schoolyard environment. For the past four years, the BSI has funded the renovation of 48 public schoolyards. Two years ago, the BSI approached staff at the Arboretum to discuss how to ensure that the newly designed playgrounds were places for outside

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The garden will provide a new, unique destination for visitors, offering a diverse collection of woody shrub and vine taxa in an elegant botanic garden setting. As a collection, it will also create an array of educational opportunities: students of horticulture and landscape design as well as the general public will learn the practical uses of shrubs and vines.

In keeping with the agricultural nature of our nursery and propagation greenhouses nearby, the garden will consist of a series of terraces laid out on a gently sloping site and created by extensive fieldstone retaining walls; each terrace will have a series of planting beds separated by grass pathways. The site is framed at the top by a long, high, stone retaining wall below the bonsai house that runs for more than five hundred feet in length and reaches almost eight feet at its maximum height. Stonedust paths lead visitors along this great wall among vine structures to a vine-covered pavilion overlooking the garden and down bluestone steps onto the great lawn that sweeps downhill through the center of the terrace system. Despite a thirty-foot difference in grade between the top and bottom of the garden, it will be fully accessible to wheelchairs and mobility-impaired visitors.

Construction of the Shrub and Vine Garden will require closing the greenhouse and bonsai area for a period of six months. While construction should be complete by Thanksgiving, the planting of shrubs and vines will be delayed until the spring of 2002. We believe that this new collection, displayed in a beautiful garden setting, will make a unique contribution to the horticultural resources of the Arboretum and the City of Boston.

2001 PIPD Releases

In its continuing efforts to share exceptional woody plants from the living collections with progressive nursery professionals, the Arboretum is releasing two outstanding plants in its Plant Introduction, Promotion, and Distribution Program for 2001.

Fothergilla gardenii 'Harold Epstein' was first collected in Jesup County, Georgia, by the late Harold Epstein of Larchmont, New York, plantsman extraordinaire. Originally classified as a separate species—*F. parvifolia*—later investigations have placed it within *F. gardenii.* It is a diminutive shrub with a low, dense, mounding form that slowly reaches a height of 10 to 12 inches and a width of 16 to 18 inches in about five years. The white, bottlebrush-like flowers are fragrant and appear in late April to early May. The dark-green foliage of summer turns yellow to vibrant orange-red in autumn. Though its overall appearance is delicate, the Harold Epstein fothergilla thrives in full sun and is insect- and disease-resistant. Its ability to sucker and spread allows it to form a good groundcover mat.

Liquidambar acalycina

Liquidambar acalycina, a Chinese sweetgum, was introduced into the U.S. in 1980 by the Sino-American Botanical Expedition, in which the Arboretum was a participant. Its three-lobed leaves give this species an appearance very different from our native, five-lobed *Liquidambar styraciflua.* Spring foliage is burgundy-red, maturing to dark green in summer, and finally becoming yellow in autumn. Specimens that have been growing at the Arboretum for 20 years are narrow and upright in habit with smooth, silver bark. The tree appears to be as easy to grow as other members of its genus are, and it exhibits no serious pest or disease problems.

Nurserymen interested in participating in the PIPD program should contact Tom Ward by fax at 617/524-6413.

Terry Sharik, Arnold Arboretum Associate, talks about his textbook project

Dendrology, or "the study of trees," is taught in virtually every university that offers an undergraduate degree in forestry. In the U.S. alone, this amounts to more than sixty schools. The advanced courses students take may vary, but all of them take dendrology near the beginning of their studies. Indeed, the degree of enthusiasm generated in the dendrology course may spell the difference between a student staying in forestry and choosing another field.

Typically, the textbooks used in dendrology courses cover the economically important tree species native to that country or at best to that continent (very few species occur on more than one continent). For example, of the nearly 1,000 tree species native to the conterminous United States, the beginning student enrolled in a dendrology course may be expected to know 100 species in 30 genera in some detail. Currently available textbooks offer instruction on these key species that includes morphological characteristics important in identification, together with information on geographic distribution, size of mature individuals, economic uses, and various aspects of the ecology of the species. The challenge for the instructor is to make this catalogued information come alive, and this is no easy task.

I am writing a dendrology textbook for undergraduates that reaches far beyond current textbooks in its geographic scope and in its attention to the aspects of form and function that adapt trees to grow in particular environments. The text will focus on ecologically and culturally important genera of trees in the temperate regions of the world. Focusing on genera instead of species (most genera extend over more than one continent) will expose students to the major patterns in the evolution of tree habit and enable them to appreciate the variations on a theme that exist in the species constituting a particular genus. This global genus approach will allow instructors to supplement the text with study of local and regional woody plant floras and observations of trees in their natural habitats, thus helping the material come alive.

Focusing on the relationships between form and function will also help students to understand why, for example, species of some genera survive where heavy snowfall and cold climates are the norm, while others thrive in regions where water is scarce most of the year. This, in turn, can lead to an appreciation of the changes in species distribution that may occur as a result of impending global climate change. The approach also has the virtue of shifting the emphasis from a static to a process orientation.

In September 2000, I relocated at the Arnold Arboretum as part of a one-year sabbatical leave from Utah State University. With over 2,000 species and nearly 5,000 taxa, the living collections of temperate-region woody plants from all major continents are clearly among the best in the country. The plant collections together with the herbarium specimens and literature on woody plants worldwide, both in Jamaica Plain and Cambridge, make this an ideal location for my preparation. Later on, I anticipate traveling to other continents to observe and photograph species of the genera to be covered in the textbook in their natural habitats.

We are clearly at a point in history where how we manipulate our local forest ecosystems has global implications, a fact that needs to be more deeply appreciated by undergraduates who will manage those ecosystems and their resources. I hope this project will inspire a more global approach to dendrology that instructors will in turn instill in their students.

Dr. Sharik is Professor and Head of the Department of Forest Resources, in the College of Natural Resources, at Utah State University, Logan, UT 84322-5215. While at the Arboretum, he can be reached by telephone at 617-524-1718 ext. 140 or by e-mail at tlsharik@cnr.usu.edu.

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learning as well as recreation. This request was sparked by the Arboretum's program Seasonal Investigations, a yearlong course of study funded by the National Science Foundation, which supports teachers who wish to incorporate outdoor tree studies in their science curricula.

In 1999, with partial funding from the BSI through a grant from the Greater Boston Urban Resources Partnership, the Arboretum began a pilot project with the Nathan Hale School to identify and develop program elements for a schoolyard arboretum that could be used by other BSI-funded schools. From October 1999 through February 2001, Arboretum staff worked with the teachers and principal to incorporate an arboretum into the schoolyard plans and to create a professional development program that supports outdoor studies using the trees

The project included a series of monthly teacher workshops and meetings devoted to increasing teachers' knowledge of trees and to considering how teachers might incorporate tree study into science lessons. One outcome was a list of trees that offer a variety of bark textures, flower forms and times, leaves, and overall shapes.

The project culminated in a schoolwide election of a favorite tree. Each candidate was introduced through photographs and descriptions. The students then researched the trees on a special website, and finally everyone voted. When the overwhelming favorite—*Acer saccharum* (sugar maple)—was announced at the next week's assembly, students broke into enthusiastic applause.

This project has allowed us to identify issues related to integrating a schoolyard arboretum into the educational experiences of teachers and their students. These issues include the time required for both teachers and students to adequately explore questions and ideas; professional development efforts that address the use of the outdoors as well as science content; the kinds of support, both human and technical, that can aid in such an endeavor; and the importance of school leadership in reaching a successful conclusion.

There is much to celebrate about this pilot study. Participating teachers learned how to incorporate outdoor studies into their science curriculum. The entire school community is aware of the arboretum in the schoolyard and has established a sense of stewardship around the continued growth of these trees. We have learned a great deal about what makes such a project work well and are seeking funding to continue this work. To learn more about this program, visit the special schoolyard arboretum website www.arboretum.harvard.edu/~schoolyard/nsf).

Upcoming Events

Lilac Sunday

The Arboretum's annual celebration of lilacs will occur on Sunday, May 13—Mothers' Day. The only day when picnicking is allowed on the grounds, Lilac Sunday is a time-honored tradition for visitors who enjoy the sights and scents of our extensive lilac collection. The day includes food, dance performances, a limited number of lilac plants for sale, lots of lilac information, and, of course, the lilacs! Admission is free, and the event occurs from 10:00 am to 4:00 pm.

Fall Plant Sale

Mark your calendars for Sunday, September 16, when the 21st Annual Fall Plant Sale will be held at the Case Estates in Weston. For updates as they become available, you can check our website—www.arboretum.harvard.edu. We anticipate quality and quantity in all areas: plant selection, attendance, and weather.