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Winter 1990

arnoldia

The Magazine of the Arnold Arboretum

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GRAY HERBARIUM

arnoldia

Volume 50 Number 1 Winter 1990

Arnoldia (ISBN 004-2633; USPS 866-100) is published quarterly, in winter, spring, summer, and fall, by the Arnold Arboretum of Harvard University.

Subscriptions are $20.00 per calendar year domestic, $25.00 per calendar year foreign, payable in advance. Single copies are $5.00. All remittances must be in U.S. dollars, by check drawn on a U.S. bank, or by international money order. Send subscription orders, remittances, change-of-address notices, and all other subscription-related communications to: Helen G. Shea, Circulation Manager, *Arnoldia*, The Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130-3519. Telephone (617) 524-1718.

Postmaster: Send address changes to:
Arnoldia, Circulation Manager
The Arnold Arboretum
125 Arborway
Jamaica Plain, MA 02130-3519.

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Arnoldia is set in Trump Mediaeval typeface and printed by the Office of the University Publisher, Harvard University.

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Front cover: A close-up of the male inflorescence of *Salix gracilistyla* at the Arnold Arboretum. Photo by Gary Mottau.

Inside front cover: *Rhododendron yakusimanum* curled up in response to the cold.

Back cover: *Actinidia kolomikta* in full variegation. Photographed at the Royal Horticultural Society at Wisley, England, by Nan Sinton.

Inside back cover: *Rhododendron yakusimanum* in the uncurled and curled state. Photos by Rácz and Debreczy.

Special Issue

Zoo Horticulture: Plants and Animals Together at Last

For most of this century, the term *zoological garden* has seemed a misnomer, mocked by frustrated animals pacing back and forth in barren cages. Over the past twenty years, however, the reality of this grim image has slowly been eroding. New zoo design strategies have transformed animal enclosures into "habitat exhibits," which combine plants with other naturalistic elements to simulate the look and feel of "wild" nature.

Horticulture has come of age in the field of zoo management, as carefully crafted plantings are seen as contributing both to the welfare of the captive animals and to the enjoyment and education of visitors. This issue of *Arnoldia* displays a small sampling of the creativity and skill that can be found in the modern zoological landscape.

The creation of realistic habitat simulations in zoos serves two important purposes. It recognizes, first, that in nature animals exist in specific environments and, second, that the closer an enclosure can approximate the animal's natural home, the greater the probability the animal will exhibit more natural behaviors and, if all goes well, will reproduce successfully. Indeed, habitat exhibits evolved partly out of public concern and, in some cases, outrage over the conditions endured by many of the animals.

A second force driving the evolution of habitat exhibits is their powerful influence on the way visitors perceive zoo animals. Designers of habitat exhibits supplant the often depressing experience of viewing animals in metal cages with that of being immersed in a wild landscape, where barriers between animals and the visitor are minimized. In some exhibits, traditional roles are reversed, and the visitor gets the feeling of being confined, while the animal roams free.

The net result of these changes is that the visitor's appreciation of the animals is enhanced, and the link between animals, their habitats, and conservation is permanently etched on the mind of the viewer. At long last zoological gardens across the country are beginning to live up to their names.

A field of small boulders used to protect grasses and wildflowers from the constant pressure of half-grown snow leopards at play. © New York Zoological Society Photo.

Wilderness Horticulture: Himalayan Highlands on the Hudson

John Gwynne

Plants are playing an increasingly important role in the "immersion" exhibits of leading zoos.

Imagine searching for a glimpse of the elusive snow leopard in the high Himalayan wilds. Your imagined trek would depart from main roads to wander narrow uphill footpaths, past thickets of wild magnolias and overarching bamboo, through groves of fir and birch, and up steep grassy meadows dotted with purple-blue *Geranium himalayense.* Perhaps you'd come across a flimsy rustic bridge of rope-tied logs fitted between great boulders spanning a steep-sided mountain brook where ferns, *Ligularia,* and candelabra primula grow in the moist soil.

Terrific! A mother snow leopard with two cubs is spotted among the talus boulders of the grassy slope. Crouching behind boulders,

Millions of Americans can now witness a snow leopard in the snow — a sight previously seen by only a few field scientists. © New York Zoological Society Photo.

The Himalayan Highlands exhibit has room for people to read graphic messages about conservation.

the cats are almost perfectly camouflaged, tails slowly twitching, as a scarlet-chested tragopan pheasant works its way down the hillside, pecking at wind-scattered grass seeds.

Just such an experience formed the basis for the design of a new type of ecological exhibition recently created, not in the mountain wilds of Nepal or China, but in an oak wood in New York City. Here a determined team of zoologists, field scientists, exhibition designers, landscape architects, horticulturists, sculptors, welders, and graphics specialists—all employed by the New York Zoological Society—joined efforts to build a place that captures the feeling of montane Asia. Together, they moved mountains of soil and scree, planted thickets of bamboo and twenty-five-foot firs, and even sculpted rocky outcrops and a great fallen tree of steel, concrete, and epoxy to match the site's geology and woodlands. Named "Himalayan Highlands," the exhibition at the Bronx Zoo offered the opportunity to build a sanctuary for snow leopards, red pandas, white-naped cranes, and Temminck's tragopans. The design team also purposely created a dynamic place where visitors are encouraged to learn about wilderness, about the importance of plant-animal interactions, and of the urgent need for special conservation efforts.

Potential for Public Education

While conceiving of Himalayan Highlands as a naturalistic place for animals, the design team also recognized the potential to enhance the visitor's appreciation of wild places and wild species. The challenge was to transcend typical zoo formulas, which concentrate on exhibiting animals within containments that are clearly manmade (buildings, architectural moats, fences, faux rock cliffs) and that deal with the animals' natural ecology only second-hand by means of signs or explanations by docents.

Himalayan Highlands was to be different, a place that would try to create the primary experience of a trek across an Asian hillside. While transporting an actual mountain slope intact would have been optimal, the more practical challenge was to recreate enough similar elements, combined in appropriate ways, so that visitors would feel immersed in the same environment as the animals. Without having to read, they would see a snow leopard teaching her cubs or a crane probing for tubers along a pond edge, and they would be able to learn how this bit of nature works. Unlike traditional zoo design where the manmade dominates, here the intent was to recreate a wild environment worth exploring, worth learning about, and worth preserving.

The primary educational goal for Himalayan Highlands was to impart an overall affective message—to get people to care. Educational graphics were carefully designed to provide a subtle yet important sublayer of interpretation; for example, a replica of a weathered ibex skull encourages people to read a small sign discussing leopard diets. Messages deal with plants, habitats, animal

Visitors wander through a simulated wilderness landscape in the Himalayan Highlands exhibit.

ecology, and conservation; and a concentrated effort was involved in their writing, fabrication, and siting so that they seem to fit into the landscape.

Sculpting with Bulldozers

Because zoo biology mandates a barrier between animals and visitors, it was decided to separate the two by giving most of the woodlands to the animals and by restricting people to a winding path that leads around rocks and plantings to several viewing structures. So in one place a wood ramp was designed to bring people up to a viewing deck that cantilevers toward the woodland treetops favored by red pandas for their daytime roosting. In another spot, a blind of rough poles was built in a wild-looking, ten-foot-tall thicket of giant *Miscanthus* grass providing an open view into a marshy pond for the cranes.

In another location, the rustic underside of a Nepalese bridge provided the model for a shaded public structure at the edge of a grove of black cherry trees frequented by snow leopards. Here a gauzy screen of fine piano wire, stretched tautly vertical and dark-stained, is attached to the underside of the rustic bridge, as if emerging from the scree below. Easy to see through, especially in the shadow of the bridge, this flimsy-looking film of wire is sufficiently strong to separate animals and people. Two of the nearby cherry trunks are actually thirty-foot aluminum poles, covered with a skin of epoxy, sculpted and painted to match the living trees. These poles support a tentlike aviary of fine wire mesh that keeps the cats in the foreground where visitors can see them but is itself nearly invisible in the flickering light of a natural woodland backdrop. Near the visitors, what looks like a large flat boulder is actually fabricated of fiberglass-reinforced concrete cast from a mold taken of a real boulder. Its secret is internal heat coils, which create a warm dry perch for the cats to enjoy on wintery days.

By the careful siting of viewing places, designers could screen undesirable views and focus attention on handsome vistas deep in the woods. Painstaking attention to detail insured that such manmade elements as structural poles were hidden by rocks or plants, or disguised within the rustic vernacular architecture of Nepal. Authentic cultural details were used to reinforce the sense of place: prayer flags marked exhibit entrances, a pile of prayer stones were placed along the public path, and architectural details were painted by a Nepalese artist. When setting boulders to support rustic bridges, skilled New York masons were asked to transcend their usual professional neatness by building walls in a haphazard and unsound-looking fashion with no mortar showing, a detail that helps achieve the look of nature reclaiming human efforts.

Special efforts were made to bring in many tons of topsoil and talus and to regrade the site—where possible around existing trees—to create a rough undulating topography and multiple microclimates for new plant communities. To make Himalayan Highlands believable as a wild place necessitated developing a new attitude towards naturalistic gardening, which might be termed "wilderness horticulture." The horticultural intent was to create an Asian planting with a feeling of wildness—a landscape that did not look newly planted, or even planned at all.

The woodland site in the Bronx Zoo was chosen in large part for its existing bedrock outcrops and cool northeastern exposure. It was dominated by natural stands of oak, tulip tree, and ash, their trunks measuring up to three feet in diameter. The understory included black cherry, swamp maple, a few invading *Ailanthus*, and some previously planted flowering dogwood. Although American rather than Himalayan species, most were kept to enhance the final exhibition by providing not only important shade for the animals but also a sense of scale and timelessness. Fortuitously, these genera have close relatives that form part of the Asian forest.

Hardy Himalayan Plants for New York

Finding authentic, hardy Himalayan plants was no easy task. The results of an exhaustive search of stock available from American

The graceful habit of Cedrus deodara, *an important feature in the Himalayan Highlands exhibit. Photo by Rácz and Debreczy.*

nursery catalogues were cross-referenced with research into the flora of sites in Nepal, Tibet, or South China that might serve as a model for Himalayan Highland's planting list. Nepal was initially favored, especially oak woodland sites near Annapurna, as ideal for this project because of the remnant presence of both snow leopards and red pandas, plus the distinctive beauty of local cultural artifacts. However, since New York's winter climate is harsher than that of much of the Himalayas and since hardy Nepalese plants (especially in large sizes) are relatively scarce in nurseries, a decision was made to expand to a generalized plant list of Sino-Himalayan flora, with a sprinkling of North American analogs. This compromise was necessary to achieve the proper sense of scale and the desired effect. For example, it was frustrating to envision the dappled shade of a spectacular grove of white-barked *Betula jacquemontii* from Asia when plants here were only available in one-gallon pots. To achieve the immediate effect of mature birch groves required the substitution of non-Himalayan species.

In spite of frustrations, a remarkable number of hardy Asian plants could be located, sometimes in sizes large enough to plant on a site accessible to the public. More than a dozen deodar cedars over fifteen feet tall were located in a mid-Atlantic nursery. Other appropriate woody plants included *Callicarpa bodinieri*, *Acer griseum*, *Hippophae rhamnoides*, *Pieris japonica*, *Potentilla fruticosa*, *Mahonia bealei*, *Cotoneaster salicifolius*, *Viburnum* ssp., *Sarcococca hookerana* var. *humilis*, and *Hydrangea*. Large clumps of bamboo (*Phyllostachys aureosulcata*) were transplanted from Long Island. Herbaceous goatsbeard (*Aruncus dioicus*), bugbane (*Cimicifuga simplex*), and geranium (*G. himalayense*) were deemed tough enough to survive and eventually may be joined by temperate aroids and other specialties.

A number of especially desirable plants posed special problems. The fabled blue poppy (*Meconopsis betonicifolia*) was considered too intolerant of New York summers to warrant initial planting, but seeds of it have been obtained for experiment in a cool niche. Few of the true Himalayan wild "species" rhododendrons, so distinctive of Asian forests, are hardy enough. Some were tried (including *Rhododendron campanulatum*, *R. campylocarpum*, *R. forrestii* var. *repens*, *R. nivale* ssp. *boreale*, and even *R. cinnabarinum* and *R. barbatum*) and managed tentative footholds in protected locations, but could not be relied upon for mass effect. Consequently, several locally hardy rhododendron hybrids had to be used. Forms were chosen that are not immediately recognizable to most people (to avoid connotations of suburbia) or that have relatively small flower trusses similar to the wild species. Several good-sized plants of the white-flowered hybrid 'Dora Amateis,' with one Himalayan parent (*R. ciliatum*), were donated. A few plants of the North Asian *R. mucronulatum* 'Cornell Pink' were included for their unexpected sparkle early in spring and their willowy forms reminiscent of Himalayan lepidote thickets.

The marvelous tree-sized blood-red *R. arboreum* that so impressed explorers in the early twentieth century would have been an appropriate and spectacular plant for the Himalayan Highlands exhibit, especially as their groves are now being decimated by firewood gatherers in Nepal and elsewhere in Asia. *R. arboreum* is, however, impossibly tender for New York winters, so large plants of the dark currant-red Consolini/Dexter hybrid 'Francesca' were substituted, chosen for their distinctive color and upright stature. Planted on berms, someday these red-flowered trees may arch over visitors' heads as the true *R. arboreum* does in Asia.

Crucial Wilderness Planting Details

Since the intent was not to create a garden but to recreate a wild place, care was taken during installation to site plants in appropriate places and with correct associations and to space them irregularly. Where possible, larger-sized plants were located in the center of a cluster to replicate natural growth patterns.

Bamboo and magnolia fit naturally together on lower portions of the site, with fir and low-

Seeing snow leopards in a green environment enhances the quality of the interaction between visitors and animals.
© *New York Zoological Society Photo.*

growing rhododendrons on the rocky promontories. To suggest "krumholtz" wind pruning, distinctive of treeline firs, the team even discussed sandblasting lightly the northwest side of some plants. This idea was rejected, only because of the inappropriateness of this windblown look under overtowering oaks.

Much of the site was heavily bermed to exaggerate the roughness of the topography and to screen visitors' views of one another. The zoo's own aged manure was used liberally in the topsoil mix to retain moisture, especially on slopes. While grounds keepers of most gardens and public parks carefully remove dead vegetation, old gnarled stumps and deadfall were purposefully incorporated into the plantings to make this site seem wilder. All visible saw-cut ends were buried or disguised by "aging." Deadfall limbs were carefully sited among new plantings both for natural effect and to form low barriers to discourage people from wandering from paths. Not only were spacings between plants purposefully irregular but understory trees were planted at tilted angles to suggest their reaching for light. Plants with uneven shapes were obtained from nurseries in preference to symmetrical plants (undoubtedly to the delight of the local nursery). Where "saucers" of bark mulch were built around recently installed plants to facilitate watering, these regular forms were disguised with dead leaves. Much of the site, including mulched areas, was seeded irregularly with a fine-textured, "uncut" red fescue. On an irregular terrain, this clumping grass cover was effective in helping to disguise a newly planted look, to unify the massings of plants visually, and to enhance the impression of naturalness.

While not needing the maintenance typical of many public displays, Himalayan Highlands does require eyes trained in naturalistic horticulture. Weed species need to be recognized and removed. Pruning needs to be

People in an elevated viewing area can observe a red panda in the trees only a few feet away; the native forest lies beyond.

discreet and done with knowledge. The comparatively unorthodox beauty of a tuft of brown grass in winter needs to be recognized, appreciated, and left untouched, while a viburnum branch needs inconspicuous pruning when crowding a neighboring fir. Unlike a static museum exhibit, a planted site is a living place—its continual change creates new horticultural opportunities but also necessitates constant, subtle observation.

Certain species, such as the bamboos, are now maturing sufficiently to allow thinning for fresh browse for bamboo-eating red pandas. Other species require replacement, such as the initial short-lived plantings of American birches. The project will never be "done." Indeed, the goal is that, over time, the analogous North American plants will be replaced by more authentic Himalayan species. While the exhibit needed to look established when it opened, it is also a living place that can develop and change.

Exhibits to Encourage Saving the Wilderness

The Himalayan Highlands exhibit is both a subtly complex and popular place for visitors but, as an experiment in environmental "immersion" and "wilderness horticulture," it is not unique. In the Bronx Zoo alone, Himalayan Highlands is joined by huge new wild habitats where visitors can wander through an extensive and dramatic Asian rain forest, visit a rhino wallow, or a sparse African alpine habitat. Serious commitments to expansive landscape replication and specialized horticulture are now found in several American zoos aided by the recently formed American Association of Zoological Horticulture. We are witnessing a world with its wild lands and biological diversity fast disappearing and with its scarce refuges becoming increasingly insularized, inadequate, and degraded. The rate of tropical deforestation has recently accelerated to one hundred acres each minute. To try to combat the losses, zoos now are changing rapidly in order to become more effective sanctuaries.

While public interest in zoos has burgeoned and awareness of environmental destruction has increased, the idea of building educational wilderness immersion exhibits to reveal the beauty and ecology of wild places does not need to be the sole province of zoos. Imagine a botanic garden encouraging visitors to wander through a moody, beautiful, Carboniferous swamp forest of giant horsetails, cycads and tree ferns, along with an occasional primitive reptile. A huge greenhouse nearby could shelter a spectacular arid southwestern Madagascar spiny forest, complete with eroded stream beds for people to explore, as well as baobabs, rare tortoises, and marvelously specialized endemic flora.

To lobby effectively for wild places, we must make their values evident. If we cannot actually bring thousands of people to primitive tree fern forests, montane Ethiopia, or a vanishing Himalayan forest, we do have the ability to convey some of the fascination and beauty of those places here. The words of the Senegalese philosopher Baba Dioum succinctly express this intent:

> In the end, we will conserve only what we love.
> We will love only what we understand.
> We will understand only what we are taught.

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Landscaping for Realism: Simulating the Natural Habitats of Zoo Animals

Donald W. Jackson

In Atlanta, Georgia, horticulturists have created the illusion of a West African rain forest and an East African savanna with hardy, woody plants.

What does a horticulturist or landscape architect strive to attain when choosing plants for a naturalistic animal exhibit in any major zoo? Should visitors come upon bananas and tropical figs complementing an exhibit featuring giraffes or zebras that naturally roam the hot, arid Serengeti? Let's hope not. Likewise, they should not be confronted by trees that resemble the acacias of arid Kenya and Tanzania in a lowland gorilla exhibit.

In order to simulate a particular geographical area as closely as possible, zoo horticulturists must have a thorough knowledge of the region's overall geology, climate, economy, and social customs—all critically important for installing an appropriate habitat for zoo

Lowland gorilla in the African rain forest exhibit at Zoo Atlanta.

The lush feeling of the Ford Tropical Rain Forest at Zoo Atlanta.

animals. To create a lowland gorilla habitat in Zoo Atlanta, our goal was to gather as much information on the region as possible in order to simulate its home convincingly.

Simulating Tropical Rain Forests

What botanical characteristics tend to dominate the lush rain forests of Cameroon, West Africa, the home of the lowland gorilla? If we think back to our childhood and recall old movie footage of Tarzan, numerous lianas or tropical vines probably come to mind, a fairly accurate representation of the flora of the region. Brief but frequent rains and high humidity also characterize tropical areas in Cameroon as well as similar areas throughout the world, and the rain forest canopy has more levels or strata than we are familiar with in the deciduous woodlands of eastern North America.

The tremendous diversity of animal life strikes anyone who has seen or read about a tropical rain forest. An almost unimaginable array of mammals, amphibians, reptiles, birds, fish, and especially insects lives in the tropics—a great number of which scientists have yet to describe. Although the variety of plant life is equally diverse, many plants have certain features in common, such as large leaves with a relatively smooth, waxy upper surface and long "drip tips," two features that help shed excessive rainfall in the humid tropics. In contrast, species native to the Serengeti and other arid regions tend to have small leaves that help them conserve as much precious moisture as possible through reduced transpiration.

The ideal method of landscaping a naturalistic exhibit of animals from tropical regions is to use exclusively those plant species that are native to tropical forests. To be truly accurate, only flora indigenous to Cameroon, West Africa, should be used to landscape a lowland gorilla enclosure, and only those plants that grow in the rain forests of Borneo and Sumatra should be selected for an orangutan exhibit.

Although such choices would be optimum, this goal is obviously not realistic. Since very few American zoos are located in climates without frost, such an endeavor would make little sense in an outdoor exhibit. Even in an indoor exhibit, the costs of obtaining native plants both for the initial landscaping and for replacements over the long term—even if it were possible to procure them—would be prohibitively expensive.

However, even when we substituted non-native material in our lowland gorilla complex at Zoo Atlanta, well over $40,000 worth of non-hardy tropical plants were used outdoors, including up to 20-foot-tall scheffleras, 16-foot-

The foliage of Magnolia macrophylla, *the bigleaf magnolia, at the Arnold Arboretum. Photo by Rácz and Debreczy.*

tall areca palms, and countless numbers of philodendrons, anthuriums, and bananas. These plants are overwintered in large polyhouses and simply add a tropical flair to the exhibit during the warmer months. They must be viewed as "icing on the cake," however, since the real horticultural backbone of nearly any zoo exhibit is made up of cold-hardy species and cultivars that *simulate* the indigenous flora of the animal's native habitat.

Temperate Trees with a Tropical Look

The large, glossy evergreen leaves of the southern magnolia (*Magnolia grandiflora*) resemble the foliage of a number of tropical species, especially figs, quite effectively. A number of other magnolias are frequently used by zoo horticulturists to simulate the world's tropical habitats. The bigleaf magnolia (*M. macrophylla*) and the umbrella magnolia (*M. tripetala*) are both superb simulators with their extremely large leaves. Those of the bigleaf magnolia measure two to three feet in length; those of the umbrella reach one to two feet. An added bonus is the huge flowers, produced in early summer; those of the bigleaf magnolia can grow to over twelve inches in width; those of the umbrella reach from seven to ten inches.

The biggest deterrent to using either of these two species to create a tropical-looking landscape is not their appearance but their poor availability within the nursery trade. Because their coarsely textured foliage makes them difficult to incorporate successfully into either a residential or commercial landscape design, few nurseries grow either the umbrella or bigleaf magnolias. And those that are avail-

The attractive compound foliage of Rhus typhina, *the staghorn sumac. From the Archives of the Arnold Arboretum.*

Aralia elata *in full bloom at the Arnold Arboretum. Photo by Rácz and Debreczy.*

able in nurseries are usually only an inch or so in diameter and at best six to eight feet in height.

Two other magnolias valuable for simulating a rain forest environment are the sweetbay (*M. virginiana*) and the cucumber tree (*M. acuminata*), with leaves that can reach ten inches in length and bearing a reasonably long "drip tip." The sweetbay is readily available; its glossy leaves and fragrant flowers are highly attractive but unfortunately do not grow as large as those of most other magnolias. The cucumber magnolia is much harder to locate although, with persistence, large specimens can be found in the fields of old wholesale nurseries. My experience with the cucumber magnolia corroborates the general opinion that it is difficult to transplant.

Two additional members of *Magnoliaceae* often used in a simulated rain forest exhibit are the native American tulip tree or tulip poplar (*Liriodendron tulipifera*) and the Japanese anise tree (*Illicium anisatum*). The flowers of the tulip poplar are particularly appealing in that they have a delectable fragrance of vanilla and green and orange coloring. Unfortunately, they are not produced in quantity until the tree reaches the age of fifteen years or more, and a height of twenty to thirty feet.

Among the best of the cold-hardy plants for use in simulating the tropical rain forest are the empress tree or royal paulownia (*Paulownia tomentosa*) and the northern catalpa (*Catalpa speciosa*). The paulownia is particularly fast-growing and, like the catalpa, boasts very large heart-shaped leaves and tropical-looking flowers. Neither of these species is much sought after for planting in the home landscape or as street trees, so both are rather difficult to locate in large sizes within the nursery trade. Likewise, the ailanthus (*Ailanthus altissima*) with its large pinnately compound leaves remains a good choice for the zoo horticulturist striving to introduce a tropical flair to the landscape.

The long pinnately compound leaves of the smooth sumac (*Rhus glabra*) and staghorn sumac (*R. typhina*) make these species possible candidates for use in rain forest habitats. Both grow exceedingly fast and, except for the cut-leaf varieties, are not frequent components of the home landscape. The lantanaphyllum viburnum (*Viburnum x rhytidophylloides*), hardy rubber tree (*Eucommia ulmoides*), devil's walking stick (either *Aralia spinosa* or *Aralia elata*), and cultivars of the common rose mallow (*Hibiscus moscheutos*) are other hardy plants that can effectively simulate the atmosphere of tropical rain forests.

The various species of temperate bamboos, particularly within the genus *Phyllostachys*, can be extremely important in habitat exhibits. In general, they are available from wholesale nurseries in sizes and quantities sufficient to meet the demands of landscaping large exhibit areas, and their cold-hardiness is greater than many horticulturists realize.

While the leaves of the white mulberry (*Morus alba*) are the food of silkworms, the fruitless (male) cultivars are valuable to the zoo horticulturist not only for their vigorous growth and spreading form but also because their foliage provides an excellent browse for many zoo animals from colobus monkeys to giraffes.

Willow (*Salix* sp.) is another multi-purpose plant for the zoo horticulturist. Although the leaves are not particularly large, their long narrow shape somewhat simulates the foliage of the bamboos characteristic of tropical areas. Branches of small diameter can simply be cut in early spring and stuck into moist soil where they quickly take root. These willow saplings soon form impressive thickets that can be easily and cheaply used to screen unsightly vistas or to hide the backs of small buildings. As the willows continue to mature and become too tree-like, they can be thinned out to keep the colony dense and shrubby. Like white mulberry, the leaves of willow are an excellent source of browse for many zoo animals and, with their fast growth, they can be frequently harvested for this purpose.

Creative Methods for Simulating a Rain Forest

As mentioned, vines or lianas are very important components of the world's rain forests. We found one of the best vines to use to simulate Cameroon, West Africa, is the trumpet vine (*Campsis radicans*) with its long tubular, two-inch-wide flowers and rampant growth. Its blooms can range in color from scarlet to orange or even yellow, depending on the cultivar; its Zone 4 cold hardiness allows it to be planted in most zoos throughout the country. The trumpet vine's large pinnately compound leaves, along with its wide availability, make it a first-rate choice to simulate the tropical habitats of many diverse animals—from a shy tapir to an agile and inquisitive siamang.

Although a wide variety of vines, ranging from the sweet autumn clematis (*Clematis paniculata*) to the Chilean jasmine (*Mandevilla laxa*), can be used by zoos located in more southern climates, some of the best vines are just not available in nurseries. As a substitute, the simple stringing of dead grapevines throughout the trees can give an amazingly realistic effect to a rain forest exhibit. Also the strategic placement of deadfalls and brushpiles along public walkways can dramatically add a touch of authenticity to a rain forest exhibit.

At Zoo Atlanta, a dead twenty-two-inch-caliper southern magnolia—with a wide multi-branched crown—was hoisted up by crane, and a portion of its lower trunk simply "planted" in concrete near one of the exhibit's main animal viewing areas. The tree had died a number of weeks before, but we used it to help convey an image of the struggle of life and death in the forest. More important, the use of deadfalls and brushpiles—when combined with interpretive graphics—depicts the destructive effects of slash-and-burn agriculture within the world's tropical rain forests and can provide an educational message regarding the wise use of our world's natural resources for visitors of all ages.

The flowers and foliage of Albizia julibrissin. *From the Archives of the Arnold Arboretum.*

Simulating the East African Plains

In addition to the tropical rain forests, another environment that affords the zoo horticulturist a challenge is that of the plains of Kenya and Tanzania in East Africa. The plants used to simulate the authentic habitat of giraffes, lions, zebras, elephants, and fleet-footed Thomson's gazelles look much different from those chosen to complement a lowland gorilla or a white-handed gibbon exhibit.

Unlike tropical plants with large leaves and "drip tips," the trees and shrubs that a zoo horticulturist would choose to depict the plains of Kenya and Tanzania would almost all have thorns or spines and small leaves to simulate the native flora's need to conserve water. Species and cultivars of selected ornamental grasses would also be appropriate, as are associated landscape features, such as artificial termite mounds.

Simulating East African acacias is most often accomplished in zoos by planting broad-crowned, irregularly shaped honey locusts (*Gleditsia triacanthos* var. *inermis*) and removing the lower branches to make them appear to have been browsed. Like those of the honey locust, the small leaflets of the mimosa (*Albizia julibrissin*) make it an excellent simulator of the acacias of the Serengeti. Although seldom recommended for the home landscape for a number of reasons, its broad-spreading crown provides unique opportunities to zoo horticulturists.

In the southeastern United States, the yaupon holly (*Ilex vomitoria*) is a common and often overused plant in the general landscape. Although its small leaves are valuable in simulating an arid environment, the form of specimens sold in nurseries is seldom very natural in appearance. We were fortunate

*Large naturalistic yaupon holly (*Ilex vomitoria*), intentionally planted on an angle, in the Masai Mara East African Savanna Exhibit.*

enough to locate some very large and overgrown yaupons growing in the back corner of a large wholesale nursery, and they are now one of the premier focal points of Zoo Atlanta's new East African plains exhibit.

The two- to three-inch thorns of the cockspur hawthorn (*Crataegus crus-galli*) also make it a valued addition to any exhibit housing lions, zebras, giraffes, and similar animal species. While its thorns are very realistic, they are also potentially dangerous, particularly to small children. The use of this hawthorn in a zoological landscape is, therefore, restricted to areas that can be easily seen and appreciated but are totally inaccessible to both the animals and the visiting public.

The following list of plants will help zoo horticulturists simulate the arid plains of Kenya and Tanzania: Adam's needle (*Yucca filamentosa*); small soap weed (*Yucca glauca*); Russian olive (*Elaeagnus angustifolia*); Japanese barberry (*Berberis thunbergii*); Siberian pea shrub (*Caragana arborescens*); Warminster broom (*Cytisus x praecox*); pampas grass (*Cortaderia selloana*); ravenna grass (*Erianthus ravennae*); Chinese pennise-

NEWS

FROM THE ARNOLD ARBORETUM

ARBORETUM A WINNER AT SPRING FLOWER SHOW

Lilacs bloomed in March when the Arnold Arboretum presented a display focusing on the diversity of lilacs at the Massachusetts Horticultural Society's Spring Flower Show. Since lilacs are rarely shown as forced plants, the exhibit drew applause from both the public and judges. On opening day it received the Ruth S. Thayer Prize, the Massachusetts Horticultural Society's $1000 cash prize, a Silver Medal, an Educational Award, and a Cultural Commendation.

One of the premier awards in the show, the Ruth S. Thayer Prize, was given for the Arboretum's presentation of *Syringa vulgaris* 'Frederick Law Olmsted.' In keeping with the rules of the award, this free-flowering, lightly scented white lilac has not yet been introduced commercially. A seedling of 'Rochester' with a globose habit, 'Frederick Law Olmsted,' was selected by Richard (Dick) Fenicchia, formerly Park Superintendent, Highland Park, Monroe County Parks Commission, Rochester, New York.

The Arboretum's Chief Plant Propagator and resident lilac specialist, Jack Alexander, won high praise from both experts and the public for achieving the "impossible" in forcing the plants for opening night.

New Englanders are known for having a great affection for lilacs — witness the crowds that visit the Arboretum each Lilac Sunday (May 20, 1990!). Peak visitation of 43,000 is said to have been reached in 1941. But during their ten-day appearance at the show more than 180,000 visitors had an opportunity to look, sniff and "select" their favorites. The exhibit included some of the classic French hybrids ('Mme Lemoine,' 'President Grevy') as well as the eye-catching *Syringa vulgaris* 'Sensation' with its picotee edging of white on the purple blossoms. *Syringa x prestoniae* 'Charles Hepburn' and *Syringa x chinensis* added tones of warm mauve-pink. Two "standard" *Syringa meyeri* 'Palibin' marked the entry to a rustic pathway and a small weathered bench surrounded by *Syringa patula* 'Miss Kim'.

During the ten-day run of the show lilacs and other plants were monitored, groomed and changed on a daily basis. The efforts were rewarded with the prestigious Arno H. Nehrling Award, judged on Thursday and presented "to the exhibitor who executes an original design, who stages a display of excellence, who sets up on schedule, and maintains the exhibit in top condition throughout the Show."

The Arboretum thanks Kurt Tramposch of Weir Meadow Nursery and Dale Chapman for assistance in obtaining plants, Chris De Rosa for the loan of stone, and David Kersey for the teak bench. The exhibit was designed and coordinated by Nan Sinton and Jack Alexander with much help from all the Arboretum staff and volunteers.

CHINESE PENJING AND JAPANESE BONSAI

Despite the fact that the Chinese originated the concept of miniaturizing trees in containers over 1200 years ago, most Westerners are familiar with this absorbing form of gardening only by way of the much younger Japanese bonsai. For a variety of historical reasons, distinctive penjing styles are virtually unknown to Americans.

Mr. Hu Yun Hua. Photo by Peter Del Tredici

The Arnold Arboretum, which has recently acquired ten specimens of penjing from China, is honored to have the opportunity to present a lecture/demonstration on penjing styles and techniques by Mr. Hu Yunhua, a leading connoisseur and practitioner of the ancient art. Among his publications, *Chinese Penjing, Miniature Trees and Landscapes*, and *Penjing the Chinese Art of Miniature Gardens* have been translated into English.

This one-of-a-kind event will be held on **Friday, April 27, from 6:30 to 8:30 at the Hunnewell Visitor Center.** The fee is $15 for members and $18 for non-members.

On Tuesday, April 10 from 3:30 to 4:30 at the Hunnewell Visitor Center, Arboretum staff member Peter Del Tredici will present a slide-lecture on the history of the Larz Anderson bonsai collection, the oldest in North America. The lecture will be followed by a rare behind-the-scenes tour of the collection. The fee is $8 for members, $10 for non-members.

THURSDAY EVENING LECTURES

Gardens of America, Thursday. April 12, by Diane Kostial McGuire.

From the simple herb gardens of New England colonists through the imposing gardenesque designs of the Victorians to contemporary California outdoor rooms, this slide-lecture will illustrate the themes inherent in an astonishing range of American garden visions and their relationship to the cultural patterns of their times.

Mixing It Up in the Mixed Border. Thursday, April 19, by Elsa Bakalar.

Creating a long-blooming "mixed border" entails going beyond the familiar range of plants. While perennials are the backbone of the summer garden, the adventurous gardener goes a step further and introduces summer bulbs and unusual annuals to give a range of color in flower and foliage and keep a garden glowing into the fall.

Plant Hunting in Kashmir. Thursday, April 26, by Christopher Chadwell.

This lecture on the woody plants, perennials, and alpines of Kashmir will include cultural as well as botanical information about this beautiful part of the world by a knowledgeable and well-travelled botanist.

All lectures are open to the public and will be held at the Hunnewell Visitor Center from 7:00 to 8:00 PM. The fee is $12 for members and $15 for non-members.

THE RHODODENDRONS ARE COMING

The Massachusetts Chapter of the American Rhododendron Society will be hosting the annual National Convention at the Tara Hyannis Resort and Hotel from Wednesday, May 30 through Sunday, June 3, 1990.

The theme of the convention is "Rhododendrons for the 90's: The Northeast Perspective," and will feature hardy, adaptable plants with attractive foliage, improved color, and an extended blooming season. The Convention will offer numerous tours, lectures, and workshops, a flower truss show, and a plant sale. Additional information may be obtained from Anne Reisch at (508) 371-0755 after business hours.

TWO NEW BOOKS AVAILABLE

The Arnold Arboretum Plant Inventory

"New and improved, updated and easy to use" may sound like advertising copy, but it serves to describe the recently published Plant Inventory. A major revision of the inventory of plants in the Arnold Arboretum collection has been made from the recently completed computerized plant records data base. Each plant in the Inventory now is listed:

- alphabetically by scientific name
- in clear, readable type
- with an indication of collection in the wild
- with Arboretum map coordinates

This edition, three times the size of the previous *Arnold Arboretum Plant Inventory,* contains a wealth of information about the approximately 6,000 taxa that make up the Living Collections of the Arboretum. It also includes an index of common names and a grid map for locating plants on the grounds. The cost is $21.00 including postage and handling within the United States. Foreign orders with payment in U.S. funds should add $4.00 per book. Send orders to: The Bookstore, Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130.

Flora of the Lesser Antilles

The Arnold Arboretum is proud to announce that the six-volume *Flora of the Lesser Antilles,* a long-term project of Dr. Richard A. Howard, formerly Director of the Arnold Arboretum and recently appointed Vice-President for Science, New York Botanical Garden, are now available.

These six volumes constitute the first comprehensive flora of the area, presenting a keys to genera as well as species. For each genus and species a complete modern description is given which includes color as well as measurements of floral parts. The descriptions are followed by a listing of each plant's general distribution as well as a list of its distribution within the Lesser Antilles. All volumes are profusely illustrated with line drawings that are both highly artistic and accurate. All known species reported from the Lesser Antilles, both introduced and native, are included.

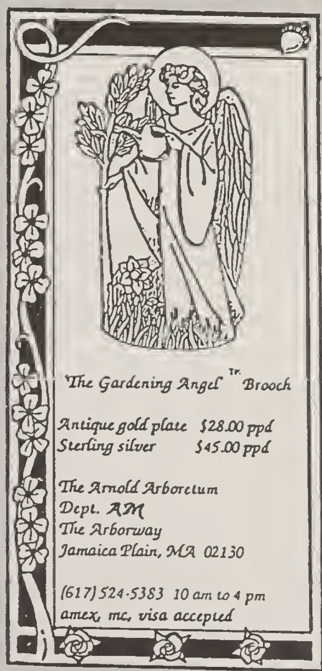
All volumes in the series are available, either individually or as part of a full set, which is available at the special price, including shipping, of $260 (add $5 for shipping outside the US). For volumes 4, 5, and 6 only, the special price is $205.

Vol. 1. *Orchidaceae*	$20
Vol. 2. *Pteridophyta*	$25
Vol. 3. *Monocotyledoneae*	$35
Vol. 4. *Dicotyledoneae,* 1	$75
Vol. 5. *Dicotyledoneae,* 2	$85
Vol. 6. *Dicotyledoneae,* 3	$85

Checks should be made payable to the Arnold Arboretum andall orders should be addressed to the attention of: Frances Maguire, Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130

BOOKSTORE OFFERINGS

The recently expanded Bookstore wants to remind all members of their benefit in taking advantage of their 10% discount. Realizing that many members are out of state, we will offer book and other merchandise selections via the *Arnoldia* insert. They will include new publications and products developed especially for the Arboretum. Your purchases help support the Arboretum and its programs.



TREE CHEERS FOR KIDS AN ARBOR DAY EVENT

To herald the coming of spring, and as part of a tradition of tree planting, the Arboretum will hold its annual Arbor Day celebration on Sunday, April 29. Winning elementary school poets who have been selected from among this year's Tree Cheers for Kids poetry contestants will be present to read poetry at the tree-planting ceremony. "Billy B.," the talented natural science song-and-dance man, will host this engaging ceremony that honors the bond between children and their feelings and imaginings about trees. These events, which will begin at 2:00 p.m., will be followed by Billy B. in concert performing such now-famous songs as "The Rock and Roll of Photosynthesis."

A variety of other activities will occur throughout the day including vegetable and fruit printing, talks with a state forester, tree-seed planting in take-home containers, tree games, and visits from urban wildlife.

If you would like to be involved as a volunteer for part of the day, please contact Diane Syverson, Children's Program Director, at (617) 524-1718.

1988 Arbor Day poetry contest winner, Julia Turner, helps plant a tree at the Arnold Arboretum

PARKS DEPARTMENT AND ARBORETUM WORKING TOGETHER

The following memorandum was recently issued by Lawrence A. Dwyer, commissioner of the Boston Parks and Recreation Department.

The 1000-year lease the Parks and Recreation Department has with the Arnold Arboretum constitutes the oldest park partnership in the City of Boston. Under the terms of the lease the Arnold Arboretum is responsible for the "living collection" as well as buildings. The Parks Department is responsible for the infrastructure—the roads, drainage, walls, etc.—and safety.

We enjoy a good relationship with the Arnold Arboretum. The Boston Park Rangers, begun as a program in the Arnold Arboretum, continues to be in strong evidence and make contributions there. Our Maintenance Unit helps with routine maintenance such as the repair of benches. And, for the first time in recent history, under the initiative of the Major's capital plan for the city, we have been able to allocate funds for some capital repairs.

In 1989 $100,000 was spent on the Walter Street wall. At the community meeting in which this decision was made, the need for repair paving of the much travelled Bussey Hill road and sidewalks as well as drinking fountain repairs was articulated. This fall I met with the Director of the Arnold Arboretum, Dr. Robert Cook, and this need was again brought to my attention. The Parks Planning and Development unit has examined the full range of needs determined by a master plan written by the Arnold staff and feels this is an appropriate project. As a result of this and my discussions with Dr. Cook, I have asked that bid documents be prepared and work begin on this project. I thank you for your continued interest in the Parks and Recreation Department and the Arnold Arboretum.

If you have any questions please contact Victoria Williams at 725-4505.

tum (*Pennisetum alopecuroides*); maiden grass (*Miscanthus sinensis* 'Gracillimus'); eulalia grass (*M. sinensis*); and hardy orange (*Poncirus trifoliata*).

Toxicity and Other Constraints

Whether it be the simulation of a rain forest in tropical West Africa, the arid plains of Kenya and Tanzania, or some other region of the world, zoo horticulturists are constrained in many ways in their efforts to create the "natural" habitat of a specific animal. For example, oleander (*Nerium oleander*), commonly seen in gardens throughout the deep South, is not used in a zoological setting because of its toxicity. Likewise, while some plants may be difficult to locate in the nursery trade, others are impossible to obtain except through professional contacts at arboreta or botanical gardens. One example that comes readily to mind is the Chinese toon tree (*Cedrela sinensis*). Few public gardens can even claim it as part of their collection, although its large pinnately compound leaves, strongly resembling those of the ailanthus, evoke a tropical feeling. While widely available, certain varieties and cultivars with variegated foliage or with crimson-colored leaves, such as zebra grass (*Miscanthus sinensis* 'Zebrinus') or the ever-popular red-leaved Japanese barberry (*Berberis thunbergii* var. *atropurpurea*), are of little use for creating a natural-looking habitat.

Animal-related damage to plants can be quite extensive if precautions are not taken. Elephants and rhinos can be particularly destructive as a result of their immense weight and strength. Both animals must always be kept well away from the trunks and lower branches of trees within their exhibits. Boulders and other large-sized barriers, such as logs, can also be strategically placed around the drip lines of trees to guard against soil compaction.

Plants must also be protected against the sheer strength of a lowland gorilla. Fiberglass tree casts can be used to protect the bark of mature shade trees within gorilla enclosures. Final texturing and coloring give the casts a realistic appearance when fitted around the tree's trunk.

Significant damage to plants can be caused by a wide range of other animals. The bark of any tree must always be protected against the sharp claws of lions or leopards. Likewise, the playfulness of tiger cubs can be particularly rough on any landscaping within their exhibit if care is not taken. Finally, in areas where ducks and geese are allowed to range freely over lawn areas, the effects of grazing and soil compaction can be much more significant than most visitors would ever imagine.

In some cases, human behavior can cause problems, as in the case of the Chinese chestnut (*Castanea mollissima*), which cannot be located near our gorilla exhibit because of its nuts. The nuts can be thrown by children, and its spiny fruit husks can present additional liabilities along pedestrian walkways. Suffice it to say that some plants that superficially appear useful in complementing an animal exhibit cannot even be considered by zoo horticulturists.

Despite its constraints, zoo horticulture has come a long way in the past decade or two in an effort to display animals in a convincing simulation of their native environments. Look closely at the types of plants used around the exhibits on your next visit to a major zoo. You may be pleasantly surprised by what you recognize.

Donald Jackson is Curator of Horticulture at Zoo Atlanta in Atlanta, Georgia.

An African Tropical Forest in Boston

Matthew A. Thurlow

The newest indoor exhibit at Franklin Park Zoo in Boston is the centerpiece for revitalization.

The "African Tropical Forest" is the newest exhibit at the Franklin Park Zoo in Boston. The object of this three-acre indoor-outdoor exhibit is to take the zoo visitor on a safari through a West African tropical forest. Each turn in the path offers a new chance to sight African wildlife in naturalistic habitats. No bars or cages separate the visitors from the animals. Moats disguised as stream beds permit unobstructed views of the animals, and strategically placed glass allows visitors to come face to face with some of the forest's more impressive animals.

The African Tropical Forest is housed in the largest free-standing building of its kind in the United States, measuring 45,000 square feet, with over 28,000 square feet of general exhibit area. The tripod support beams rise 75 feet at the apex supporting the coated white cloth roof. Artificial rockwork throughout the building was designed to provide over 75 planting beds, which hold the largest collection of tropical plants in New England. The planters are placed so that the flora will develop into a lush canopy of vegetation above the public walkways. The 150 animals may be the centerpiece of the African Tropical Forest, but it is the 3,000 plants that create the tropical-forest setting that makes the gorillas, hornbills, and bongos feel at home.

The upper level of this indoor forest is supported by fiddleleaf ficus (*Ficus lyrata*), rubber trees (*Ficus elastica*), banyan trees (*Ficus retusa*), schefflera (*Brassaia actinophylla*), fishtail palms (*Caryota mitis*), and kapoks (*Ceiba pentandra*). Many of the hundred birds flying freely through the forest have found that the upper reaches are fine places to perch. The Hadada ibis roost throughout the upper story.

To exhibit some animals, such as the pygmy hippos and yellow-backed duikers, a forest-clearing effect was required. Medium-growth plants were installed to create this effect: banana plants, bird-of-paradise, Australian tree ferns, dracaenas, and philodendrons surround these cleared areas. The giant white bird-of-paradise plants (*Strelitzia alba*) have been a great success and bloom repeatedly to the delight of zoo visitors.

Throughout the entire building, a lush understory planting features elephant ears (*Alocasia sanderana*), ginger (*Zingiber officinale*), heliconias, and many fern species. Where streams from the waterfalls flow, umbrella plants (*Cyperus alternifolius*), Egyptian paper plants (*Cyperus papyrus*), walking iris, and bamboos were planted. Epiphytes, or air plants, hang from the rock faces and trees. Creeping figs (*Ficus pumila*) are rapidly growing out of any crack or crevice in which they can get a roothold.

A Developing Ecosystem

The plants in the African Tropical Forest were installed in 1989, one year ago. Since that time many interesting changes have been noticed. Most rewarding is the tropical forest ecosystem that is developing. With the thickening of the forest canopy, light to the under-

A lowland gorilla in its tropical habitat at Metroparks' Franklin Park Zoo.

story is being reduced, creating a mosaic of microclimates. Just as in an actual tropical forest, the plants compete for access to the light. In open areas where light is more intense, the plants grow and spread at their own rate. In the shaded areas, shade-tolerant plants have overtaken other species. The vines (*Tetrastigma voinieranum* and *Clerodendrum thomsoniae*) planted in the forest floor are beginning to creep up the stalks and trunks of other plants to fill in the gaps in the canopy.

Certain trees partially defoliate in response to the reduced levels of light. Part of the routine maintenance inside the pavilion is the selective pruning of the trees to allow more light to reach the lower areas. Care is taken in the pruning to make sure that the trees maintain their natural appearance. The birds in the forest help in this endeavor. In landing on perches that will not support their weight, the birds break off branches in a random pattern.

Pest control presents special problems in the controlled environment of the African Tropical Forest. Normal means of control, such as contact pesticides, systemics, or injections, are not used because of their toxicity to the animals. In general, infested plant material is cut off and removed immediately. Insecticidal soaps are used widely because they are nontoxic to the animals.

Predatory insects are also being used on an experimental basis, with some noteworthy surprises. To combat the spread of aphids, 150,000 ladybird beetles were released within the pavilion. The aphids, which are deleterious to the plants, produce a honeydew on which ants feed. The forest's resident ant population has begun to protect the aphids from the beetles. The symbiotic relationship that has developed between the ants and the aphids is yet another reminder that the forest is a living, evolving ecosystem that humans cannot always control.

Matthew A. Thurlow is the Director of Landscape Design and Maintenance for MetroParks Zoos in Boston and Stoneham.

The Arnold Arboretum in Winter
A Photo Essay

István Rácz and Zsolt Debreczy

Pinus pungens, *the Table Mountain pine*

Miscanthus sinensis *by the pond*

Pinus mugo *and Roxbury pudding stone near the old dwarf conifer beds*

The legume collection

Picea abies *'Pendula,' the weeping Norway spruce*

The tracks of skiers and hikers among the lilacs

The pictures in this essay were photographed on ORWO NP 15 and NP 22 film using a Pentacon Six camera, both made in East Germany.

Why Do Rhododendron Leaves Curl?

Erik Tallak Nilsen

A physiological ecologist looks at the significance of temperature-sensitive leaf movements in Rhododendrons.

For more than two hundred years, the genus *Rhododendron* has been a focal point for scientists and horticulturists. During the mid-nineteenth and early-twentieth centuries, a fascination with the genus stimulated many botanists to visit its center of diversity in remote parts of Burma and China in search of new species. The renowned botanist J. D. Hooker of Kew noted the leaf curling and drooping of *Rhododendron arboreum* in his *Himalayan Journals* of 1855, and explorers such as E. H. Wilson, F. Kingdon-Ward, and R. Farrar made frequent notes on the temperature-sensitive (thermotropic) leaf movements in rhododendron. In addition, both amateur and professional rhododendron enthusiasts have made countless reports of leaf curling in various rhododendron species.

Rhododendron maximum *in winter. Photo by Rácz and Debreczy.*

Leaf movements in plants were first categorized by Charles Darwin in 1880 in his groundbreaking book *The Power of Movement in Plants.* Darwin pointed out that many plant parts, and particularly leaves, move in response to a number of extrinsic (environmental) and intrinsic (physiological) factors. The most important extrinsic factors are light intensity (phototropic), light direction (heliotropic), water content (hydrotropic), and temperature (thermotropic). The most frequently observed case of thermotropic movements occurs in plants in hot, dry environments where leaves move upward and become vertical to avoid excessive light absorption. The thermotropic leaf movements of *Rhododendron* are unusual because these movements are in response to cold temperatures and the leaves become pendent rather than vertical.

Research on the thermotropic movements of rhododendron leaves began in 1899 with the work of Harshberger. In 1933, a Japanese scientist, Y. Fukuda, studied the leaf-curling patterns of *Rhododendron micranthum*, making the important observation that its leaves could be kept from curling if he covered them with snow, thereby insulating them from cold air temperatures. Based on these observations, Fukuda concluded that the thermotropic leaf movements were correlated with leaf rather than air temperature.

My research on thermotropic leaf movements of *Rhododendron* began in 1984 with three main questions: (1) What are the specific seasonal and daily patterns of leaf movements, and how are they affected by climatic factors? (2) What is the physiological cause of thermotropic leaf movements and how does it relate to the leaf ultrastructure? (3) What is the adaptive significance of leaf movements to rhododendrons in their native habitats?

Before I began my research project, I was well aware of the popular dogma concerning the significance of leaf-curling and drooping movements, which claimed that this phenomenon was an accurate air temperature sensor. Frequently, I heard the statement: "When I look out of my kitchen window, I know how cold it is by looking at my rhodo leaves." Most authors believed that this curling served one of two purposes: either it prevented water loss in a dry winter environment where the soil water was frozen and unavailable; or it protected the leaves from damage by repetitive freezing and thawing.

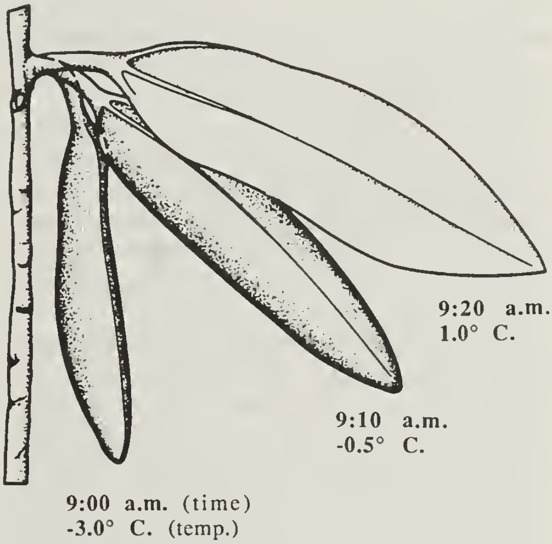


Figure 1. A diagrammatic representation of the leaf movements in Rhododendron maximum. *Changes in leaf orientation move from curled and pendent at 9:00 a.m. to flat and more horizontal by 9:20 a.m.*

Six Possible Theories

My training in plant-stress physiology allowed me to propose six possible scenarios for the adaptive significance of thermotropic leaf movements in rhododendron. I will discuss each possibility in turn, along with supportive or contradictory evidence from my research program.

Evolutionary Relict Theory. This theory is the hardest to support or refute because it is based on a long-term evolutionary perspective. Theoretically, thermotropic leaf movements could have evolved in response to climatic conditions in the geological past, perhaps during the ice ages of the Pleistocene. Current interglacial conditions differ from those that led to the evolution of these leaf movements.

Thus thermotropic leaf movements in rhododendron are a relict and have no adaptive significance to plants under the current climatic conditions.

This theory is plausible because *Rhododendron* is an ancient genus, with a fossil history extending through several glacial and interglacial periods. In addition, this species is long-lived and clonal, two characteristics that reduce the rate of evolutionary change.

One argument against the evolutionary relict theory is that those rhododendron species that demonstrate cold tolerance are those species with the leaf movements. For example, *R. ponticum* and *R. macrophyllum* show little if any leaf movement in the same garden in Virginia, and these two species are not cold hardy. On the other hand, two extremely hardy species, *R. maximum* and *R. catawbiense*, show prominent leaf movements. In addition, my experiments on the physiological causes of leaf movements clearly indicate that they require no metabolic energy and that they occur *after* complete turgor loss. Since these movements do not require energy, there is no reason why evolutionary processes would select against them.

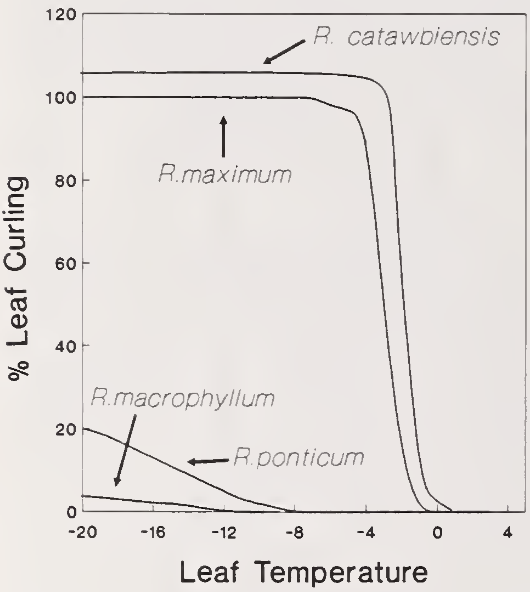


Figure 2. The relationship between leaf curling and leaf temperature for four Rhododendron *species growing in a common garden.*

Mechanical Theory. The leaves simply droop to protect themselves from mechanical damage due to the accumulated weight of rime, ice, and snow. Rhododendron leaves are subject to a considerable buildup of ice, up to 1.5 centimeters thick, during winter months. Even under these conditions, however, the leaves are tenaciously held to the branches, and I have never observed them damaged by ice buildup. Quite clearly mechanical protection is not a likely explanation for the adaptive significance of thermotropic leaf movements.

Desiccation Theory. Many reports suggest that thermotropic leaf movements are a mechanism to prevent desiccation during cold periods. In fact, until recently this has been the main explanation for the significance of rhododendron leaf movements. According to this theory, the action of curling is thought to reduce the transpiring leaf area by creating a moist microsite around the stomata of the lower leaf surface to reduce water loss and protect against desiccation.

Several lines of evidence can be brought against this theory. First, the leaf stomata are not open during cold periods. In fact, they *cannot be induced* to open during the cold months. When stomata are closed, the internal leaf water is unaffected by changes in atmospheric humidity. Therefore, leaf curling can have no impact on the leaf's water balance. The fact that there is only a very small evaporative demand placed on the leaf during cold weather further suggests that very little water is conserved by the leaf-curling behavior.

Second, the waxy cuticular layer on the upper surface of the leaf is relatively thick and effectively inhibits the flow of water through the epidermal cells. Theoretically, tension placed on the cuticle layer by curling could induce fissures in this cuticle and actually increase the loss of water from the epidermis.

Third, I have taken many thousands of rhododendron leaf-water potential measure-

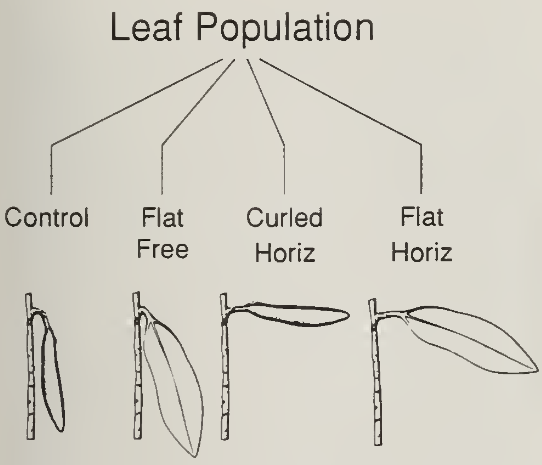


Figure 3. A diagrammatic representation of leaf treatments used to determine the adaptive significance of leaf movements in the genus Rhododendron.

ments during the winter and the summer in Virginia. These data provide no indication of water stress during the winter months. I have found that leaf-water potentials (an index of the energy in water in the leaf) are directly related to temperature. When I measure the water potential of a leaf on a cold day, then let the leaf warm up and measure again, the warmed measurement will be larger than the cold measurement even though there has been no change in the leaf-water content. This means that the low water potentials measured by other workers in the winter are not the result of desiccation, but rather the direct influence of temperature on the leaf water.

As a final point, the desiccation theory depends upon a limited availability of water from the soil as a consequence of its being frozen. The evidence does not support this notion because leaf movements in rhododendron begin months before the soil freezes. Also, the fact that leaf curling can be repetitively stimulated on detached leaves indicates no influence of the roots on the leaf curling or uncurling processes. The observation that curling fails to occur when the leaf is covered with snow further contradicts the desiccation theory. If leaf curling were dependent upon desiccation, the presence of snow on the leaf should have no impact on the response of the leaf to the lack of water moving up from the root zone.

Heat Balance Theory. The thermotropic leaf movements of many desert plants, in which the leaves move upward into a vertical position, serve the purpose of reducing leaf temperature by reducing the total quantity of light absorbed by the leaf. Thermotropic leaf movements in rhododendron are different because these movements occur in response to cold rather than hot temperatures. Leaves that are horizontal and flat have a greater exposure to the sky than those that are pendent and curled. Energy budget calculations made with a model rhododendron leaf indicate that a horizontal leaf could have a leaf temperature 3 to 6 degrees Centigrade *lower* than the air temperature while the pendent and curled leaf temperature will match the air temperature. Temperatures between −25 and −35 degrees C. are usually considered lethal to Appalachian rhododendrons. Air temperatures in the mountains frequently reach −15 to −17 degrees C., suggesting that leaf temperatures could come close to the lethal values *if leaf curling did not occur.*

Interpreting the heat balance data is further complicated by the type of canopy trees shading the rhododendron plant. The presence of a thick deciduous canopy or a moderate evergreen canopy would cut down on heat loss. One might compare the canopy to a blanket for the subcanopy plants. In several wild rhododendron populations, with and without a forest canopy cover, I forced leaves to remain flat and horizontal during the winter months. Repetitive measurements of leaf temperature throughout several nights at all sites never found more than a 4 degree C. difference between leaves with or without curling and drooping movements. Actually, only the leaves on plants without an overhead canopy showed more than a one degree difference between the flat horizontal leaves and the night air temperature. This small effect of leaf movement on leaf temperature is not likely to be significant in preventing leaf damage due to freezing. In general, the canopy over the rhododendron plants has a strong ameliorating effect on winter nocturnal leaf temperatures, and leaf movements have little to no effect in most of the wild rhododendron habitats on the East Coast.

Photoinhibition Theory. A very active field of research in plant-stress physiology is the influence of multiple environmental factors on plant physiology. One of the first case studies involved the interaction of cold temperatures and bright light on leaf physiology. These studies demonstrated that leaf cell membranes are susceptible to damage by intense radiation when they are cold. The membranes most susceptible to damage are those in the chlorophyll-rich chloroplasts. In particular, the membranes supporting photosystem-2 (a group of proteins that captures light energy and converts it to chemical energy) are most susceptible. The damage occurs during cold leaf temperatures when there are no outlets for the light energy captured by photosystem-2. In this situation the protein-membrane association between photosystem-2 and the chloroplast membranes is disturbed, resulting in a physiological dysfunction termed *photoinhibition*.

The quantity of light absorbed by the leaf during the winter is the critical determinant of the potential for photoinhibition. Irradiance conditions under a canopy of leafless trees are higher in the winter than in the summer, which means that rhododendron plants experience the highest radiation of the year during the coldest weather. Under these conditions, leaf drooping and curling act to reduce the quantity of light impinging on the leaf during the coldest temperatures, thereby preventing or limiting photoinhibition.

I tested the possibility of cold-induced photoinhibition by high light in my leaf manipulation studies. My measurements of leaf photosynthesis decreased by as much as 50 percent in leaves prevented from moving during the winter. In addition, diagnostic techniques using the interaction between light intensity and photosynthesis clearly pointed to photoinhibition as the root cause of the decrease in photosynthesis.

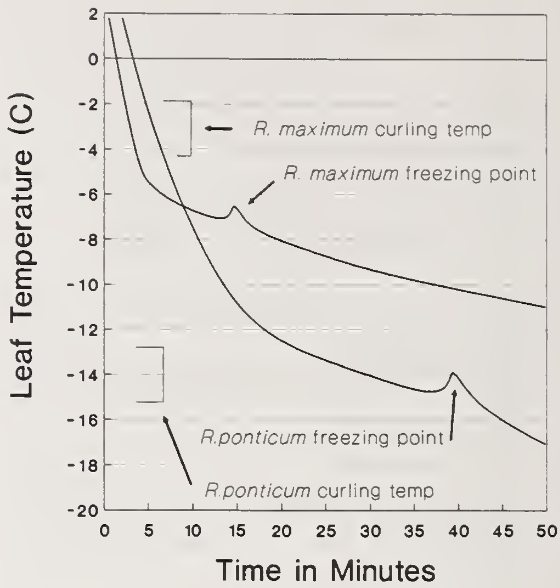


Figure 4. Thermal emission (freezing point) and the temperature range for leaf curling of Rhododendron maximum *and* Rhododendron ponticum.

During this leaf manipulation study, it was significant that leaf curling had little influence on the potential for photoinhibition. Rather, it was the drooping of the leaves that protected the leaves from photosynthetic damage. Indeed, leaf angle and leaf curling should be treated as distinct phenomenon. Leaf curling responds directly to temperature, while leaf angle responds to the water potential of the petiole. To be accurate, one should separate these movements in terms of both their physiological cause and their adaptive significance.

Freezing damage theory. Along with many others, Jacob Levitt has demonstrated that most of the damage caused by leaf freezing is a result of ice crystals piercing cellular membranes, followed by too rapid a rate of rewarming after freezing. The field of cryogenics has clearly demonstrated that tissues are best preserved by rapid freezing and slow rewarming. Leaf freezing points of rhododendron in the Appalachian mountains are −8 degrees C. on the average. Of course there is variability between species and times of the year, but this amounts to a range of less than 2 degrees C. Winter temperatures in these mountains are normally −10 degrees C. or lower. Consequently, the rhododendron leaves freeze on most evenings. Daily temperature is normally near −2 degrees C., so the leaves also thaw daily. *Rhododendron* is one of the few evergreen genera on the East Coast that has the capacity to tolerate frequent freeze and thaw cycles. Energy budget models (as well as our field measurements) indicate that horizontal flat leaves will thaw more rapidly than the pendent curled leaves. In particular, leaf curling will reduce the leaf area exposed to light and thereby slow the rate of thaw, protecting the leaf from freezing damage.

Summary

Our research on leaf movements in *Rhododendron* over the past five years has answered several questions. Leaf curling and leaf drooping are distinct behaviors with different responses to climatic factors and possibly different adaptive significances. Leaf angle is controlled by the hydration of the petiole, as affected by water availability from both the soil and the atmosphere and by air temperature. In contrast, leaf curling is a specific response to leaf temperature, and the leaf hydration state has little effect. The physiological cause of leaf curling is not well understood, but the mechanism must lie in the physiology of the cell wall or regional changes in tissue hydration.

The thermotropic drooping of rhododendron leaves most likely serves to protect them from membrane damage due to high irradiance and cold temperatures during the long Appalachian winters. In addition, the thermotropic leaf curling in *Rhododendron* may serve to prevent damage to cellular membranes during the process of daily rethawing that often occurs during the early morning. Our initial results with species comparisons indicate that leaf movements may be an important factor determining cold hardiness in *Rhododendron* species.

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Kolomikta Kiwi

Gary L. Koller

The 1990 Membership Dividend from the Arnold Arboretum.

Exceptional hardiness, vigorous growth, delicious fruit, and brightly variegated leaves are the attributes that make the kolomikta kiwi (*Actinidia kolomikta*) the choice for the 1990 plant distribution to the Friends of the Arnold Arboretum. Native to Manchuria, Korea, Japan, and northeastern China, the plant was first described by Carl Maximowicz in 1856 from specimens he collected in the northern Amur river valley of Manchuria, where the plant was called "Kolomikta or Kotomikta" by the local inhabitants.

First introduced into Europe shortly after its discovery, *Actinidia kolomikta* was growing in France prior to 1872 and reached England by 1877. The Arnold Arboretum introduced the plant into North America when it obtained plants from Lavalle Nursery in Segrez, France, in 1880 and from Veitch and Sons Nursery in Chelsea, England, in 1881. The plant has been growing at the Arboretum ever since. In Western gardens, kolomikta kiwi is cultivated primarily for its pink-and-white variegated leaves.

The variegation pattern in *Actinidia kolomikta* is both distinctive and unpredictable. The new leaves emerge green and remain so until near the time of flowering in mid-May when the youngest leaves begin to change colors. The half of the leaf adjacent to the petiole holds its green color while its distal tip first turns a light metallic green. This light green tip eventually turns white, which then becomes tinged with pink or raspberry-rose, producing a dramatic tricolored effect. Interestingly, these color changes are limited to the upper surface of the leaf, the underside remaining a uniform dull green throughout the whole process.

The upper-surface variegation generally lasts several weeks until chlorophyll production returns to normal, masking the showy colors. While both male and female plants produce colorful leaves, growers report that the male plants produce the best foliage display. This has led to the selective propagation of male plants by nurseries, and may partially explain why very few plants in cultivation produce fruit.

It is not known what function these leaf-color changes serve in nature. Peter Del Tredici, of the Arboretum staff, has speculated that they may function to attract pollinators to the flowers, which are largely hidden beneath the leaves. It may be that the bright colors function like the red bracts of the poinsettia plant (*Euphorbia pulcherrima*), which attract pollinators to the tiny flowers in their midst. From a distance, the colored leaves of *Actinidia kolomikta* make the plant look as if it is covered with showy flowers. If the plant appears this way to insects, then it may well be that the brightly colored leaves function to attract pollinators from a greater distance than the flowers by themselves could. All this is speculation, however, and field work planned for this spring at the Arboretum will determine just how closely flower production and leaf coloration are linked.

Although this plant has been cultivated in North America for over a century, gardeners have only recently considered the genus *Actinidia* as a fruit-producing crop suitable for northern landscapes. Just two or three years

The variegated foliage of Actinidia kolomikta. *From the Archives of the Arnold Arboretum.*

ago it was virtually impossible to locate kolomikta kiwi in nurseries, but now many offer it as a newly introduced plant. Unlike many other worthy species, the kolomikta kiwi was able to escape the confines of botanical gardens to reach a wider audience.

Russian Research

After a century of testing, considerable information has been gathered about this plant. It possesses exceptional cold hardiness, for it is said to be able to survive winters as low as −40 degrees Centigrade (−40 F.) in parts of the Soviet Union. Such hardiness, coupled with its ability to produce a large crop of tasty fruits 18 millimeters long by 10 millimeters wide (0.7 inches by 0.4 inches), has made it a home-gardening success in the Soviet Union. Over the years, Russian horticulturists have introduced a number of cultivars whose fruits were selected for their earliness, size, flavor, sugar, and vitamin C content, as well as for their greater ability to stay on the vine once ripe.

In 1986, a number of these Russian cultivars were imported from the Vavilov Institute Agricultural Experiment Station in Leningrad by Northwoods Nursery in Molalla, Oregon. During the spring of 1989, Northwoods shared the following cultivars with the Arnold Arboretum for evaluation: 'Aromatnaya,' 'Krupnopladnaya,' 'Matovaya,' 'Nahodka,' 'Paukste,' 'Pavlovskaya,' 'Sentyabraskaya,' and 'Urozainaya.' According to Northwoods Nursery the cultivar 'Krupnopladnaya' means "large" in Russian, and this is the cultivar with the largest fruit presently cultivated in North America. Michael McConkey of Edible Landscapes in Afton, Virginia, reports that 'Krupnopladnaya' has proved the strongest, most vigorous grower of the new Russian introductions in their area, and that it has attractive purplish winter stems.

The cultivar 'Ananasnaya Michurina,' developed by the famous Russian fruit breeder I. V. Michurin, has been represented in botanical gardens in this country for many years. The name translates as "Michurin's Pineapple" and refers to the flavor of the fruit. Michurin has written that 'Ananasnaya' was a selection from a group of third-generation *Actinidia kolomikta* seedlings raised in 1925. European growers who have seen and grown this plant believe it is probably a hybrid of *Actinidia arguta* and *A. kolomikta*. Several American growers have shortened this cultivar name to 'Anna,' a practice that is bound to lead to confusion since many will think they represent two different cultivars. These new Russian cultivars will require a few years of trial to determine how they differ from one another, and which will perform best in our climate.

Actinidia kolomikta. *Tab. 9093 from* Curtis's Botanical Magazine, *1925.*

Cultivating the Kolomikta Kiwi

Both vigorous and adaptable in its growth, kolomikta kiwi can climb to heights of fifteen meters (50 feet) in its native woodland habitat. Vines twine into the canopy of large shrubs and small trees, and then sprawl out across their crowns. The plant explorer Radde reported that the kolomikta kiwi thickets on the middle Amur were so thick that the forest was almost impenetrable. Barry Yinger, a contemporary plant explorer, reports finding this plant at high altitudes in northern Japan, in open woods of birch, spruce, and fir. It is an amazing experience, Yinger says, to encounter brightly colored leaves hugging the tree trunks in the shade of the forest. This provides us with a clue for using the plant in urban conditions. Imagine the columns used to support a porch or shed transformed into pillars of tricolored leaves.

In its native haunts, this forest plant remains in varying degrees of shade for most of the day. In dense shade, growth lacks vigor and the foliage of kolomikta kiwi stays green throughout the summer. At the edges of the forest, and near the top of the canopy where light levels are high, the distal tips of many leaves become suffused with the characteristic white and rose-pink. Yinger reports that variation in leaf color in natural populations offers future growers the opportunity to select individuals with leaf colors and patterns more distinctive than those now in cultivation. At present, the introduction of new cultivars from Japan is restricted because of *Pucciniastrum actinidiae,* a rust that infects plants in that country.

The vines thrive in full sun in northern areas, but as one moves south to areas with longer, hotter summers, plants benefit from some shade. Best growth of kolomikta kiwi occurs on well-drained, fertile loam. Once planted, young vines usually require two to three years to get established before they produce either their tasty fruits or their colorful foliage. Several growers in the South have reported that the spring growth often breaks dormancy early, only to be cut back by frost. However, the plants resprout readily and are only seldom killed outright.

Where soils are heavy or drainage is poor, this plant becomes susceptible to phytophora root rot. Mark Houston of the California Kiwifruit Commission reports that *Actinidias* are also susceptible to nematodes. Because *Actinidias* are shallow-rooted, they require mulching and supplemental irrigation during periods of drought. *Actinidias* grow best in acid soils with the pH between 7.0 and 5.0. The literature reports that roots are sensitive to fertilizers, and care must be taken with these chemicals.

Actinidia kolomikta is the slowest-growing species in the genus. In Massachusetts, annual growth is generally about one to two meters (three to six feet) with a maximum spread of three to six meters (ten to twenty feet) during a single growing season. Kolomikta kiwi also tends to produce a lighter structural framework than other *Actinidia* species, making it a good choice where growing space is limited or labor required for pruning is in short supply. This characteristic is useful to the gardener, for it allows one to construct a support structure that is more delicate and open in its detailing than those needed for most other *Actinidias*.

When the vine is grown primarily for fruit, it is better to set the plant on an arbor that one can walk beneath to facilitate the harvest. When grown primarily for foliage, kolomikta kiwi can be beautifully displayed on a lattice set directly against a wall or woven through a free-standing wire fence. It is also delightful when grown on a structure that can be seen from an upper-story window, allowing a clear view of the most brightly colored leaves.

Because of its exceptional hardiness and shallow root system, kolomikta kiwi deserves to be tested for use in containers on terraces and rooftops.

Planting for Fruit

For a fruit crop, gardeners need to keep in mind that this species produces both staminate (male) and pistillate (female) plants, and that both sexes are required for fruit set. To complicate the matter, some plants may occasionally bear flowers of the opposite sex while others are reportedly bisexual. Nurseries and fruit breeders have selected plants that are reliably male or female for more dependable crop production. A ratio of at least one

The blossoms of Actinidia kolomikta. *Photo by Rácz and Debreczy.*

male plant to five to eight female plants is recommended to maximize fruit production. Bear in mind, however, that even in Manchuria, when both sexes are planted together in gardens, fruit set can be problematic.

While other *Actinidia* species have been known to pollinate *Actinidia kolomikta*, it is best to use a male of the same species so that both plants will flower at approximately the same time and there will be no sexual incompatibilities. Where multiple species of *Actinidia* have been grown together, both natural and artificial hybrids have been reported to occur. It is these plants that offer the promise of increased fruit size, yield, vigor, and more colorful foliage for the gardens of tomorrow.

In Massachusetts the flowers are produced in mid-May and stay in good condition for a week to ten days. The blossoms are white with dark-purple stamens, 1 to 1.5 centimeters across (1/2 inch), and are borne in clusters of one to five flowers. They produce a mild fragrance, similar to that of lily-of-the-valley (*Convallaria majalis*), and are largely hidden beneath the foliage. Flowering occurs only on wood produced the previous growing season, so pruning is required to reduce the buildup of older non-flowering growth.

In Massachusetts, kolomikta kiwi fruit matures in late August or early September, about one month earlier than *Actinidia arguta*. Depending on the cultivar, fruits range from the size of small grapes (1 to 1.5 cm) to that of a small plum (1.5 to 2.5 cm). They are smooth-skinned, bear a dark-green flesh, and have a taste more intense and flavorful than the commercial kiwis (*Actinidia deliciosa*) found in supermarkets. Because the fruits are smooth-skinned, they can be eaten without peeling—much as one would eat a grape. In Asia, fruits of *Actinidia kolomikta* are used for jams and jellies, are dried or salted; and are used for winemaking and as desserts and garnishes. According to Tanaka's *Encyclopedia of Edible Plants*, the Japanese also use the leaves in a variety of ways: they parboil them for soup, preserve them in salt, or use them as an ingredient in cooking.

People who are interested in learning or sharing the latest information about the genus *Actinidia* should consult the *Actinidia Enthusiasts Newsletter*, P.O. Box 1466, Chalan, Washington 98816. This publication is on file in the library of the Arnold Arboretum.

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Spring 1990
arnoldia
The Magazine of the Arnold Arboretum

U.S. 41.8 (5)

DEC 14 1990

GRAY HERBARIUM

arnoldia

Volume 50 Number 2 Spring 1990

Arnoldia (ISBN 004-2633; USPS 866-100) is published quarterly, in winter, spring, summer, and fall, by the Arnold Arboretum of Harvard University.

Subscriptions are $20.00 per calendar year domestic, $25.00 foreign, payable in advance. Single copies are $5.00. All remittances must be in U. S. dollars, by check drawn on a U. S. bank, or by international money order. Send subscription orders, remittances, change-of-address notices, and all other subscription related communications to: Helen G. Shea, Circulation Manager, *Arnoldia*, the Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130-3519. Telephone (617) 524-1718.

Postmaster: Send address changes to:
Arnoldia, Circulation Manager
The Arnold Arboretum
125 Arborway
Jamaica Plain, MA 02130-3519

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Arnoldia is set in Trump Mediaeval typeface and printed by the Office of the University Publisher, Harvard University.

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Front cover: The pollination drop on the single terminal ovule of a *Juniperus squamata* cone. Photo by T. Takaso.

Inside front cover: The detoxification of the cassava root in Mitu, Colombia. After soaking in water overnight, the cassava pulp is subjected to pressure in fibrous squeezing instruments called *tipitipis*. The poisonous content of the pulp is eliminated with the water. Photo by R. E. Schultes.

Back cover: *Cornus kousa*, growing at the Case Estate in Weston, Massachusetts. Note the distinctive arching habit. Photo by P. Del Tredici.

Inside back cover: *Cornus florida* in bloom at the Arnold Arboretum. Photo by I. Rácz and Z. Debreczy.

Page

Cornus kousa fruit, actual size.

"Pollination Drop" Time at the Arnold Arboretum

Tokushiro Takaso

Come spring, the hidden pollination processes of conifers can be seen with a hand lens.

Pollination is a critical event in the life of seed plants. Observant gardeners tend to realize that conifer pollen, unlike that of most garden flowers visited by insects, is dispersed by wind. They are generally unaware, however, of the array of processes that relate to the capture of conifer pollen by the ovules—the future seeds. In the Arnold Arboretum's rich collection of conifers, pollen capture generally occurs in spring. These events are subtle and unobtrusive and can scarcely compete with the simultaneous extravagance of azalea and lilac blossoms. However, with a little patience—and the use of a hand lens—the viewer can observe a process that turns out to be both beautiful and mysterious.

Gymnosperms, the group of seed plants to which conifers belong, are distinguished by possessing exposed (or "naked") ovules at the time of pollination. The apex of the conifer ovule (the *micropyle*) receives the pollen directly, usually by means of a drop of fluid (*pollination drop*). Angiosperms, or flowering plants, on the other hand, retain their ovules within a closed structure (the *carpel*), and the process of pollination does not involve a pollination drop.

Although the pollination-drop phenomenon is easily observed, remarkably few detailed studies have ever been made of it. A large living collection of conifers, such as that of the Arnold Arboretum, offers the ideal opportunity to obtain basic information with relatively simple tools.

Taxonomic Distribution of Pollination Drops

Conifers that are known to produce a pollination drop include all the species that have been studied in the families Cephalotaxaceae, Cupressaceae, Taxaceae, and Taxodiaceae. In the Pinaceae, only the genera *Picea* and *Pinus* produce a pollination drop (*Abies, Cedrus, Larix, Pseudotsuga,* and *Tsuga* do not). These genera have a range of ovular morphology and pollen-engulfing mechanisms that appear to be more specialized than the pollination drop and that are therefore thought to be derived, in evolutionary terms, from the drop system. Since non-coniferous gymnosperms like the cycads, *Ginkgo,* and *Ephedra* possess a pollination drop, it is usually assumed that this general mechanism is ancestral. There is even fossil evidence for the existence of a pollination drop (Rothwell,1977).

Recently, Professor P. B. Tomlinson of Harvard University has determined that most of the Podocarpaceae in the South Pacific possess a pollination drop associated with unusual pollen-retaining features. Other Southern Hemisphere conifers, namely *Agathis* and *Araucaria* (Araucariaceae), lack pollination drops and have developed unusual mechanisms involving long pollen tubes.

Observing Pollination Drops

In most conifers native to temperate latitudes, pollen release in spring is a clear indication

Juniperus communis. *Each cone produces three ovules and three droplets, one of which was removed for this picture. The droplets remain separate because the integument orifice of each ovule has an oblique orientation.*

that ovules are receptive. Conspicuous exceptions to this rule are *Cedrus*, which sheds its pollen in fall, and *Calocedrus*, which sheds its pollen in the winter. Table 1 lists the times when drops have been observed in various conifers in the Arnold Arboretum, as well as additional information about drops in natural habitats elsewhere in Massachusetts and Canada.

While most of the data in Table 1 was collected during daylight hours, it is known that secretion of the drop occurs at night in most *Pinus* species. It seems likely that nighttime initiation of the drop is a general phenomenon, while its persistence into the day is variable. Dr. John Owen at the University of Victoria in British Columbia has studied the conifers of western North America and discovered that individual ovules on the same tree can exhibit the drop for varying lengths of time, two to four days in *Pinus contorta* (Owens et al., 1981) or one to two weeks in *Pinus monticola* (Owens and Molder, 1977).

Anyone having access to native or cultivated conifers can easily see the pollination drop. The chief problem is the logistical one of simply being able to locate ovulate cones, given that in large trees they are generally located only on the upper branches of the tree. On most cultivated trees, however, one can usually find a low-hanging branch with a few accessible cones. Pollination drops in the Cupressaceae are the easiest to observe, in particular those of the shrubby junipers.

At pollination time, the ovulate cones are small and inconspicuous, but once located, they are seen to be attractive and often colored (either pink, yellowish, or green), and the drop can be spotted on the tip of the micropyle. If the drop is not visible on the tree, a cut branch kept in water and enclosed in a plastic bag will usually produce drops in a warm room. One needs to make repeated observations to date the event in a given species because the time period varies among individuals and at different latitudes and altitudes.

Exudation and Pollen Capture

An ovule consists of a *nucellus* enclosed by its coat or integument. Above the level of the nucellus, the integument forms a narrow passage, the micropyle, which leads to a cavity surrounding the nucellar apex, the pollen chamber. Subsequent events that relate to fertilization occur within the nucellus and eventually result in the formation of an embryo. The integument becomes the seed coat as development proceeds, but these events all occur after pollination.

At the time of pollination, the ovule takes the form of a vase with a short neck, the mouth of the vase being the opening of the micropyle. This mouth may be either bi-lobed or, more often, irregularly lobed. Secretion of the pollination drop is thought to be the result of changes in cells at the apical part of the nucellus (Owens and Molder, 1980; Owens et al., 1981). Once produced, the fluid passes up the micropyle and makes a round droplet at its mouth. Examples of secreted drops are shown in the accompanying photographs.

If the integument has two apical lobes or arms, as in *Picea* and *Pinus*, the fluid may simply form a film between them, held by surface tension. In principle, wind-borne pollen has to fall directly on the pollen drop to be available for fertilization. Since this is a very small target, it is not surprising that a variety of mechanisms have been developed to make the process more efficient. Karl Niklas at Cornell University has evidence from wind-tunnel experiments that the aerodynamic design of the conifer cone produces wind eddies that cause pollen to fall out of the air currents (Niklas, 1985; Niklas and Pau U, 1982).

These physical mechanisms, however, do no more than deposit pollen in the general vicinity of the ovule. *Pinus* has apparently elaborated the mechanism of pollen capture by two further steps. First, the integument arms and surface of the ovule secrete microdroplets, only visible at high magnification, which can cause pollen to stick to the surfaces that produce them (Owens et al., 1981). Second,

Table 1. Pollination Drop Observation Times

TAXON	LOCATION	DATE
Cupressaceae		
Chamaecyparis obtusa	Arnold Arboretum	20 April, 5 May, 1989
C. pisifera	Arnold Arboretum	26 April 1989
*C. thyoides**	Gardner, Mass.	26 April 1989
Juniperus chinensis	Arnold Arboretum	3 April 1989
*J. communis**	Petersham, Mass.	28 May 1989
J. squamata	Arnold Arboretum	20 April, 5 May, 1989
*J. virginiana**	Concord, Mass.	26 April 1989
Thuja occidentalis	Arnold Arboretum	3 April 1989
T. plicata	Arnold Arboretum	3 April 1989
Pinaceae		
*Picea sitchensis**[1]	Sooke, B.C., Canada	late April 1978
*Pinus contorta**[2]	Victoria, B.C., Canada	May 4-20, 1980
Taxaceae		
Torreya nucifera	Arnold Arboretum	9 June 1989
Taxodiaceae		
Cryptomeria japonica	Arnold Arboretum	26 April 1989
Taxodium distichum	Arnold Arboretum	20 April 1989

* Natural populations; [1] Owens and Molder (1980); [2] Owens, et al. (1981)

Chamaecyparis thyoides *(White Cedar), scanning electron micrograph of young cone (x 240), collected April 20, 1989, at Cedar Swamp, Gardner, Massachusetts. The flask-shaped structures are ovules (young seeds) shortly before the time of pollination. Dissection and photography by Marcheterre Fluet.*

Juniperus virginiana. *Numerous pollination droplets terminate the female cones.*

Taxodium distichum. *Two ovules develop in the axil of each fertile bract. Arrow points to the droplet.*

the normal pollination drop secreted by the nucellar apex fills up the entire micropylar region and picks up any pollen adhering to the microdroplets. Withdrawal of the pollen drop by drying or even active absorption pulls adhering pollen down the micropylar tube and into the pollen chamber. Repetition of secretion and absorption can occur in unpollinated ovules in *Pinus*, but probably not in *Picea* (Owens and Molder, 1980).

In an experiment carried out in 1935, Doyle and O'Leary artificially added pollen to one of the two ovules of each bract of a pine cone. Where pollen was added, the drop was absorbed within five or ten minutes, while the fluid of an unpollinated ovule remained unchanged. The authors concluded that the presence of pollen is the stimulus for halting the secretion of the pollen drop.

In most conifers, after pollen is drawn into the micropyle, the integumentary arms, if present, collapse, and the micropyle itself closes by cell enlargement and division. The pollen chamber is thus sealed off, and pollen germinates within the closed cavity.

Whether the mechanism of pollen drop absorption is biological or physical remains unclear and only a few chemical analyses of drops have been made. The pollination drop of *Pinus nigra* contains three sugars—glucose, fructose, sucrose (McWilliam, 1958). In *Taxus baccata*, in addition to the same sugars, it contains phosphates, amino acids, peptide, and organic acids (Ziegler, 1959). A more recent study by Seridi and Chesnoy (1988) added an unidentified oligosaccharide that was consistently present in *Cephalotaxus*, *Taxus*, and *Thuja*. Additional amino acids and galacturonic acid are also present. Fructose seems to be the most abundant sugar, perhaps as a source of nutrition for the germinating pollen.

More Work Is Needed

Many uncertainties remain in our knowledge of pollination mechanisms in conifers. Doyle and O'Leary (1935) mention the differences between observations carried out in the field versus the laboratory. Ideally the subject should be examined in cones on attached branches, and an arboretum collection with

Torreya nucifera. *The enclosed ovule is exuding a droplet.*

some diversity of species can facilitate this work.

Pollination drops have great practical importance since they can be one of the factors that limit commercial seed production. Because seed supply often sets a limit to reforestation programs, pollination-drop research in British Columbia has been supported by the Canadian Forestry Service. At the same time, the academic biologist needs to know the evolutionary pathways by which alternative pollination mechanisms have been produced.

Spring is lilac time at the Arnold Arboretum, and the period when public visitation is at its peak. Those visitors who stray from the well-trodden paths will find their daring rewarded among the conifers. The pollination drop, when viewed with a hand lens, provides a window into a seldom seen world where beauty and biology come together in harmony.

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Dr. Takaso is a post-doctoral fellow at the Harvard Forest in Petersham, Massachusetts. The research described in this article was supported with funds from a Putnam Fellowship awarded by the Arnold Arboretum.

Polly Wakefield among her oldest kousa dogwoods, nearly thirty feet tall, planted along the path down to the terraces. Photo by Peter Del Tredici.

A Fascination with Dogwoods

Mary M. B. Wakefield

Observations on thirty-four years of growing *Cornus kousa*.

I will always remember the day that my mother exclaimed: "What are we going to do? Hector wants to remove the old granite steps from the path down the terraces. He says the horses can't see them in the tall grass and they'll stumble over them when dragging the mowing machine."

At that time, over thirty years ago, the steps were all that was left to mark the path through the eighteenth-century cherry orchard after the last two trees had died. What a pity, I thought, to remove the last remaining vestiges of what had once been such an important feature of the place.

After thinking it over, we decided to experiment. Why not try planting out some of the young dogwood trees that I had raised from seed collected during plant propagation classes at the Arnold Arboretum? By planting them at either end of each group of steps—they were already tall enough to be seen above the hay—they might solve Hector's problem, and beautify the place at the same time. Thus began a project that eventually extended the length and breadth of each terrace and on into the fields beyond. It continues to this day.

This all started in 1956 when I began collecting dogwood seed during a class in plant propagation at the Arnold Arboretum taught by Roger Coggeshall. Near the summit of Bussey Hill was a group of dogwoods, and members of the class were given their choice as to which trees to collect from. I chose the fruit of one particular *Cornus kousa* because it was much larger than that of those growing nearby. It was a round-headed tree, and it was growing near two other kousas, by which it may have been pollinated.

For a number of years, I continued to take the same plant propagation course and each year I collected from the same three trees, and all the kousa dogwoods that I planted over the next thirty-four years—and I now have more than six hundred of them spread over several acres—are descended from these particular Arboretum specimens.

The large-fruited kousa was No. 79-41-B, a grafted plant received by the Arnold Arboretum from Clarence Lewis of Skylands Farm, Sloatsburg, New York, on January 11, 1941. Its two neighbors were Nos. 18386-A and -B, siblings grown from seed sent by A. Coffin of Locust Valley, New York, in 1923. The A plant had an interesting and distinctive bark, exfoliating to expose patches of light gray. It was more upright in habit than its sibling, which was round-headed and bushy.

As all my trees are the descendants of the specimens growing at the Arnold Arboretum, this article can only attempt to describe the variation that we have found in over thirty-four years of selection and experimentation. Kousa dogwoods derived from other seed sources, or from the wild, would probably manifest variation in different characteristics.

An Excellent Ornamental

How fortunate for me that it was *Cornus kousa* seedlings that were available when we needed trees to demarcate the path. I have

The exceptionally large fruits of Cornus kousa *(AA #79-41-B), 3.5 cm in diameter (1.4 in). Seeds collected from this plant in 1956 were the source of Polly Wakefield's first kousa dogwoods. Photo by I. Rácz and Z. Debreczy.*

found them one of the most outstanding of all the flowering trees that will thrive in the changeable New England climate. Ornamental at every season of the year, these seedlings never cease to astonish me with their vigor, their hardiness, and, most particularly, their individuality.

Cornus kousa produces flowers some two to three weeks later than *Cornus florida*. It is not until early June, when the weather has warmed up and after its leaves have expanded fully, that the kousa flower buds swell to their full size. By planting both species together, the homeowner can extend the dogwood season by three to four weeks.

With both of these dogwoods, the structure most people refer to as a flower is not really a flower. In the words of E. H. Wilson, the true flowers are "an insignificant crowded mass subtended by four, creamy white bracts, ovate and pointed and overlapping at the base, forming a cross some 3 to 4 inches in diameter." At first the leaflike flower bracts are light green but, as they enlarge, they turn a cream color, and then gradually whiten with age, before falling off in July. Unlike the native *Cornus florida*, the later kousa bracts are handsomely set off with a foil of green leaves.

I have seen many interesting variations on this "normal" pattern: on some plants, the bracts never entirely whiten but become suffused with green instead. They are probably photosynthetic and often remain in place until the fruits ripen in October. On other plants, the aging bracts may develop an attractive pink tinge before they drop, or the bracts may develop irregular pink splotches, making them look like someone spilled paint on them. The intensity and duration of this color seem to be dependent upon the weather.

The size and shape of the bracts are also extremely variable. On my trees the flower clusters, including bracts, have varied in length from 1.5 to 6.5 inches. The amount of overlap among the bracts is also variable. In some, the four bracts are completely distinct from one another, producing a star-shaped effect, while in others, the bracts are so broadly overlapping that the flowers appear square. The bracts may be evenly placed around the central flower or they may be arranged eccentrically, with three of them close together and one of them by itself. On some individuals, the flower bracts droop as they age, causing the central flowers to appear elevated, while on others, the bracts curl

Close-up of the true flowers of Cornus kousa *subtended by showy bracts. Photo from the Arnold Arboretum Archives.*

upward to produce a pronounced cup-shaped effect.

A few of my trees produce "double" flowers with two or more extra bracts, and occasionally, on some trees, one or all of the bracts are fused together to create a very distinctive effect. Several times one of my trees produced flowers in clusters of threes. Unfortunately these unusual characters did not manifest themselves annually, and therefore cannot be considered stable traits. But with a seedling there is always hope—for that is the sport of seed propagation.

The fruit of the native American dogwood, *C. florida,* is a single flesh-encased seed that appeals to birds, chipmunks, squirrels and raccoons. The fruit of the kousa dogwood is fleshy and strawberry-like, and the individual components are fused together into a single entity called a syncarp. According to a recent report by Dr. Richard Eyde, the fruit is particularly attractive to the macaque monkeys, native to Asia, who eagerly consume them, and in the process, disseminate the seeds.

When the fruits first develop, the stalk that carries them is upright, but as they develop, they become heavier and more pendulous. When fully mature they dangle from the branch tips like Christmas tree ornaments. In New England, the fruits hang on the trees for several weeks once they are mature. On most trees, the fruits develop from green to yellow to orange to bright red at different rates of speed, so all the colors may be on one tree simultaneously! Normally the fruits are 1.5 to 2.5 centimeters (.5 to 1 inch) across, but sometimes they can reach 3.5 centimers (1.5 inches). The fruits, while somewhat gritty in texture, are edible with a delicate honeydew melon flavor that cries out for an inventive gourmet cook.

Growth Habit

Experts assure us that kousa dogwoods display the same horizontal branching habit as *Cornus florida,* but my experience suggests that this is not always the case. The only generalization that seems to hold is that growth habit varies greatly from plant to plant. A tree may have a strong central leader with weak laterals, to give an upright, essentially vertical, tree; or it can have multiple trunks that eventually produce a fan-shaped tree as the weight of snow and ice spreads the branches apart.

Another variation in the kousa dogwood's general habit is the way in which it carries its flowers. They may be borne singly on short horizontal branches, or they may appear in lines of five to eleven flowers along the "top" of the branches, creating the impression of being laden with snow.

One particularly important distinction in this regard is whether or not the tree can be classed as an "upstairs" or a "downstairs" tree. As I define it, an upstairs tree, because it holds its flowers along the upper side of its branches,

The exfoliating bark of a twenty-year-old specimen of Cornus kousa. *Photo by Peter Del Tredici.*

Four different plants of Cornus kousa *showing variation in the arrangement, shape, and size of the showy bracts. Photos from the Arnold Arboretum Archives.*

Polly Wakefield in her garden. Photo by Peter Del Tredici.

is best viewed from above. A downstairs tree, on the other hand, produces flowers that are somewhat turned down and is best viewed from ground level.

No matter what the differences in flowers, fruit, or growth habit, all kousa dogwoods have beautiful exfoliating bark and leaves that turn a deep, rich wine-red color in the fall. In my garden, only the leaves of the native oaks and the Norway maples persist longer than those of the kousas.

Trials and Tribulations

In nature, both *C. florida* and *C. kousa* are understory trees, growing best in the shade of much larger deciduous trees. They prefer a light, well-drained soil, and seem to prosper near the banks of ponds or streams where moisture is continually available. In times of extreme drought, they appreciate being on the fringes of woods with nurse trees to mitigate the direct rays of the sun. They especially resent long periods of full sunlight during dry weather. Not that they won't tolerate the heat at such times, but their leaves are apt to curl temporarily and look less attractive.

The first planting of dogwoods—on the terraces where cherry trees had thrived—was spaced rather closely together to discourage the grass growing beneath them, for back then mowing grass was a real nuisance. Today moss, forget-me-nots, violets, European ginger, lilies-of-the-valley, and toadflax have become established, eliminating the need for mowing.

Because of the close spacing, the trees have shed most of their lower branches and exposed their handsome trunks. It is difficult to appreciate the subtle individuality of each plant, but *en masse* they create a lovely "dog wood."

One summer the town decreed that no water could be used for ornamental plants except by bucket—after a brief effort at compliance, I decided to dig my own well! One winter the mice wreaked havoc by nibbling the bark just above the snowline; after that, each tree was encircled with a protective chicken wire or plastic wrap.

Over the years, I have tried a variety of mulches but have found none as satisfactory as old-fashioned wood chips. A thick layer of them not only reduces the competition from weeds but also acts to conserve moisture. Perhaps most important, the mulch serves to protect trees from trunk damage by power mowers and string trimmers.

1987 and 1988 were drought years in New England, and I was faced with the choice of losing recently transplanted kousas from lack of water or irrigating them with our overhead irrigation system. I decided to use our system liberally even though this sometimes meant running it right through the night. This practice unwittingly created conditions that were favorable to the spread of the recently described dogwood anthracnose fungus. [See article p. 16.] Fortunately, I found it on only a few trees and there has been no further sign of the disease on any of the kousas since we stopped watering at night.

A Bright Future

It is surprising to me that kousa dogwoods are so little planted in this part of the world. This may change dramatically in the near future, however, given that *C. florida* is considered highly susceptible to the deadly dogwood anthracnose, while *C. kousa* is but little affected.

My hope is that some day *C. kousa* will be so much in demand that the nurseries will find it worthwhile to carry cultivars, thereby enabling the purchaser to select an "upstairs" tree or a "downstairs" tree, one with large or small fruits, or one with broadly overlapping bracts or bracts that scarcely touch. Toward this end, my goal continues to be to select and propagate those trees with particularly distinctive characteristics. Over the years, I have named and patented several plants, including 'Fanfare' with a narrow, upright growth habit; 'Silverstar' with an arching, vase-shaped form; and 'Moonbeam' with unusually large flowers. Two of my selections, 'Triple Crown' with three flowers per cluster and 'Twinkle' in which some of the inflorescences produce extra bracts, are not reliable in these characteristics and are no longer distributed.

My collection is the result of an amateur hobbyist working in her spare time without scientific skill or equipment. Today more and more researchers are working with the kousa dogwood, and recently Elwin Orton of Rutgers University successfully crossed it with both *C. florida* and *C. nuttallii*, opening the door to future improvements.

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Anthracnose Threatens the Flowering Dogwood

Craig R. Hibben

Methods for diagnosing and controlling this new disease.

Something unusual began happening to the flowering dogwood during the late 1970s. *Cornus florida*, one of eighteen species of *Cornus* native to the United States, and probably the most widely grown as an ornamental plant, began to decline over parts of the Northeast. The common stresses on dogwood—borers, soil-borne diseases, drought, and winter kill—did not appear to be major causal factors. From an investigation of declining dogwoods in arboretum and woodland sites in southeastern New York, the cause was identified as a new fungus disease, *dogwood anthracnose* (Hibben and Daughtrey, 1988). The nature and control of this threat to the flowering dogwood are of interest to all those who grow and appreciate this plant.

Disease Symptoms

Dogwood anthracnose is easily recognizable. The most characteristic symptom is branch death beginning in the lower part of the canopy. Additional symptoms that can help the homeowner differentiate anthracnose from other diseases of dogwood are purple-rimmed brown spots and larger brown blotches on the leaves. The blotches sometimes expand until the entire leaf blade becomes blighted. Blighted leaves often remain hanging on the branches, even over the winter period.

Infection spreads through the petioles of infected leaves into the stems. Infection can also appear on the current year's branches as tiny sunken lesions that form in the bark. The tips of infected branches die, and a reddish-purple zone often forms between the living and dead bark. Infection progresses downward until entire branches die.

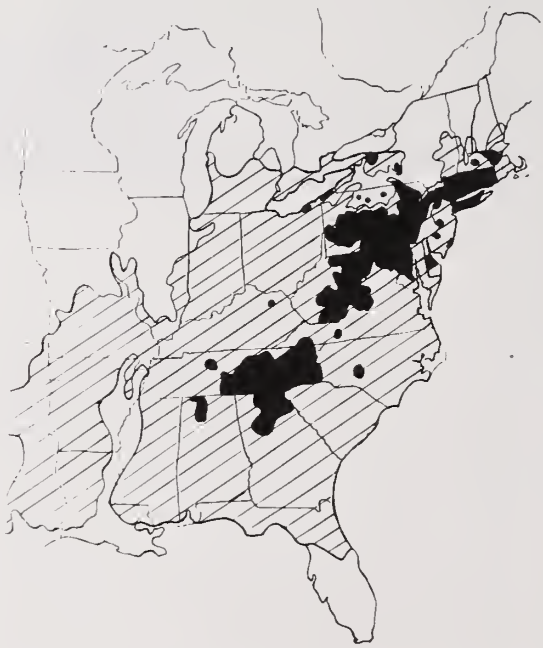

Figure 1. Natural range of Cornus florida *in eastern U. S. (hatching) and approximate range of dogwood anthracnose (black) in 1989. Disease reports compiled by W. Jackson and R. Anderson, U.S.D.A. Forest Service.*

Dogwoods with dieback often produce clusters of epicormic branches (watersprouts) along the trunk and larger branches. When the epicormic branches become diseased and die back, infection moves into the adjoining trunk or branch causing cankers, which are detectable by sunken, swollen, or cracked areas in the bark. Cutting beneath the outer bark reveals patches of dead brown tissue in the inner bark and outer sapwood. The cumulative effect of the cankers is to girdle the stems, which leads to additional branch mortality.

Anthracnose affects dogwoods of all ages and sizes. The disease moves slower in trees located in sun-exposed sites. In fact, infected dogwoods that have received proper cultural care sometimes fully recover. Infected understory dogwoods in wooded sites, where moisture and shade conditions favor the disease, often die within five years. In some northeastern forest sites, once heavily populated with flowering dogwood, few live dogwoods, including seedlings, remain today.

Wind-Dispersed Spores

When leaves and branches from infected dogwoods are examined with a hand lens, numerous reddish-brown to black bumps can be observed on dead tissue. These are fungus fruiting bodies that, when moistened, exude single-celled spores in gelatinous masses or threads. It is these tiny spores, wind spread during rainy periods, that initiate infection on the new leaves of dogwood in the spring.

As more leaves and branches die, new spores are produced. The incredible abundance of spores that form on dead leaf and stem tissues assures that infection can reoccur throughout the growing season whenever moisture conditions are optimum. Even the hanging blighted leaves play an important role in the disease cycle, as dripping rainwater easily transports spores to the leaves below.

From the structure and dimensions of the fruiting bodies and spores, the fungus was identified as belonging to the genus *Discula*. The *Discula* fungus has also been isolated repeatedly from leaves and stems of diseased dogwoods. Successful inoculations of healthy dogwoods with pure cultures of *Discula* provided the conclusive evidence that this fungus is the cause of the anthracnose disease of *C. florida*

One theory suggests that recent periods of drought and unusually severe winters have weakened dogwoods, making it more susceptible to attack by *Discula*. The anthracnose fungi, including those attacking oak, maple, and sycamore, are strong pathogens, and they

Figure 2. Lower-branch dieback in dogwood with anthracnose.

Figure 3. Infected dogwood leaves showing spots and blotches.

Figure 4. Blighted leaves remain hanging on infected dogwood.

do not require a weakened host to cause disease. To reverse the scenario, it is more likely that the infection by *Discula* has predisposed dogwoods to the detrimental effects of recent climatic events. For example, infected dogwoods in our woodland study plot showed far greater winter kill than uninfected dogwoods in the same site. Infected dogwoods are also more likely to be invaded by *Armillaria* (shoe string) root rot, a soil-borne disease that commonly attacks stressed trees.

Control Recommendations

Based on what we have learned about the biology of this disease, and from fungicide trials on dogwoods (Daughtrey et al., 1988), we can recommend a three-part program for the control of dogwood anthracnose.

1. Good cultural practices applied to landscape dogwoods can reduce the incidence and effects of disease. Dead branches of infected trees should be pruned out promptly to reduce the sources of spores for new infections. Epicormic branches should be clipped off to prevent their infection and the subsequent formation of branch and trunk cankers. For dogwoods in wooded sites, the only practical control measure is to thin out and open up the sites to provide more sunlight and better air circulation.

Since dogwoods are especially vulnerable to periods of drought because of their shallow root systems, supplemental watering during extended rainless periods is beneficial. Overhead sprinklers should be avoided because wet foliage is more likely to become infected. The application of a balanced fertilizer late in the fall or in early spring will improve tree vigor. Watering and fertilizing dogwoods will not necessarily increase their resistance to anthracnose, but the trees will be better able to recover from the detrimental effects of infection.

2. Fungicides will provide protection against infection. The fungicides Daconil 2787® (chlorothalonil) or Manzate 200® (mancozeb), sprayed three times at approximately ten-day intervals during leaf expansion in the spring, will provide good protection for dogwood foliage. If these fungicides cannot be obtained, Benlate® (benomyl) can be substituted. It is important to apply the fungicide during the spring when dogwoods are most susceptible to infection. Infection of new leaves can also occur during wet periods throughout the growing season. Consequently, for valuable landscape dogwoods, additional sprayings at two-week intervals during the summer will provide added protection.

3. Genetic resistance to anthracnose has not yet been discovered in the flowering dogwood. The commonly grown cultivars of *C. florida* have all shown high susceptibility to the disease. Even dogwoods grown from seed collected outside the known range of the disease have proven susceptible (Santamour and McArdle, 1989). Research is under way to identify possible disease resistance in surviving dogwoods growing in woodland sites where anthracnose has been especially severe.

4. The kousa or Korean dogwood (*C. kousa*) is hardier, more pest-free, and later flowering than *C. florida*, and is a worthy replacement for it in the landscape. Under most conditions in the East, *C. kousa* has shown good resistance, although not immunity, to anthracnose. There are reports (Holmes and Hibben, 1989) that when the foliage is subjected to long periods of wetness, kousa dogwoods can suffer damage from this disease.

NEWS

FROM THE ARNOLD ARBORETUM

Maurice Sheehan and the recently restored "Rockery Spring."
Photo by P. Del Tredici.

Rockery Spring Uncovered

This year Maurice Sheehan is celebrating his twenty-fifth year as a grounds crew member at the Arnold Arboretum. Only Michael Gormley has been here longer than Maurice, by a scant six months. Both men deserve hearty congratulations for their hard work and long-time dedication to the institution.

This year, Maurice was involved in a unusual restoration project: to uncover an old spring that had been an important part of the natural and social ecology of the Arboretum during its early days, but had been forgotten in recent times. Christened "Rockery Spring," this fresh-water outlet provided clean, cool water to generations of Arboretum visitors. A pipe leading from the spring was installed in the late 1800's when the nearby road was built, and until the drinking fountains were installed in the 1930's, it served as the only source of clean water available to the public. And even after the drinking fountains were installed, the popularity of the spring remained, particularly in late summer, because the water was always cold.

In the old days, visitors to the Arboretum would sit on the large sandstone rock and put their cups under the ever-flowing pipe. At one time the spring was fenced to keep leaves from blowing in and clogging it up. But time and vandalism took their toll, and around 1965 the fence had to be taken down. Following this, Rockery Spring fell into disrepair, becoming choked with leaves and overgrown with vegetation. Eventually, almost everyone forgot about it except Maurice, who suggested to Superintendent Pat Willoughby that the spring ought to be restored to its former state. Pat thought it was a great idea, and in April of this year the restoration project was begun.

As well as pulling off twenty years of plant growth, new puddingstone stepping stones were installed to bring the spring back to its original condition. Clean gravel was added to the stone path and new plantings were put in below the spring, including ferns, astibe, lilies-of-the-valley, bugbane and *Kiringeshoma palmata*. Thanks to Maurice we now have a beautiful "new" feature at Arnold Arboretum, just across the road and down from the rockery. Take a look at it next time you visit, but please don't drink the water since its quality has not yet been tested.

The 1990 Arboretum Interns Arrive for Spring

Ever since the days of E. H. Wilson, the Arnold Arboretum has been offering students summer internships in horticulture. The program has grown in breadth and depth over the years and has attracted world-wide recognition for its high quality.

The interns get hand-on experience in several areas, including the grounds, the library, the greenhouse, and plant records, in Jamaica Plain and at the Case Estates. As part of their training they participate in classes two afternoons a week to study woody-plant identification, horticultural maintenance, and landscape design. Several field trips supplement the classroom learning.

This year eighteen interns were chosen from a record number of applicants to the program from Europe, Canada, and the United States. They are graduate or undergraduate students in landscape design, ecology, and plant and soil science.

Some of the 1990 Arboretum interns: top left, Julia Hintringer, Putzbrunn, West Germany; David Callard, Winchester, MA; Judith Wasserman, Cambridge, MA; Karlton Holmes, Cambridge, MA; Donna Harrington, (no longer here); Carol Kohler, South Hadley, MA; Mary Altermatt, Portland, ME; Kevin Williamson, Medfield, MA; Hillary Quarles, New Haven, CT. Not shown are: Gail Allen, Plymouth, NH; Eddie Ashton, Truro, Nova Scotia; Greg Dowd, Dover, MA; Melanie Evans, North Chelmsford, MA; Matthew Giroux, Holderness, NH; Michael King, Amherst, MA; Hillary Maharam, Brookline, MA; Andre McCloskey, Washington, DC; Maryellen Sullivan, Dorchester, MA. Photo by P. Del Tredici.

ARBORETUM PARTICIPATES IN LINNEAN SOCIETY MEETING

The Botanic Gardens Conservation Secretariat and the Commonwealth Science Council sponsored a meeting this May in London on conserving biological diversity in botanic gardens. The program included a presentation on "Preserving Genetic Diversity through Curatorial Practices" by the Arnold Arboretum verification project leader, David Michener, now working as Curator at the Matthaei Botanic Garden of the University of Michigan. Donald Falk of the Center for Plant Conservation spoke on"Integrated Strategies for Conservation of Biological Diversity." An audience of botanic garden professionals from Sri Lanka, Israel, the Canary Islands, Denmark, Holland and the United States attended, including Nan Sinton from the Arnold Arboretum.

LILACS IN MONTREAL

The Montreal Botanic Garden was host to this year's International Lilac Convention attended by Jack Alexander, Nan Sinton and former Arboretum Plant Propagator Al Fordham. The program included a visit to Mont Royal Cemetery where E. H. Wilson is buried. At the request of the members of the Lilac Society, Al gave an impromptu speech on his memories of the Arboretum's renowned plant explorer. The Arboretum will be the site for the International Lilac Society convention in May 1992.

Rhododendron calendulaceum growing under the oaks at the Arnold Arboretum

RHODODENDRON SOCIETY VISITS

Over two hundred participants in the American Rhododendron Society's Annual Convention visited both the Arnold Arboretum in Jamaica Plain and the Case Estates on Sunday, June 3. The weather was cloudy and windy but, thankfully, dry.

In Jamaica Plain the mass plantings of the flame azalea, *Rhododendron calendulaceum,* were enough in bloom to delight the visitors. The arboretum has one of the largest collections of this spectacular plant anywhere outside of the wild. The Ghent azaleas, which have strong genetic ties to the flame azalea, were at their peak of bloom. Among the evergreen rhododendrons, numerous comments were overheard concerning the improved maintenance in the Rhododendron Dell along Bussey Brook. The work that grounds crew, interns, and volunteers have put into the area over the last two years is clearly paying off.

After leaving Jamaica Plain the visitors went to the Case Estates to view the Rhododendron Society Display Garden in Weston.

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SPRING ART EXHIBITION BLOOMS AGAIN

The traditional Lilac Sunday Art Competition was revised this year to accommodate the thousands of glorious subjects and views offered by the Arnold Arboretum. Artists were solicited via art magazines and newsletters. A total of seventy three artists submitted two hundred sixty two slides for initial review. Selections for inclusion in the exhibit were based on relevance as Arboretum subject matter, design quality, and technique. The twenty nine final art works will be on display in the Visitor Center until June 30.

The winner of this year's competition for the 1990 poster was "Lilac Frenzy" by Maria Paglia of Harvard, Mass. The poster was reproduced as a limited edition of 300 and was signed and numbered by the artist on Lilac Sunday, May 20. It sells for $40.00 and is available at the Bookstore.

Artist Maria Paglia signing copies of the 1990 lilac poster, "Lilac Frenzy."

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Figure 5. Proliferation of epicormic branches on infected dogwood.

Fortunately, *C. florida* and *C. kousa* are sexually compatible. From a long-term breeding program at Rutgers University (Orton, 1985), several dogwood hybrids are soon to be introduced with improved vigor and pest resistance—including, everyone hopes, resistance to anthracnose.

Origin of the Epidemic

Attempts to explain the origin and timing of dogwood anthracnose raise some interesting questions about this disease. In the mid-1970s, a similar outbreak of anthracnose occurred in the native western flowering dogwood (*C. nuttallii*) in the Pacific Northwest. *Discula* was identified as the cause (Salogga and Ammirati, 1983). After comparing fungal isolates from infected *C. florida* and *C. nuttallii,* we concluded that identical or related strains of *Discula* were attacking both dogwoods. This new disease appeared to be attacking related hosts at the same time in both geographic regions.

The periodic wet, cool springs of the Northeast and the yearly rainy season encountered in the maritime Northwest are conditions conducive to anthracnose fungi. But the reason for the sudden epidemic of the disease over part of the northeastern range of *C. florida* and for its coincidental outbreak in *C. nuttallii* is unknown. There are several hypotheses. The outbreak of the disease near ports of entry on both coasts of the U.S. raises the possibility of this particular *Discula* species being a recent import on some other host plant. Alternatively, perhaps the disease has been endemic but at levels too low to be noticed. A shift in rainfall and temperature patterns, or a mutation in the fungus resulting in a new, highly virulent strain, could account for the recent emergence of the disease. There is also some evidence that acid rain makes dogwood foliage more susceptible to invasion by *Discula* (Anderson et al., 1989).

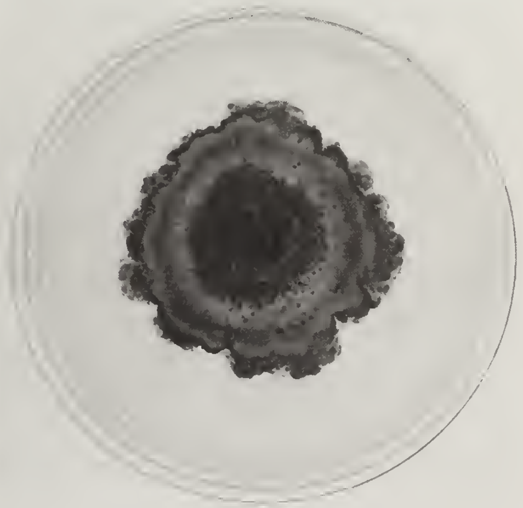

Figure 6. Pure culture of Discula *fungus causing dogwood anthracnose.*

But more research is needed before the role of acid rain in dogwood anthracnose is fully understood.

Dogwood anthracnose has now established itself in natural and ornamental populations of flowering dogwood in parts of the Northeast for over a decade. Surveys indicate that the disease has spread gradually southward and westward since the early 1980s. We anticipate that *Discula* sp. will continue to have a significant impact on dogwood—with disease severity varying considerably from year to year, depending on weather conditions during the growing season. In the meantime, research is continuing with emphasis on the epidemiology and control of dogwood anthracnose.

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Gifts of the Amazon Flora to the World

Richard Evans Schultes

Many valuable plants were originally domesticated in the now threatened rain forest of the Amazon basin.

When the famous Russian botanist Nikolya Vavilov outlined the major regions of the world that had given man most of his principal cultivated plants, he did not include the Amazon Valley. Nor did his nineteenth-century predecessor Alphonse De Candolle, the pioneer in the field of phytogeographic study, look to the Amazon as the source of important cultivated plants. Since the exploratory work of these two botanists, most modern specialists have concentrated either on one species or on members of one genus or family rather than on entire regions. As a result, the Amazon basin, with few exceptions, has never been accorded the intensive research that such a rich flora deserves, especially as a potential source of useful species.

The Amazon drainage area, as large as the United States, is for the most part covered with a dense tropical rain forest and is bathed by one-fifth of the world's fresh water; it has a rich and varied flora of an estimated 80,000 species of higher plants. The more accessible areas have already given the world some of its more important economic plants while the vegetation of many of the hinterland regions is still unexplored, awaiting both botanical and chemical investigation.

Unless strong conservation measures are strictly enforced, many species and even some genera may become extinct. It is vitally important to preserve as many sources of germ plasm as possible for the benefit of future generations.

Among the most important species that have entered the world economy as major players, as discussed in detail in the following article, are the pineapple, *Ananas comosus*; the Brazil nut, *Bertholletia excelsa*; achiote, source of an orange-red dye for foods and cosmetics, *Bixa Orellana*; the curares, *Chondrodendron tomentosum*; the cocaine-yielding shrub, *Erythroxylon Coca*; the edible peach palm, *Guilielma speciosa*; the rubber tree, *Hevea brasiliensis*; the tapioca plant or cassava, *Manihot esculenta*; and cacao, source of chocolate, *Theobroma Cacao*. Of the numerous ornamental plants that have come from the Amazon, we will discuss only one, the royal water lily, *Victoria amazonica*.

PINEAPPLE

Ananas comosus (L.) Merrill
Family: Bromeliaceae

The pineapple is unknown in the wild, but it may sometimes escape from cultivation and give the appearance of being wild. There is every indication that the plant is Amazonian in origin, although, as with other cultigens, some uncertainty remains. One theory holds that the Tupi-Guarani Indians first cultivated it in Paraguay and with their migrations took it to Amazonia. Evidence for this theory is the presence in Paraguay of several species

The wild pineapple, Ananas ananassoides, *considered by some botanists to be the ancestor of the cultivated pineapple,* Ananas comosus. *Rio Piraparana, Comisaria del Vaupes, Colombia.*

believed to be related to *Ananas comosus*. All of these wild species are seedy types in contrast to the generally seedless pineapple. They all have the same chromosome number, and they all are capable of hybridizing with one another.

Close relatives of the pineapple are also found in the Amazon, especially *Ananas microstachya* and *A. ananassoides*; and the area of greatest variability of *A. comosus* is the western Amazon. The Colombian Witoto Indians of the Igaraparaná River area, for example, have more than twenty-four "varieties" of the pineapple, each with its native Indian name. Such variation suggests that *A. comosus* originated as a cultigen in the Amazonia of Colombia or Peru.

By the time that Europeans arrived in the New World, the pineapple was widely distributed throughout tropical America. Records before 1600 place the pineapple along both the Pacific and Atlantic coasts of South and Central America. Columbus saw the pineapple on his second voyage, and one of his officers attempted to describe it: "There were some fruits like artichoke plants but four times as tall which gave a fruit in the shape of a pine cone, twice as big, which fruit is excellent; and it can be cut with a knife like a turnip, and it seems to be wholesome." A pineapple was taken as a special gift to the Emperor Charles V of Spain, and one was presented to King Charles II of England in 1672.

The many references to the pineapple in the early chronicles indicate that this strange fruit caught the fancy of Europeans. It was introduced very early to the Old World tropics and reached virtually all parts of the Far East before the end of the sixteenth century. Today, as is well known, the commercial center of cultivation is in Hawaii.

The pineapple is unique among fruits in containing a chemical constituent that aids digestion, a proteolytic enzyme known as *bromelin*. Bromelin is milk-clotting and is employed in tenderizing meat and in the leather industry. In modern pharmacy, it is used in treating sprains, contusions, and other injuries since it is a depolymerizer and modifier of permeability.

BRAZIL NUT
Bertholletia excelsa Humboldt et Bonpland
Family: Lecythidaceae

One of the most majestic trees of the humid forests of Brazil, Guiana, and Venezuela, *Bertholletia excelsa* is the source of the Brazil nut of commerce. An enormous tree, primarily of the Amazon, it frequently attains a height of 160 feet. The globular fruit, which ripens from January to June, is often called the "monkey pot." A woody or boney capsule with a terminal lid, the fruit measures six inches in diameter and weighs up to five pounds. Each fruit contains from twelve to twenty-four nutritious three-sided nuts, the white "meat" of which consists of 70 percent fat and 17 percent protein. Each tree can produce three hundred or more fruit pods.

It is said that the monetary value of Brazil nut exportation from Amazonian Brazil is second only to that of rubber, but as the slow-growing tree is not cultivated, virtually all production of Brazil nuts comes from wild forest trees. Dutch traders began exportation of Brazil nuts in the early 1600s. Today many thousands of tons are exported, more than ten thousand tons to the United States alone.

ACHIOTE
Bixa Orellana Linnaeus
Family: Bixaceae

This small, profusely fruiting tree, known as *achiote* in Spanish and *annatto* in Portuguese, yields enormous amounts of seeds (up to 600 pounds per tree), each covered with a reddish aril, the source of an orange-yellow dye. The crushed seeds are usually soaked in water, and the water is then evaporated to make a

VRVCV.

An early drawing of achiote, Bixa Orellana. *The pods contain seeds that are covered with a reddish aril, the source of an orange-yellow dye. Left: from Hernandez,* Rerum Medicarum Novae Hispaniae Thesaurus *(1651). Right: from Piso,* De Indias Utriusque Re Naturali et Medica Libri *(1658).*

brightly colored paste. The dye is added as a spice to soups, cheeses, and other foods, especially in tropical countries in both hemispheres. The dye is a good source of vitamin A, which is often deficient in the diets of many hot, humid areas.

Much achiote is now exported to industrial countries in North America and Europe, particularly to color oleomargarine, since some of the synthetic aniline dyes formerly used are now believed to be carcinogenic. It is also employed as a dye for woolens and is sometimes employed in the paint, varnish, lacquer, cosmetic, and soap industries.

Among many South American tribes, who know the plant by one of its Brazilian names (such as *urucú*), achiote is valued as a source of decorative body paint. *Bixa Orellana*, named for the early Spanish explorer of the Amazon river, Francisco de Orellana, is not known in the wild. Some suggest that it was domesticated from the large forest tree *B. excelsa* of the southwest Amazon of Brazil.

Long before Europeans arrived in the New World, achiote had spread throughout tropical America. When the Spaniards conquered Mexico, it was already firmly established. The Aztecs, who called it *achiotl* ("medicine good for dyeing"), extracted a strong fiber from its bark, valued it as a dye, and even added it to their chocolate drinks. Medicinally, it is used as a gentle purgative.

CURARE

Chondrodendron tomentosum Ruiz et Pavón
Family: Menispermaceae

The use of arrow poisons by Indians of the South American rain forests is a very old practice. Although many different kinds of arrow poisons are prepared from many different kinds of plants, they are all indiscriminately called *curares.* The two most important types—the so-called true curares—use, as their basic source of toxicity, species of the loganiaceous genus *Strychnos* or the menispermaceous genera, particularly *Chondrodendron.* The name *curare* is a corruption of two Tupi Indian terms meaning "bird" and "to kill."

The early traveler Peter Martyr first chronicled curares in numerous works written during the quarter century following Columbus's first voyage to the New World. He mentions several "varieties" of arrow poisons and records that the natives had an antidote for the poison and practiced cauterization for arrow-poison wounds. Martyr is responsible for a story, often repeated and embellished by later writers, of old women "skilled in the art, who are shut in at certain times and furnished with the necessary materials; during the two days they watch and distill the ointment . . . If the women are well and not found half dead from the fumes, they are severely punished; and the ointment is thrown away as being valueless; for the strength of the poison is such that the mere odour of it . . . almost kills its makers."

In the early nineteenth century, sundry naturalists and travelers wrote about curare—von Humboldt, Waterton, von Martius, the Schomburgk brothers, and others—but it was Baron von Humboldt who recorded the first eyewitness account of its preparation. Probably all these early accounts referred to *Strychnos*-based curare, since they came from travelers who had encountered the poison in Venezuela or the Guianas.

Reports of the menispermaceous-based curares of the Amazon are of a much later date. The most important is undoubtedly that of the German plant explorer von Martius who, in the 1820s, found a species of *Chondrodendron* used in curare-making by Indians on the River Japurá on the Brazilian-Colombian frontier.

Nine species of the Menispermaceae are known to be employed in the preparation of curares. It is, however, the arrow poison made

A Kofan Indian medicine man and his student preparing curare. This tribe produces a wide variety of curares, many prepared from bioactive plants unknown in other parts of the Amazon. Comisaria del Putumayo, Rio Sucumbios, Colombia.

basically from *Chondrodendron tomentosum* that has become important in Western medicine during the last sixty years. This curare has a number of alkaloids but owes its activity as a skeletal muscle relaxant primarily to d-tubocurarine, which has become an indispensable adjunct of modern surgery and is used for treating various neurological conditions.

The plant is an enormous forest liana, climbing into the crowns of the tallest trees. The active principles are contained in the bark, which must be scraped off. As a consequence, repeated exploitation eventually kills the vine. The plant has never been cultivated, mainly because it is extremely slow-growing. There appears, however, to be a danger that the source of the brownish, resinous syrup may become scarce as a result of intensive exploitation and increasing forest devastation. When the curare syrup can no longer be procured from natural sources, is there anything that can successfully supplant it?

Barasaba Indians collecting leaves from the coca plant, Erythroxylon Coca *var.* Ipadu. *Comisaria del Vaupes, Rio Piraparana, Colombia.*

COCA LEAF

Erythroxylon Coca Lamarck
Family: Erythroxylaceae

Recent research has established that there are two distinct species of *Erythroxylon* and two varieties, all of which are excellent sources of the active principle, cocaine. *Erythroxylon Coca,* the most important species, is cultivated in the Andes at relatively high altitudes, between 1500 and 4500 feet, from Colombia south to Bolivia and northern Argentina. From this species the variety *Ipadu* has been developed, unusual in its ability to thrive in the tropical climate of the western Amazon. From *E. novogranatense,* a distinct variety *truxillensis* has developed on the drier parts of the Andean slopes, up to 4500 feet. This variety is now widely cultivated in the coca fields of the Trujillo region, and archeologic records indicate that it was formerly grown along the dry coastal regions of Peru as early as 1900 B. C.

The method of coca use in the Amazon regions varies considerably from that of the highlands where there are natural sources of calcium or lime necessary for the extraction of cocaine within the user's acid mouth. In the Amazon, where sources of the alkaline admixtures are not readily available, the Indians have discovered that the ashes of a number of leaves are alkaline and can, when mixed with a powder of the coca leaves, result in the extraction of the active principle during mastication of the leaves.

The principal alkaloid, cocaine, was isolated in 1860, and its physiological effects were studied in 1862. Two years later, it was recommended in Western medicine as an excellent local anesthetic. It is still valuable, especially in ophthalmological and ear, nose, and throat surgery. It is the use of the purified alkaloid—not the aboriginal employment of the leaves or powder as a masticatory among South American Indians—that may lead to dangerous addiction.

PEACH PALM

Guilielma speciosa Martius
(=Bactris Gasipaes HBK.)
Family: Palmae

Every Indian settlement in the western Amazonas has *Guilielma speciosa* planted around the houses as an excellent source of food in the fruiting season. The fruit—the size and color of a peach—is rich in carbohydrates (primarily starch) and has copious oil. Of high nutritional value, it is extremely delicious when roasted or boiled. Many of the native tribes have festivals during the first week of April at the time of the principal harvest; the Yukunas of Colombia hold their *kai-ya-ree* dance for four days at this time. At these festivals, flour of the fruit often takes the place of flour of *Manihot esculenta,* and unleavened bread is prepared from it in great quantities.

While the edible fruit represents by far the most important economic value of *Guilielma speciosa,* the palm has a number of other uses in aboriginal societies. Some Indians esteem the palm heart; others employ the inflorescence as a flavoring agent in cooking. The hard "wood" is fashioned into bows, lances, and other weapons; and the usually spine-covered trunk has been used to make fences around houses to protect inhabitants from enemies. Even the root has often been considered medicinal.

The precise locality of domestication of this palm is apparently unknown. The early explorer Henry Walter Bates wrote: "[It] grows wild nowhere on the Amazons. It is one of those few vegetable productions . . . which the Indians have cultivated from time immemorial and brought with them in their original migration to Brazil." Modern botanical research suggests that the plant probably originated on the eastern slopes of the Peruvian Andes, either from the wild *Guilielma mattogrossensis,* spreading into the central part of the Amazon by way of the Madeira River, or from *G. microcarpa* and *G. insignis.*

In the western Amazon, especially in Colombia, there are many types of *Guilielma speciosa* in which the seed aborts, and the whole fruit then consists of starchy endosperm. Furthermore, there are types without the usual horrible spines on the trunk, making collection significantly easier. Recently, a comprehensive collection of germ plasm of the palm over a wide area has been initiated. It behooves these collectors to penetrate the northwest Amazon of Colombia—difficult because of rapids and waterfalls throughout the region—to salvage some of these interesting clones before they disappear.

Guilielma speciosa is destined to play a very important part of future tropical agriculture, especially for third-world people living in overpopulated areas unsuited to modern agriculture. It is one of the most promising gifts of the Amazon forests.

RUBBER

Hevea brasiliensis (Willd. ex Adr. Juss.) Muell.-Arg.
Family: Euphorbiaceae

Undoubtedly the most important Amazonian gift to the world has been the source of Para rubber, *Hevea brasiliensis.* No other plant has had so rapid and drastic an effect on civilization as this tree, which today is the source of more than 98 percent of the world's natural rubber. It is also one of the most recently

The peach palm, Guilielma speciosa, *is usually planted in circular or rectangular rows around Indian houses. The highly nutritious fruit ripens in late March or early February in the Western Amazon. Rio Kananari, Amazonian Colombia.*

Hevea brasiliensis, *the source of commercial rubber produced in plantations of Asia. This species produces the highest quality rubber, and is one of the ten* Hevea *species native to the humid rain forests of South America. Comisaria del Amazonas, Rio Loretoyacu, Colombia.*

domesticated of the major crop plants. Prior to its introduction to the Old World by the English in 1876, and its adaptation to plantations in the British and Dutch colonies of Asia, wild trees of the Amazon had satisfied the global needs of rubber.

The production of rubber from forest trees led to an industry reducing thousands of

A typical field of the cassava, Manihot esculenta, *at Rio Kananari, Comisaria del Vaupes, Colombia.*

Amazonian Indians to near slavery—in some regions amounting to actual slavery, torture, and wanton murder. When the plantations began to supply the world demand for rubber prior to World War I, the nefarious forest industry gradually disappeared, for the well-supervised Asiatic plantations could make available a better and cheaper product than that obtained by the uncontrolled tapping of wild trees widely scattered in the jungle.

Thus the domestication of *Hevea brasiliensis* has had two beneficial results: it created a dependable source of high-quality rubber at a reduced price, making possible the development of numerous new industries, especially modern automotive and later air transportation; and it saved countless thousands of Amazonian Indians and their cultures from annihilation.

The changes that selection and genetic research have brought about in *Hevea brasiliensis* have been unbelievable, particularly in the yield of latex. The early plantations, based on seed material, gave 350 to 400 pounds of rubber per acre per year; numerous "improved" clones now yield more than 3000 pounds per acre.

There are ten species of *Hevea*, all native to the tropical forests of South America, especially in Amazonia. In addition to *Hevea brasiliensis*, two (*H. Benthamiana* and *H. guianensis*) yield usable rubber—but of an inferior quality. The latex of the other seven species is very low in *cautchouc*, the rubber molecule.

CASSAVA
Manihot esculenta Crantz
Family: Euphorbiaceae

Hundreds of thousands of human beings living in the tropics of both hemispheres receive their carbohydrate nourishment from a euphorbiaceous shrub variously known as *yuca, cassava, mandioca* (Spanish), or *macacheira* (Portuguese). The same plant is also the source of tapioca used by peoples in temperate zones around the world where *Manihot esculenta* cannot be grown. While we know hundreds of cultivated strains of this species, cassava is unknown in the wild. All the strains are grouped in two categories as either "bitter" or "sweet" cassava, depending on the amount and distribution in the root of a cyanide-producing, highly toxic cyanogenic glycoside.

Both strains contain the poison. In the bitter one, the glycoside is concentrated primarily in the rind, which must be peeled from the starchy root before use. In the sweet varieties, the glycoside is in the rind and also throughout the starch of the root. In the Amazon, the bitter strain is almost exclusively cultivated.

From a taxonomic point of view, *Manihot esculenta* is one of the most complex economic plants known, and many "species" have been described, which we now know represent strains, races, or ecotypes. Early writers tended to identify northwestern Brazil as the region where this cultigen had its origin, while later authors favored the savannas of Venezuela and Bahia, Brazil. Mexico and Central America—and even Africa—have been suggested as sources, but without reliable supporting evidence.

Recent botanists postulate that the "sweet" and "bitter" strains of *Manihot esculenta* originated separately and developed independently. And a most recent survey of the evidence—botanical, ethnobotanical, ethnological, and archeological—concludes that "sweet" cassava was first domesticated in Mesoamerica, whereas "bitter" cassava was probably first cultivated in northern South America. Since Brazil exhibits extreme cultigen diversity, as well as an abundance of related species of *Manihot*, that country would offer favorable conditions for the hybridization and development of new strains.

Although there is no firm evidence, it is possible that cassava was among the first food plants to sustain man in the American tropics. Archeological remains indicate that the plant has been used as a food in the humid tropics of the New World for at least 2500 years; secondary and circumstantial evidence suggests that its cultivation may go back some 4000 years.

Early European voyagers to the New World tropics mentioned cassava. As early as 1696, one British writer on plants stated it was "one of the most generally used of any provision all over the West Indies, especially the hotter parts, and used to victual ships." Now *Manihot esculenta* has spread throughout the tropics of the world, and in the warm parts of Africa and southeast Asia especially, it has become a staple food. It is one of the dozen plants that quite literally feed the human race.

The chocolate plant, Theobroma Cacao, *escaped and growing wild at Amanaven, Comisaria del Vichada, Colombia.*

CHOCOLATE
Theobroma Cacao Linnaeus
Family: Sterculiaceae

The source of chocolate and cocoa butter is a relatively small bushy tree believed to be of hybrid origin and native to the Amazonian slopes of the eastern Andes of Colombia and Ecuador. When and how it traveled to Mexico in pre-Conquest times are still mysteries, as it would have had to pass over high and cold mountains where this tropical cultigen could not survive. One theory proposes that *Theobroma Cacao* "spread throughout the central part of Amazonia-Guiana westwards and northwards to the south of Mexico." But if it took this route, it would have had to traverse desert areas on the coast of Venezuela and Colombia where the cacao plant could not grow. Its odyssey remains a mystery to this day.

The word *chocolate* comes from the Nahuatl name of the plant—*chocolatl*—among the Aztecs. In every European language except English, it is known correctly as cacao. *Cocoa,* which is a corruption of cacao, is not only wrong, but often leads to confusion with the names *coca* and *coconut.*

Although apparently not used by South American Indians before the arrival of Europeans, *Theobroma Cacao* was highly prized in Mexico where the Aztec ruler received cacao seeds as tribute from subjugated tribes of the tropical parts of the empire. Throughout Mexico and Central America, it was probably grown for more than two thousand years, and the natives believed that it was a gift directly from the gods. Perhaps Linnaeus considered this belief when he named the genus *Theobroma* from the Greek "food of the gods."

One of the earliest and most reliable of the Spanish chroniclers, Hernandez, the physician of the King of Spain, spent five years studying the medicinal plants of the conquered Aztecs. He distinguished four kinds of cacao in Mexico and wrote of the use of the seeds as food, drink, currency, and medicine (a treatment for dysentery). He warned, however, that immoderate use "obstructs the intestines, destroys the complexion and caused a general degeneration of the health."

The Aztecs had special spices or flavoring agents for their various chocolate preparations including vanilla (*Vanilla planifolia*) and red pepper (*Capsicum* spp.). Another, that is still in use today in Oaxaca, is the aromatic, fenugreek-flavored flowers of a bombacaceous tree, known today as *flor de cacao* (*Quararibea funebris*).

Of the six New World plants rich enough in caffeine or caffeine-like compounds to be used as stimulants, only *Theobroma Cacao* has acquired enough worldwide fame to take a place alongside coffee (*Coffea arabica*) and tea (*Camellia sinensis*) of the Old World.

The world's largest water lily, Victoria amazonica. *Each flower lasts one day: in the morning it is white, but during the day the floral parts turn first pinkish, then purple. By nightfall, the flower has been pollinated by a beetle. Comisaria del Amazonas, Leticia, Colombia.*

ROYAL WATER LILY

Victoria amazonica Sowerby
Family: Nymphaeaceae

The world's largest water lily, *Victoria amazonica*, stands out as probably the most spectacular of Amazonia's gifts to ornamental horticulture. Better known as *V. regia*, named in honor of Queen Victoria, this beautiful denizen of inlets, oxbows, and lakes of still waters is one of the natural wonders of the Amazon. It is remarkable for its enormous leaves, measuring up to six or more feet in diameter, and its huge fragrant flowers, reaching eighteen inches across when fully open. The leaves, green above but reddish on the lower surface, have an upturned margin five or six inches high, and underneath they are strengthened with a lattice-like network of thick, spiny ribs. The nocturnal flowers, opening in the cool of the afternoon and closing by noon the following day, are pollinated by a large beetle. The fifty or more petals change in this short period from white to dark pink. The local inhabitants employ a poultice of the leaves to soften ulcers and to treat infected wounds.

Discovered in 1801, the Royal Water Lily, as it is called in English, was not well known for some thirty-five years, but during the past century and a half, it has been avidly sought as a greenhouse ornamental and may be seen among the water lily displays of most botanical gardens.

Richard Evans Schultes is Jeffrey Professor of Biology and Director of the Botanical Museum of Harvard University, Emeritus.

BOOKS

Judith Leet

Bulbs by John E. Bryan. Timber Press, 1989. 2 volumes. 451 pages. 750 colored photographs. 110 colored plates. Hardcover. $120.

The Random House Book of Bulbs by Roger Phillips and Martyn Rix. Random House, 1989. 255 pages. Colored photographs. Paperback. $21.95.

Two new books on bulbs have recently appeared, one a completely handsome, deluxe two-volume set titled *Bulbs* by John Bryan, with a jacket photograph of the Keukenhof Gardens in Holland—the tulip beds beckoning the reader to open the book. The other, *The Random House Book of Bulbs* by Roger Phillips and Martyn Rix, edited by Brian Mathew, is— on close inspection— a revised edition of a book titled *The Bulb Book*, originally published in England in 1981 by Pan Books. It is a serviceable, affordable paperback, with a much less inviting cover of assorted cut flowers produced from bulbs, with a *Fritillaria imperialis* in the center.

In heavily illustrated books, such as these, most readers probably study the photographs and captions before examining the text. In Bryan's encyclopedic two volumes—a ten-year effort—the high-quality photographs show each species in peak condition either in its wild setting or in a garden (photographs are interspersed with full-page historical botanical plates from *Curtis's Botanical Magazine*). A remarkably high percentage of the 750 photographs not only offer essential information about the plant but are aesthetically pleasing.

Authors Phillips and Rix, however, rely on "laid out photographs" in which they take four or five cut flowers, place them on a neutral background, and shoot a full-page illustration. At times the visual information is useful (particularly those that show the uprooted bulb), but at other times, the effect is of limp foliage and flaccid flowers. These pages, fortunately, are supplemented by many fine, albeit smaller, habitat photographs often taken in remote locations.

I admit to a personal bias against the "laid out" photographs: since the plants are lined up left to right and cast shadows against the background, the photographs strike me as a lifeless, artificial way of presenting flowers. For aesthetic considerations, I find myself more attuned to Bryan's approach.

As to the texts, both books attempt to deal with bulbs on a large scale—from the most common to the rarest bulbs of the world. Phillips and Rix offer a concise and knowledgeable survey of the better-known plants whereas Bryan presents the broadest possible coverage of the subject, his treatment by far the more detailed. Bryan has arranged his two volumes alphabetically by genus, a scheme that is generally convenient and workable—and one that does not require repeated trips to the index. Even more helpful, he introduces each new genus with a brief general discussion so that the reader has a sense of how all the species fit into it. This introductory discussion I very much miss in the Phillips and Rix book, which is organized by sequence of bloom, and the reader moves from a discussion of a *Narcissus* species to a *Tulipa* species without any warning or introductory text—not even a heading.

In fact, in the Phillips and Rix scheme, all the species of a genus may not be discussed together; the reader may be surprised to come upon *Narcissus poeticus* after many pages on tulips, separated from all the other *Narcissus* because of its later blooming time. Similarly, the reader may not realize a few *Fritillaria* appear pages ahead of the ninety or so species that are clumped together.

For those who want it, Bryan goes into a brief explanation of the broad divisions of the larger genera—*Crocus, Dahlia, Lilium, Narcissus*, and *Tulipa*—which helps put these familiar but potentially confusing groups into some perspective. No matter how large the genus, Phillips and Rix give their readers only short successive descriptions of individual species, and readers must make whatever sense they can of the list, quite daunting when there may be pages of entries for a given genus. For clarity of organization and of index, my choice is Bryan, although I can see where some gardeners may find it useful to see the blooming sequence and learn what plants are available in the months when their gardens need livening up. Bryan follows his introduction of each genus with sections on Culture, Propagation, Pests and Disease, and Uses.

And probably most useful of all for both the gardener and the bulb collector, Bryan then makes a selection of the most recommended species in each genus—taking full responsibility for the choices—and describes each of his choices briefly. He concludes with an often lengthy list of nonrecommended plants, either not available commercially or not garden worthy. Although Bryan allows that he has not included in his two volumes "all known varieties and species," he has assembled a vast, mind-boggling number (230 genera), including many newly discovered bulbs, particularly from South Africa, as well as many that may be potential raw material for hybridizing.

For those who consider themselves beginners, both books presuppose little knowledge; all the basics are explained or reviewed, including what a bulb is and where each species is native. Bryan's definition: "Almost all bulbous plants have a common characteristic—a dormant period," brought about by either heat and dryness or cold and snow; and he includes true bulbs, corms, rhizomes, and tubers as falling under the general term *bulb*. Phillips and Rix also allow their wide definition "to include all plants which form swollen underground storage roots or stems to survive the dry or cold season."

Both books take up all the bulbous plants that are true favorites of the garden, as well as exotic and unusual bulbs that the reader may or may not have seen. Especially noteworthy are the hundreds of rare bulbs that Bryan singles out for attention. Of *Sparaxis tricolor*, he comments: "a plant of outstanding garden merit"; of *Spiloxene capensis*, "well worth a place in the rock garden . . . where it will not fail to give you pleasure"; of the genus *Homeria*, "good plants for the sunny border where the unusual forms and colors can be appreciated." Phillips and Rix do not offer enough of these evaluating comments on the merits of the plants; with so many thousands of species and cultivars to choose from, the gardener needs guidance from and the insights of experts.

Interestingly, *Fritillaria* is singled out for description many more times in Phillips and Rix, with over 95 species warranting entries, whereas Bryan considers only 25 species garden worthy. But which of the 95 do they recommend? Bryan's comment on *F. michailovskyi* is far more pungent, "a favorite of those that know the genus," than Phillips and Rix's: "The dead petals remain around the seed capsule." Bryan's pithy evaluations are what make the lengthy lists of plant species come alive. In passing, Bryan makes an amusing comment on human destructiveness of species: "Dr. Boussard who took this picture in the wild [of a beautiful *Iris cycloglossa*] in Afghanistan, reports that it dislikes being run over by Russian tanks."

All in all, we are comparing an economy model—a small compact that does the job—with a luxury model, for those who want to travel in comfort, beauty, and style. The average gardener will be satisfied with the Phillips and Rix; the ardent gardener will want the Bryan—no question about it. The insatiable gardener may want both.

Judith Leet is associate editor of *Arnoldia* and wrote the text for *Flowering Trees and Shrubs: The Botanical Paintings of Esther Heins* (Abrams, 1987).

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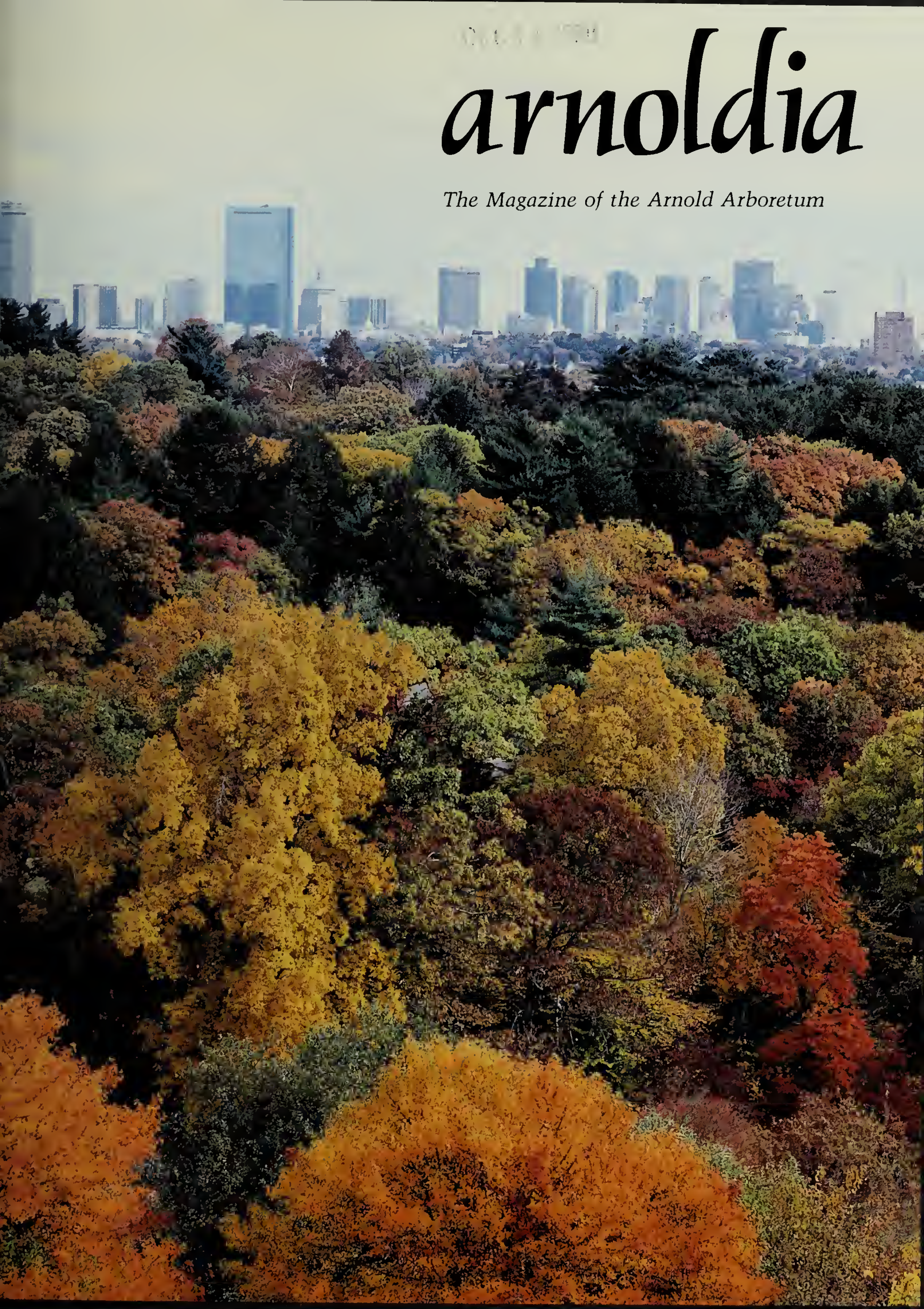
The Magazine of the Arnold Arboretum



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Volume 50 Number 3 1990

Arnoldia (ISSN 0004-2633; USPS 866-100) is published quarterly, in winter, spring, summer, and fall, by the Arnold Arboretum of Harvard University.

Subscriptions are $20.00 per calendar year domestic, $25.00 foreign, payable in advance. Single copies are $5.00. All remittances must be in U.S. dollars, by check drawn on a U.S. bank, or by international money order. Send subscription order, remittances, change-of-address notices, and all other subscription-related communication to: Helen G. Shea, Circulation Manager, *Arnoldia*, the Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130-3519. Telephone (617) 524-1718.

Postmaster: Send address changes to:
Arnoldia, Circulation Manager
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Front cover: An overview of the Arnold Arboretum from Peters' Hill. Photograph by Rácz and Debreczy.

Inside front cover: The twining stems of an old specimen of Japanese wisteria (*Wisteria floribunda*) growing at the former estate of George Rogers Hall in Bristol, Rhode Island. Photograph by P. Del Tredici.

Back cover: *Taxodium ascendens*, the pond cypress, in its native habitat in the Osceola National Forest in Northern Florida. Photograph by Rácz and Debreczy.

Inside back cover: *Abies bornmülleriana*, a little-known species, as portrayed in a plate prepared for the *Dendrological Atlas*. This fir was photographed in its native habitat in Western Turkey, on Mt. Ulu Dagh, about 1800 meters.

Page

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The First Japanese Plants for New England

Stephen A. Spongberg

When an enterprising young American doctor, George Rogers Hall of Bristol, Rhode Island, sailed to the Orient to seek his fortune by opening a small hospital in Shanghai, his contribution was destined not to be in medicine but in horticulture. His shipment of the first living plants from Japan to New England in 1861 was intended for Francis Lee of Chestnut Hill, Massachusetts, but answering Lincoln's call for enlistments, Lee consigned the plants to the historian and horticulturist Francis Parkman, who cultivated them with great success in his garden in Jamaica Plain, Massachusetts. The following year Hall returned from Yokohama, Japan, with other new plants that he brought in person to Parsons & Company, a nursery in Flushing, Long Island, to propagate. It is difficult to overestimate the importance of these early introductions in modern American horticulture.

Kousa dogwoods, hiba arborvitaes (*Thujopsis dolabrata*), Fujiyama rhododendrons (*Rhododendron brachycarpum*), sawara cypresses (*Chamaecyparis pisifera*), beautiful crab apples with semidouble flowers (*Malus halliana* Koehne var. *parkmannii*), and umbrella pines were among the first Japanese plants that arrived in Boston directly from Japan. F. Gordon Dexter, returning to New England from the Orient in 1861, agreed to take responsibility for this ligneous cargo on the seventy-day passage from Yokohama to Boston and to deliver the plants personally to Francis L. Lee of Chestnut Hill. This unique collection had been carefully assembled and established in Wardian cases for transport to Boston by Dr. George Rogers Hall, then a resident of Yokohama.

Francis Parkman (1823–1893) contributed greatly to the development of American horticulture. Best known as a rosarian, Parkman published The Book of Roses *in 1866, but the diversity of plants he grew in his garden testified to broad horticultural interests. It was in Parkman's garden on the shore of Jamaica Pond that many Japanese plants were first successfully cultivated in North America.*

During Dexter's absence from the states, Confederate artillery had bombarded Fort Sumter in the harbor of Charleston, South Carolina, and the Civil War had erupted. Francis Lee, about to respond to President Lincoln's call for troops by enlisting in the Union Army, was forced to entrust the nurture of the totally new plants to someone other than himself. He chose Boston's most celebrated horticulturist, Francis Parkman, his friend, former Harvard classmate, and Jamaica Plain neighbor.

When Parkman returned to Boston in the fall of 1846 after a summer of arduous adventure exploring the Rocky Mountain region, he was ill and physically exhausted. He had temporarily lost his sight—a recurring impairment that alternated with periods of poor vision—and suffered from headaches and an injured knee that severely restricted his mobility for the rest of his life. With assistance from his sister, the historian nonetheless began to dictate *The Oregon Trail* and plan for the numerous other historic accounts he would eventually write.

Turning to horticulture as an avocation, Parkman directed, from his wheelchair, a small grounds staff at his summer home on the shore of Jamaica Pond. Their labors and Parkman's plans transformed the three-acre site into a horticultural wonderland. The collection of roses alone consisted of over one thousand plants, and other horticultural novelties vied for the admiration of visitors. Lee knew that his new Japanese plants would be pampered under Parkman's supervision, and their growth and horticultural attributes would be duly noted and communicated at meetings of the Massachusetts Horticultural Society.

A view of Jamaica Pond from Francis Parkman's garden. The house is no longer standing (the land is now part of Boston's Emerald Necklace), nor is there a trace of the colorful garden that once flourished on the site.

The Umbrella Pine

One of the evergreen Japanese conifers, in particular, caught the eye of Parkman, who probably gave it the protection of a greenhouse before deciding to test its hardiness out-of-doors during a New England winter. Parkman may also have coined its common name, umbrella pine (*Sciadopitys verticillata* [Thunberg] Siebold & Zuccarini), to denote the spokelike arrangement of its glossy green needles. Not a pine at all, this unique tree has been placed by botanists in its own family—the Sciadopitaceae—and, like the ginkgo, it has no close living relatives. Miraculously, it too has survived from the remote geological past.

Fossils provide evidence that these trees once grew over a wide area of Eurasia and formed an important component of European forests. Brown coal deposits in Germany from the mid-Tertiary are frequently characterized by the remains of the leaves of umbrella pine, attesting to its former abundance. It also once grew in Greenland and Canada, but today the single extant species is restricted in nature to forests occurring between three and six thousand feet in elevation in the mountains on the Japanese islands of Honshu, Shikoku, and Kyushu.

The Japanese umbrella pine has proven hardy in the environs of Boston, and a grove of fifty-year-old trees has firmly established the species in the collections of the Arnold Arboretum. These individuals produce cones on a nearly annual basis, and as they mature the lower limbs die, exposing the trunks of the trees to view. Young trees rarely produce cones and usually retain their lower limbs; consequently, the cinnamon-brown bark of the trunk is obscured by the dense whorls of the dark-green, almost plastic-like leaves. As young trees, umbrella pines grow slowly and symmetrically, forming shapely, evergreen spires that are highly prized as specimen trees in the gardens of those fortunate enough to grow them. When plants can be located in the nursery trade, the prices they command reflect the esteem in which they are held. At the Arboretum, a younger generation of these trees accents the plantings in front of the Hunnewell Visitors' Center and illustrates their landscape use.

*The umbrella pine (*Sciadopitys verticillata*) constitutes one of the finest conifers available for landscape use in eastern North America. Young plants are slow-growing and achieve a symmetrical, conical habit.*

Kousa Dogwood

Another Japanese tree that Parkman was the first to grow in North America along the shore of Jamaica Pond would have aroused the interest of Asa Gray at the Harvard Botanical Garden in Cambridge. It is likely, moreover, that Parkman was aware of Gray's interest in the flora of Japan. Word of the debates at the meetings of the Cambridge Scientific Club

Dr. George Rogers Hall (1820–1899) of Bristol, Rhode Island, the physician turned trader, who first sent living plants from Japan directly to New England.

and American Academy of Arts and Sciences that had raged between Gray and Professor Louis Agassiz in 1859 had surely reached the historian's ears. These spirited discussions had been spawned by Gray's hypothesis concerning the close relationships of the floras of eastern North America and Japan and Darwin's theories of evolution. Gray had argued for the descent of species in the two regions from common ancestors, while Agassiz had attempted to defend the multiple origins of related forms. Gray's reasoning, based on his empirical assessment of factual evidence, won the day and paved the way for the debate over Darwinism, which would occupy scientific center stage in the decades ahead.

When the Japanese kousa dogwood (*Cornus kousa* Hance) first came into flower on the shores of Jamaica Pond in the middle of June, Parkman was confronted with the same sense of *déjà vu* Gray had experienced when he sorted Charles Wright's brittle, dried specimens of Japanese plants in the herbarium. The morphological similarity of the Japanese species with the flowering dogwood (*Cornus florida* L.) of the eastern United States, which had flowered earlier in May, became immediately evident. Parkman was growing in his Jamaica Plain garden two closely related species from opposite sides of the world. Here was living proof of the distributional phenomenon Asa Gray had recognized and had gone far to explain. The similarities between the two species, moreover, could be comprehended based on the concept of descent from a common ancestor in the remote past.

Like its eastern North American congener, the ornamental attributes of the kousa dogwood depend largely on the four white, leaflike bracts that subtend the small, tight clusters of true flowers. Held erect on long pedicels, the abundantly produced clusters and their associated bracts stud the branches of the shapely trees in June and appear like thousands of miniature, creamy-white pinwheels hovering above the trees' outstretched branches. The white bracts contrast abruptly with the bright green of the leaves, yet some individuals produce such an abundance of flower clusters that the foliage is almost completely obscured from view by the associated bracts. These disease and pest resistant trees are one of the most valued ornamental subjects available for planting wherever a small tree is required.

Dogwood Fruits

While the Asian and North American dogwoods are undeniably related, they differ from one another in several ways and each is classified as a distinct species. Among other differences, the fruits of kousa dogwoods differ from the individually borne seeds of the flowering dogwood, each of which sports a bright red seed coat. By contrast, the seeds developed from each flower cluster of the kousa dogwood are embedded in the flesh of a red, strawberry-like compound fruit. The weight of the fruit eventually pulls the initially erect pedicel downward, and the mature fruits hang suspended along the leafy branchlets.

One very plausible explanation for the difference in fruit types between the Oriental and Occidental species relates to their means of dispersal in nature. In the forests of eastern North America, the small fruits of the flowering dogwood are the right size for birds, which eat them and then disperse the seeds after they have passed unharmed through their digestive systems. In Japan and China, where the kousa dogwood is now known to occupy a wide range, monkeys, particularly macaques, are denizens of the same regions, and the larger, bright red, strawberry-like fruits appeal to these arboreal acrobats. These seeds also pass unharmed through the animal's digestive system and are dispersed prepackaged with primate fertilizer. Had New World monkeys occurred in the same regions as the flowering dogwood and not been blind to the color red, our native species might have evolved fleshy compound fruits similar to those of the kousa dogwood. Conversely, had monkeys not occurred in Asia, kousa dogwood fruits would probably be simple and their seeds dispersed by birds.

Parsons and Company

In April of 1862, a year after Francis Parkman received his horticultural windfall, a letter was published in *The Horticulturist or Journal of Rural Art & Rural Taste,* one of the leading horticultural periodicals of the day, which had been founded by Andrew Jackson Downing. Under the title of "Japanese Trees," the notice was signed by Parsons & Co., Flushing, March 20, 1862, and the column began:

> A few days since, while sitting in our office, there walked in a gentleman, with an intelligent face, and frank, pleasant manner, introducing himself as Dr. Hall of Japan, whom we had for some time known by reputation . . . He informed us that for the past two years he had resided in Yokohama, and being greatly interested in trees and plants, had, for his own amusement, collected in his garden all of any interest which Japan contained . . . Expecting to return home this year, he had also collected a large quantity of seeds of trees and plants, many of them unknown either in Europe or this country. These plants and seeds he had brought with him, except some six Wardian cases yet to arrive, and proposed to place them all in our hands for propagation and culture.


A large specimen of Zelkova serrata *growing on the site of Dr. Hall's former estate, North Farm, in Bristol, Rhode Island. Photographed in 1987 by P. Del Tredici.*

Relating the arrival of the Wardian cases, the article continued,

> If you have ever seen the eagerness with which a connoisseur in pictures superintends the unpacking of

The original introduction of the spreading Japanese yew, Taxus cuspidata, *growing on the site of Dr. Hall's former estate in Rhode Island. This venerable specimen is over 30 feet tall and 130 feet in circumference and has been the source of propagation material for countless generations of cuttings. Photo by P. Del Tredici.*

some gems of art, among which he thinks he may possibly find an original of Raphael or Murillo, you will have some idea of the interest with which all, both employers and propagators, surrounded those cases while they were being opened.

Among the "originals" transported to Long Island in the glazed cases were the first plants of additional Japanese trees and shrubs that are now mainstays in landscapes in New England and across North America and Europe. Included were plants of the familiar kobus magnolia (*Magnolia kobus* De Candolle) and the now more ubiquitous star magnolia (*Magnolia stellata* [Siebold & Zuccarini] Maximowicz, in America first known and offered for sale as *Magnolia halleana* Parsons), both prized for their abundantly produced white or pink flowers that herald the arrival of spring. In the Arnold Arboretum both of these precocious flowering species grow near the Hunnewell Visitors' Center and in April annually provide one of the earliest floral displays of spring.

Ten garden forms of the sawara cypress (*Chamaecyparis pisifera* [Siebold & Zuccarini] Endlicher)—each selected and maintained by Japanese horticulturists—and plants of the beautiful hinoki cypress (*Chamaecyparis obtusa* [Siebold & Zuccarini] Endlicher) were exposed to the fresh North American air from within the humid confines of the Wardian cases. Saplings and seeds of a new elm-like tree, the Japanese zelkova (*Zelkova serrata* [Thunberg] Makino)—destined a century later to be widely planted in American cities and towns as a replacement for native American elms ravaged by Dutch elm disease—provided living evidence of new species to be found growing in Japan. Seeds of Japanese umbrella pines filled a small sack, and several horticultural forms of Japanese maples (*Acer palmatum* Thunberg), Japanese wisterias (*Wisteria floribunda* [Willdenow] De Candolle), and many others, including the raisin tree (*Hovenia dulcis* Thunberg), rounded out the shipment. While most had been described in the floristic accounts of Thunberg in the eighteenth century or later by Siebold in the nineteenth century, none had ever before been available to North American horticulturists. To the zealous plant propagators of the Parsons' firm and to American horticulturists of succeeding generations, several have become the botanical equivalents of canvases by Raphael and Murillo.

One Unfortunate Introduction

Ironically, among the horticultural treasures Hall brought back to the United States, one plant in the shipment was to become more comparable to the Norway rat brought to America by the first European explorers than to any work of art by an Old World master. This particular plant proved so well adapted to the climate and growing conditions of a portion of the eastern United States that it has become a pernicious weed that plagues foresters and naturalists throughout much of the southeast. Initially referred to by horticulturists as Hall's honeysuckle (*Lonicera japonica* Thunberg), this vigorous, twining climber is now more frequently known as Japanese honeysuckle, or simply honeysuckle. This last name is most usual, particularly in the regions where the plant has invaded thousands of acres of woodlands on the Piedmont and Coastal Plain and literally overwhelmed the native vegetation. For many generations of Southerners, its flowers have perfumed the air and provided drops of sweet nectar to be sucked from the base of its tubular corolla. It has also provided untold hours of sweat and frustration on the part of those who have attempted, most often in vain, its eradication. So widespread and pervasive has it become that only its name suggests its Japanese origin.

If he were alive today, Dr. Hall might be satisfied that his name has generally become disassociated from this plant. He would undoubtedly have preferred to leave the

*The flowers of Hall's honeysuckle (*Lonicera japonica*) produce a cloyingly sweet fragrance, which perfumes large regions of the South during the late spring and early summer. Since its introduction, the plant has become a pernicious weed, invading thousands of acres of woodlands along the eastern seaboard of the United States from New Jersey southward.*

Japanese honeysuckle in his Yokohama garden. Little did he or the staff of Parsons' Nursery realize that the woodlands of much of the eastern United States from Pennsylvania southward would be forever changed by offspring of a plant carefully transplanted from a Wardian case to a nursery row on Long Island in March of 1862.

A Valuable Introduction

At North Farm, Dr. Hall's Rhode Island estate on the shores of Narragansett Bay—now a condominium development—a venerable, multistemmed Japanese yew (*Taxus cuspidata* Siebold & Zuccarini) planted by Dr. Hall on his return from Japan dominates one corner of the old garden. This tree is now over 30 feet tall and over 130 feet in circumference. A bronze plaque at its base indicates that it ranks as the first Japanese yew to be planted in North American soil. It was certainly not the last, for in northern regions of the United States this species has become the signature shrub of the modern-day urban and suburban landscape. While the Japanese honeysuckle has invaded southern woodlands, the Japanese yew has achieved the status of the quintessential landscape shrub in northern cities and towns.

Japanese yews constitute one of the mainstays of the American nursery industry. Countless thousands of balled and burlaped individuals annually fill the sales areas of bona fide nurseries as well as hardware stores, supermarkets, and other retailers who attempt to capture a part of the spring market for landscape trees and shrubs. Plants of this species used in foundation plantings alone probably number in the millions. All too frequently, yews are yearly clipped and shaped with pruning shears and hedge clippers into rounded balls, boxlike cubes, and cones. All across New England—like chessmen standing sentinel at entryways or guarding gravesites in suburban cemeteries—the Japanese yew is omnipresent and contributes to the monotonous repetition of suburbia.

The hinoki cypress (Chamaecyparis obtusa) *growing at North Farm in 1987. Photo by P. Del Tredici.*

When not pruned to within an inch of its life but allowed to grow and develop naturally, the Japanese yew assumes a pleasing, widely branching habit. Its growth rate is slow, but it will eventually achieve a good size unless pruning shears are resorted to. Its lustrous, dark-green needles contrast with the abundantly produced seeds, each embedded in a bright red, fleshy aril-like covering, adding to the ornamental aspect of the plant. Another attribute that recommends its judicious landscape use is its tolerance of light shade. When a dark evergreen is needed in such a location, the Japanese yew should rank high on the list of candidates.

A painting by an unknown Chinese artist of George Rogers Hall's Shanghai residence in the coastal city where Hall founded the Seaman's Hospital.

Dr. Hall's Medical Career

But who was Dr. Hall, recently of Japan, who brought the Japanese yew to North America, who sent cases of exotic plants to his friend Francis Lee, and who generously offered the Parsons' Nursery horticultural treasures from his Yokohama garden? A native Rhode Islander, George Rogers Hall was born near Bristol in March of 1820 and graduated with the class of 1832 from Trinity College in Hartford, Connecticut. After graduation, Hall matriculated with the Harvard Medical School class of 1846. Once his medical education was completed, he sailed for China and the new opportunities that awaited enterprising Yankees in the wake of the Opium War. Settling in the foreign compound in Shanghai, Hall formed a partnership with another physician, John Ivor Murray, and in 1852, the two medics opened the Seamen's Hospital, with beds for twelve patients.

As the number of foreign vessels calling at Shanghai increased, Hall's medical practice flourished and the hospital staff was enlarged to include another physician and an apothecary. But despite the influx of American and European seamen requiring medical attention, the venture realized only small profits. Compared with the fortunes being made in commercial ventures, the hospital business hardly repaid the efforts involved.

Leaving the hospital and his medical practice behind, Hall joined with two friends in a business enterprise. His new partners were Edward Cunningham and David Oakes Clark, both from Milton, Massachusetts. These young New Englanders had been encouraged to enter the China trade by an old hand in the business, Robert Bennett Forbes, long time Milton resident and partner in Russell & Company.

Hall's decision to give up his medical career was undoubtedly a difficult one, yet pressing financial need forced his hand. In 1850 he had returned to the United States to marry Helen Beal, daughter of a Kingston, Massachusetts, lawyer. Together they returned to Shanghai, and in the space of four years three sons were born to the young physician and his wife. With the Taiping Rebellion looming on the horizon—an internal revolt that nearly saw the overthrow of the Manchu dynasty, a revolt fueled by government corruption and a socioeconomic decline that had worsened in the wake of the Opium War—Mrs. Hall left Shanghai with their three sons and returned to America in 1854. Sadly, the youngest son, George Rogers, Jr., died on board ship. With a young family to support, Hall decided to remain in China long enough to make his fortune before returning to the States to rejoin his wife and family.

A Garden in Yokohama

It was at this time that Dr. Hall turned to business interests, and with his friend, Cunningham, first visited Japan on Cunningham's schooner yacht, the *Halcyon*. Dealing in fine Chinese and Japanese curios—porcelain, lacquer work, bronzes, jade, and ivory—brought significant profits, but even more money could be made through speculation in gold and silver. A considerable fortune was accumulated in this way, and toward the end of his Oriental sojourn Hall decided to establish himself in Yokohama, where direct access to the recently opened Japanese market was possible.

In Japan, George Rogers Hall's latent interest in plants emerged, and he diligently set about assembling a collection of Japanese species in his Yokohama garden. Many plants were obtained from Philipp Franz von Siebold, who had returned to Nagasaki and his beloved Japan in 1859, the same year Hall moved to Yokohama. Robert Fortune visited Dr. Hall when he traveled to Yokohama in 1860, and arrangements were made whereby Fortune's collections could be held in the physician's garden until they could be planted in Wardian cases for shipment to England. Without a doubt, the Scots collector shared some of his collections with the Yankee physician turned trader and plantsman.

And so it was that a first New England-bound shipment of Japanese plants arrived in Boston in 1861, and a second larger consignment arrived in 1862 when Hall returned home to Rhode Island to be reunited with his family. George Rogers Hall was the first American to send a wide assortment of Asian plants to eastern North America, where most were destined to join their New World relatives in landscapes across America.

This article was excerpted from Dr. Spongberg's forthcoming book, *A Reunion of Trees* (Harvard University Press, 1990). This book is the first volume of a three-part Arnold Arboretum Sourcebook Series, funded in part by the National Endowment for the Humanities.

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The Ghost Bramble—*Rubus lasiostylus hubeiensis*

Richard Schulhof

The 1980 Sino-American Botanical Expedition has produced yet another horticultural gem.

To the chagrin of most of its inhabitants, winter renders the landscape of New England a quiet composition of browns and grays, speckled with evergreens and snow. Despite the somberness and length of our winter, the design of most cultivated landscapes does little to brighten the winter season, deferring always, it seems, to the more obvious bounties of spring. Yet there are plants that instill drama and beauty in the winter landscape, and make enjoyment of the garden more than a short, seasonal affair. The silver-stemmed brambles, appearing in the landscape as bold, arching stripes of white, are a notable example.

While species of the genus *Rubus* are most commonly known as providers of delicious fruit, or as flowering ornamentals, at least three species—*R. cockburnianus*, *R. biflorus*, and *R. lasiostylus*—are grown for the winter ornament of their silver-white canes. Although rarely found in American gardens and difficult to locate in the nursery trade, the silver-stemmed brambles are further recommended for their undemanding cultural requirements, their resistance to pests and diseases, and their adaptability to the stresses of urban environments.

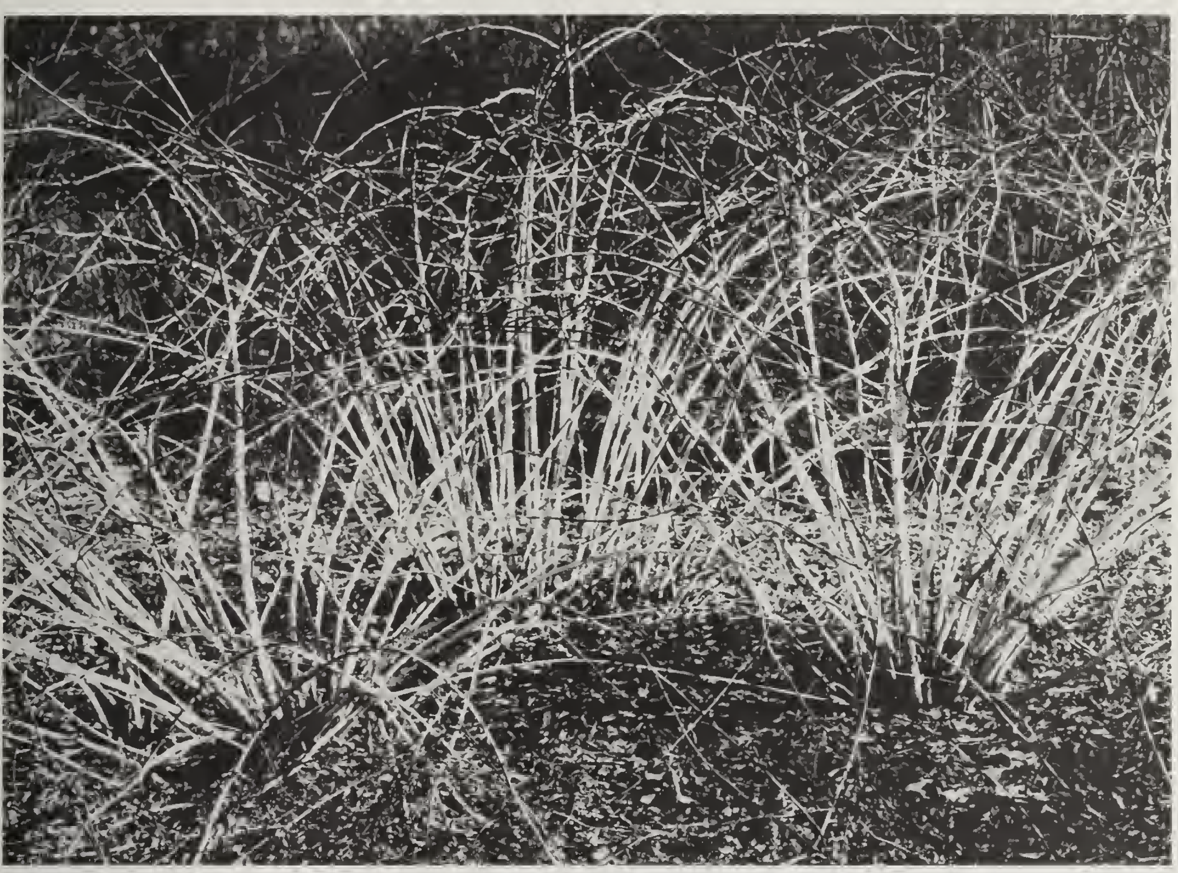
Introduction in 1980

Rubus lasiostylus var. *hubeiensis*, or the "ghost bramble," is a relatively recent addition to this ornamental group and perhaps the best among them for winter stem color and overall habit. Indigenous to the Shennongjia Forest District of Western Hubei Province in central China, the plant was found growing amidst *Sinarundinaria* thickets on steep slopes and in disturbed meadow areas. Seeds of this species were brought to the United States through the 1980 Sino-American Botanical Expedition, and seedlings raised in the Dana Greenhouses were planted out in the Arboretum's Bradley Rosaceous Plant Collection in 1985. It has since become one of our most talked-about plants during the winter months.

Appearing as if whitewashed or made of chalk, the whiteness of the canes derives from a thick, waxy bloom coating the stem. The arching six- to eight-foot plant develops a dramatic, fountain-like form, and is most remarkable for its ability to reflect light. On cloudless winter days at the Arnold Arboretum, the plant shines like a beacon, serving as a focal point for a broad expanse of landscape.

In summer, *R. lasiostylus hubeiensis* partly recedes from view, cloaked in foliage that is generally free of both insects and diseases. Of medium texture, the four- to six-inch-long leaves consist of three to five ovate leaflets that can be either lobed or unlobed. A cool lime-green color, they provide a pleasing contrast to the rust-red prickles and white stems. Notably, the prickles, though bristle-like, are vicious enough to make this plant an effective barrier shrub.

Attractive but unspectacular, the pinkish-white, dime-sized flowers appear twice a sea-



The general habit of the ghost bramble, Rubus lasiostylus hubeiensis, *growing at the Arnold Arboretum. Photo by Rácz and Debreczy.*

son. The first-year canes produce a terminal inflorescence at the end of the summer. The following spring, the canes branch profusely, with each branch producing an abundance of flowers. The orange-red fruits that follow are described by some as more showy than the flowers, and though they are edible, they seem to lack the rich flavor of commercial raspberries.

Maintaining the older canes for flower and fruit production does, unfortunately, mean sacrificing winter effect. In their second year, the canes tend to lose their glaucous bloom over the course of the winter, never regaining the striking whiteness of their youth. At the Arboretum, the unexceptional flowers and fruit are seldom seen as the plant is coppiced annually to produce a fresh crop of first-year canes.

Aside from several minute botanical distinctions, the variety *hubeiensis* differs from variety *lasiostylus* in having fruits that are orange-red instead of whitish. Also, in the two specimens available for comparison, *hubeiensis* appears to have a whiter and fuller waxy bloom on the stems.

Evidence that *Rubus lasiostylus hubeiensis* is the best of the silver-stemmed brambles comes from side-by-side comparison with *R. cockburnianus*, the most commonly cultivated member of the group. Not only does *hubeiensis* have a whiter and longer-lasting

The foliage of the ghost bramble. Photo by Rácz and Debreczy.

stem color—the true test for any "ghost bramble"—but also it possesses a more graceful and upright habit. Though debate persists in some quarters, performance comparisons at the Arnold Arboretum suggest the superior ornamental qualities of *R. lasiostylus hubeiensis* will, in time, make it the silver-stemmed bramble of choice in winter gardens across the country.

Propagation

Experiments with the propagation of this variety are ongoing at the Arboretum. Thus far, unlike most members of the bramble clan, *R. lasiostylus hubeiensis* has proven surprisingly difficult to propagate. Hardwood cuttings taken in August rooted with only a 10 percent success rate, while root cuttings removed in April did even worse, producing shoots at only a 9 percent rate. Fortunately softwood cuttings taken in mid-June produce more favorable results. Among a variety of hormone treatments, "Hormone Root B" (IBA 4,000 parts per million plus 15 percent Thyram) was the most

Close-up of the canes of the ghost bramble. Photo by Rácz and Debreczy.

successful, with 87 percent of 24 cuttings producing roots.

Though more trials are needed, the performance of *R. lasiostylus hubeiensis* in gardens on both the East and West coasts suggests that it is highly adaptable, tolerant of heat and drought, pest free, and amenable to either full sun or light shade. It has also proven to be a vigorous grower, spreading both by suckering shoots and by rooting cane tips that come in contact with the ground. At the Arnold Arboretum, the ghost bramble appears to be less invasive than many other *Rubus* species and can be effectively restrained by annual coppicing or by removing the suckers.

Attractive as a specimen or in a small mass planting, the ghost bramble would contrast beautifully against a carpet of *Vinca minor* or *Ajuga repens*, or against a dark evergreen backdrop. Hardy to at least USDA Zone 5, it should be tried as a barrier shrub, as a bank planting, or in a winter garden where its architectural form and striking color may be most effectively applied.

For information on obtaining cuttings of this plant, please write to:

Rubus, c/o Richard Schulhof
Arnold Arboretum
125 Arborway
Jamaica Plain, MA 02130

Richard Schulhof is a Mercer Fellow at the Arnold Arboretum.

The New USDA Plant Hardiness Zone Map

Peter Del Tredici

The publication of this map provides an opportunity to review the history of hardiness zone maps.

The new Plant Hardiness Zone Map, updated for the first time in twenty-five years, was released by the United States Department of Agriculture this past February. Unlike the previous edition, the map includes Alaska and Hawaii and is detailed enough to show county lines within the states. In addition, the map includes Canada and Mexico for the first time. According to Dr. Marc Cathey, Director of the National Arboretum in Washington, D.C., who oversaw the updating and production of the map, such expansion is appropriate given that "we share many plants, both native and introduced, with these countries."

The large-format map, measuring four feet by four feet, has eleven color-coded zones based on ten-degree (Fahrenheit) differences in the *average annual minimum temperatures*. As in the old map, each zone is divided into A and B regions based on five-degree differences. One new zone, Zone 11, has been added (including parts of Mexico, California, Hawaii, and Florida) where the average annual minimum temperature is above forty degrees Fahrenheit.

Data from 14,500 weather stations, gathered between 1974 and 1986, went into this update —more than twice as many stations as were used for the maps introduced in 1960 and 1965. With the additional data, small areas of microclimates are indicated for the first time. These are either cool pockets caused by mountaintop elevations or hot spots due to the heat of cities or protected valleys. The wealth of new data used to create the map also allows the borders of the zones to be drawn in more detail than before.

According to its makers, the new map does not seem to uncover any global warming trend, but it does reveal some regional changes. On both coasts, but particularly in the Southeast, temperatures are given as five to ten degrees cooler in the winter than on the previous map. Isolated pockets of the Northeast are slightly warmer; and sections of the Midwest show some minor changes, as do parts of Canada.

Since 1960, when the USDA published its first zone map, considerable confusion has arisen from the fact that it used different temperature ranges to define its zones than did its well-established predecessor, the Arnold Arboretum zone map. The publication of the latest 1990 USDA map, based as it is on more abundant and more accurate data than the Arnold Arboretum map, provides the perfect opportunity to resolve this confusion. At long last, the United States has a single, *standardized* zone map. There can be little doubt that this new USDA map is superior to any, and all, previous efforts.

Brief History of Hardiness Zone Maps

This is perhaps the appropriate time to take a brief look at the history of hardiness zone maps, the first of which was published in 1927, in Alfred Rehder's ground-breaking *Manual of Cultivated Trees and Shrubs*. This

NEWS

FROM THE ARNOLD ARBORETUM

The main reason that the Arnold Arboretum look as good as it does is because of the work of the Grounds Crew, pictured here, from the left: Patrick Willoughby, Superintendent of Grounds, Maurice Sheehan, Jim Nickerson, Mark Walkama, John Olmsted, Bruce Munch, Jim Papargiris, Michael Gormley, Bob Famiglietti, and Luis Colon. Missing from the picture are David Moran and Ken Clarke. Photo by P. Del Tredici.

Botanic Garden Meeting in Seattle

This June, six staff members of the Arnold Arboretum took part in the American Association of Botanical Gardens and Arboreta annual meeting hosted by the Center for Urban Horticulture at the University of Washington in Seattle.

Richard Schulhof gave a hands-on demonstration of the Arnold computer mapping and display system and its integration with the Arboretum's plant inventory through BG Base. This mapping application was recently developed with the support of an Institute of Museum Services grant. Jennifer Quigley led a discussion of institutional considerations in developing a computer mapping system. The presentations were part of a sold-out pre-conference workshop on computer developments for botanic gardens. Gary Koller and Richard Schulhof spoke in the session "Plant Potpourri," where they presented *Sasa veitchii, Asarum splendens* (formerly *Asarum magnificum*), and *Rubus lasiostylus* var. *hubiensis*. Nan Sinton, who serves on the Professional Staff Training and Development Committee, led off the "Education Marketplace" meeting with a presentation on "Building New Audiences for Botanic Gardens." Also attending meeting were Arboretum Director Bob Cook and Tour Coordinator Jim Gorman.

The four-day meeting brought together nearly five hundred botanic garden professionals from North American public gardens. In addition to at-tending a varied schedule of workshops and conferences dealing with all aspects of botanic garden operations, the participants visited major gardens in the Seattle area and explored the gardens and nurseries of the Pacific Northwest. Next year's meetings will be in Minnesota.

The LEAP Program

by Dr. Robert Cook

While I was director of Cornell Plantations, the National Science Foundation awarded us a grant to create an elementary science curriculum using plants as a friendly medium to teach children basic concepts in biology. Called LEAP (LEarning About Plants) this K through 6, hands-on curriculum is currently being successfully employed in the Ithaca, New York school district. Key to this success has been the training of teachers in a new pedagogical philosophy upon which the lessons are built. In 1991 the Arnold Arboretum, with seed money provided by a generous gift from the Stratford Foundation, will initiate a program of teacher training to bring this curriculum and its philosophy to the Boston area.

LEAP is unique because it is based on our current understanding of the way children learn. The young mind, even at the earliest ages, comes to the classroom with many misconceptions about the way the world works. Children will cling tenaciously to their personal world view despite the efforts of teachers because these misconceptions explain things from the child's perspective. Lessons in school are superficially learned only to achieve good test scores, and misconceptions persist. Only when the child confronts the contradictions between his or her own explanation and the actual way something works can meaningful, long-term learning occur. Thus teachers, to be truly effective, must begin with an understanding of the diversity of misconceptions in the minds of children. LEAP, when combined with professional training, can equip teachers with classroom strategies designed to help children confront their misconceptions and successfully construct more accurate conceptions.

Why should the Arnold Arboretum start training teachers? First, we already provide assistance to many schools through the excellent work of Diane Syverson in our Children's Program. LEAP will simply be an expansion to professionalize our efforts. In addition, there is a national crisis in science education. Teachers are without the means to provide science instruction, and we have a moral responsibility to address this problem with our considerable resources and experience. We are, after all, an organization that has always been dedicated to professional training. Finally, I suppose, this director of the Arnold Arboretum is at heart a teacher himself, and he believes in extending a hand to professional colleagues in a time of great need.

Dr. Robert Cook (third from left) shown with Barbara Bush and a group of directors of other Massachusetts institutions that received grants from the Institute of Museum Services in Washington, D.C. The Arnold Arboretum was awarded a $75,000 planning grant.

ENDANGERED PLANTS EXHIBITION

Original artwork portraying endangered plants was selected in cooperation with the Center for Plant Conservation (CPC) from artists in the Boston area. The works may be viewed daily in the Hunnewell Visitor's Center from 10 am to 4 pm through October 20th.

THE HERB GARDEN AT THE CASE ESTATES

In May of this year, The New England Unit of the Herb Society of America, in cooperation with the Arnold Arboretum, created a small display garden near the front steps of the Schoolhouse at the Case Estates. The purpose of the garden is to increase visitors' knowledge of herbs and to introduce the delights of growing and using them. More than twenty-two varieties of fragrant and medicinal plants are attractively arranged with stepping stones, around an ornamental bee hive. Visitors are invited to enjoy the remarkable variety of leaf colors, shapes, textures, and fragrances in the garden.

FALL BOUNTY AT THE ARBORETUM

From a first-hand report on progress in developing a sustained-management strategy for the tropical rain forest to illustrated lectures on American garden history, through hands-on propagation workshops, the Arboretum offers a rich cornucopia of outstanding programs to fit a wide range of interests. Here are some highlights of the Fall season: Dr. Peter Shaw Ashton, professor of Dendrology at Harvard University, and former Director of the Arnold Arboretum, has come back recently from meetings in Southeast Asia, where he worked with an international group of concerned social scientists and biologists to plan long-term management of the tropical forest. "Report from the Rain Forest," his slide-lecture at 2 p.m. on Sunday, November 25, at the Hunnewell Visitor Center, will bring up-to-the-minute details of this unprecedented multinational effort to save a global resource.

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Three propagation seminars attest to the popularity of this activity in Arboretum circles. Jack Alexander, the Arboretum's Chief Plant Propagator, will run an all-day session starting at 9:30 a.m. on Saturday, October 20, at the Dana Greenhouse on "Rare and Hard-to-Propagate Woody Plants." In this seminar-workshop horticultural professionals and advanced amateurs will learn specialized propagation techniques, take part in discussions, and collect on the Arnold Arboretum grounds.

David Smith, former Director of Horticulture at White Flower Farm in Litchfield, Connecticut, will give a lecture/demonstration workshop on "Classic Plants for the Mixed Border"—Russell lupines, Simons-Jeune phlox, and Frank Bishop delphinium hybrids, as well as shrub roses and tree peonies, in two all-day sessions beginning at 9:30 a.m. on Sunday, October 21 or on Monday, October 22 at the Dana Greenhouse. Participants will get hands-on experience propagating perennials and will get to keep the results of their efforts.

Dr. John Einset of Enimont, America, Inc., and former staff member at the Arnold Arboretum, will explore the latest developments in plant tissue culture at an all-day seminar to be held from 9:30 - 4:00 p.m. on Saturday, November 3 at the Hunnewell Visitor Center. He will discuss methods and equipment for clonal multiplication of plant material in "The Latest in Micropropagation Technology and Research."

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In an entirely different vein, Ruthanne Rogers, garden historian and president of the New England Garden History Society, will present a slide-lecture on the development of the designed American landscape, from the native American garden through 20th century. "American Gardens: A Proud History" will be offered on Wednesday, November 14, from 7:00-8:00 p.m. at the Hunnewell Visitor Center.

For further information on these and other programs contact the Education Registrar at the Arnold Arboretum.

RECYCLING CONFERENCE

On Saturday, November 10, 1990 at the University of Massachusetts, Boston Harbor Campus, the Massachusetts Audubon Society is sponsoring a conference on RECYCLING FUTURES, designed to give participants hands-on ways to respond to the regional, economic, and environmental aspects of recycling. With an emphasis on the economics and environmental values of recycling at home and in the workplace, the program will address a variety of topics through workshops with visual presentations and guest speakers.

For more information contact: Conference Coordinator; South Great Road; Mass. Audubon Society; Lincoln, MA 01773

BOOKSTORE OFFERINGS

The Arboretum Bookstore will celebrate the Fall season with the following new publications:

A Reunion of Trees: The Discovery of Exotic Plants and Their Introduction into North American and European Landscapes by Stephen A. Spongberg.

Published at $35.00, **special member's price:** $27.50 until 12/30/90.

Botany for Gardeners : An Introduction and Guide by Brian Capon $29.95

The Healing Forest: Medicinal and Toxic Plants of the Northwest Amazonia by Richard Evans Schultes and Robert F. Raffauf: $59.95

Stop by the store 10 am to 4 pm daily or call (617) 524-5383 for mail order information.

Ginkgo biloba *growing on Tian Mu Shan in eastern China*

Arnoldia editor Peter Del Tredici attended an international conference on "The Tree" (*L'Arbre*) in Montpellier, France during the week of September 10-15. He was joined by participants from Europe, Africa, the Soviet Union, Asia and North America. Peter presented a paper on "The Architecture of *Ginkgo biloba* "which included some of the results of the recent research in eastern China. As well as being editor of *Arnoldia*, he is working toward his PhD in Biology at Boston University, and the ginkgo is the subject of his dissertation.

MEMBERS' SPECIAL LECTURE AND RECEPTION

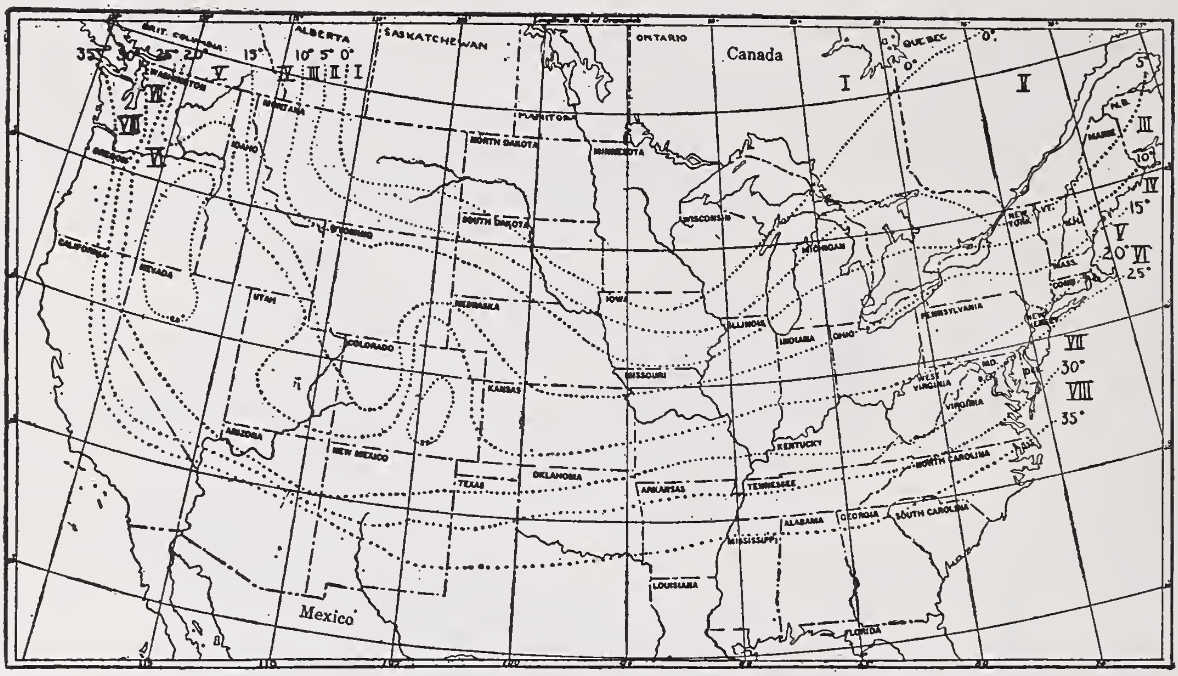
A Reunion of Trees, Thursday, October 25, 7:00 PM.

Dr. Stephen Spongberg, Horticultural Taxonomist for the Arnold Arboretum and author of this soon to be published book about plant exploration and introduction (see excerpt this issue) will discuss the creation of his book and describe the two other forthcoming volumes of this guidebook series by librarian Sheila Connor and curatorial associate Ida Hay. Following the brief lecture, members are invited to join Director Dr. Robert Cook and other staff for wine and cheese while Dr. Spongberg signs copies of his book, available to members at a special discount price.

The new 1990 USDA Hardiness Zone Map.

early attempt divided the cold temperate United States into eight zones characterized by *uniform* five-degree (Fahrenheit) differences in the *lowest mean temperature of the coldest month.* All the plants listed in the *Manual* were assigned, at least tentatively, to one of the hardiness zones. As can be seen in the accompanying figure, the lines separating the zones were very approximate.

Rough as it was, however, this map stood alone until 1938 when Donald Wyman, using data from a U.S. Weather Bureau map for the years 1895 through 1935, redrew its contours based on the *average annual minimum tem-*



The first Hardiness Zone Map from the first edition of Alfred Rehder's Manual of Cultivated Trees and Shrubs, *published in 1927. The contour lines are based on the lowest mean temperature of the coldest month.*

The second Hardiness Zone Map from the second edition of Rehder's Manual, *published in 1940. The contour lines shown here are based on average annual minimum temperatures.*

peratures, and published a new map in his book *Hedges, Screens and Windbreaks*. While based on a different temperature standard than Rehder's map, the contours of the two are remarkably close. Wyman's new map was published in the second edition of Rehder's *Manual* (1940), and the hardiness ratings of the various plants were adjusted accordingly. Wyman, with assistance from various Arnold Arboretum staff members, updated his map in 1951, 1967, and, ultimately, in 1971.

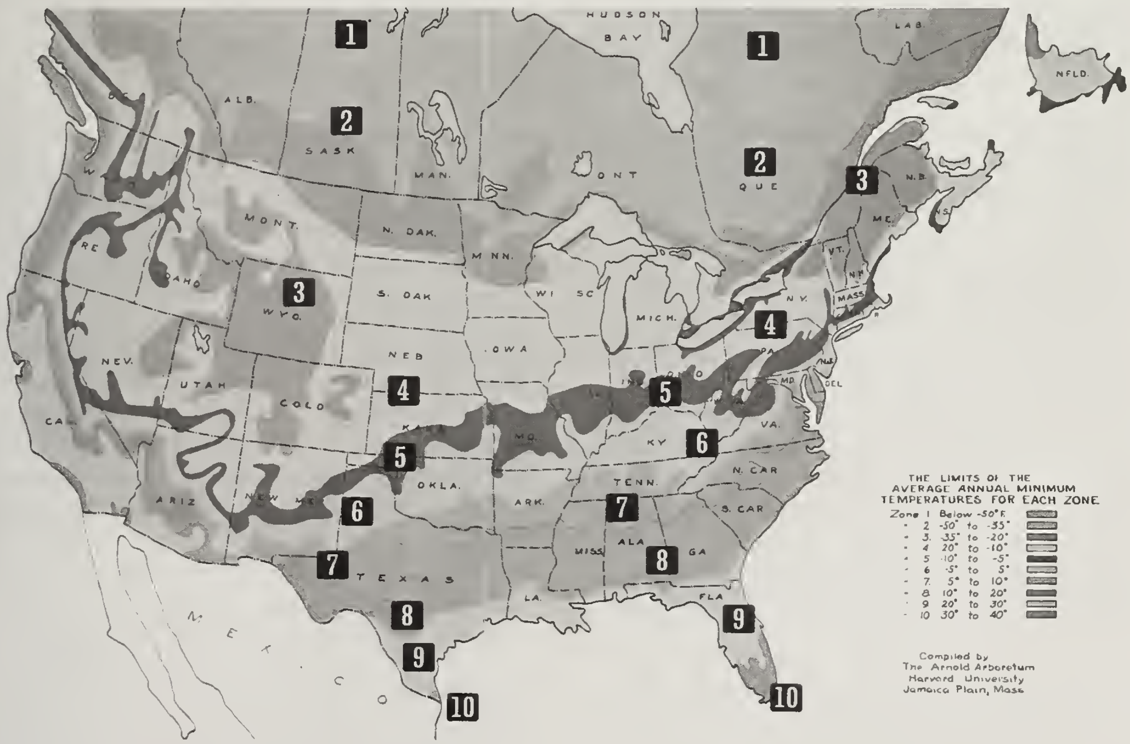
Unlike Rehder's original map, however, Wyman's hardiness zones were not based on a *uniform* number of degree differences. Some of his zones had 15-degree ranges in the average annual minimum temperature, while others were based on 5- or 10-degree ranges. In particular, it is worth noting that Boston is located in one of the two 5-degree zones.

This lack of uniformity was called into question in 1960 when the USDA produced its first hardiness zone map with zones based on uniform ten-degree ranges in average annual minimum temperature. It is interesting to note that while both the USDA and the Arnold Arboretum maps were based on the same weather station data, their differences were only in *where* the contour lines were drawn. From this perspective, it is clear that the uniformity of the USDA zones is preferable to the arbitrary Arnold Arboretum zones.

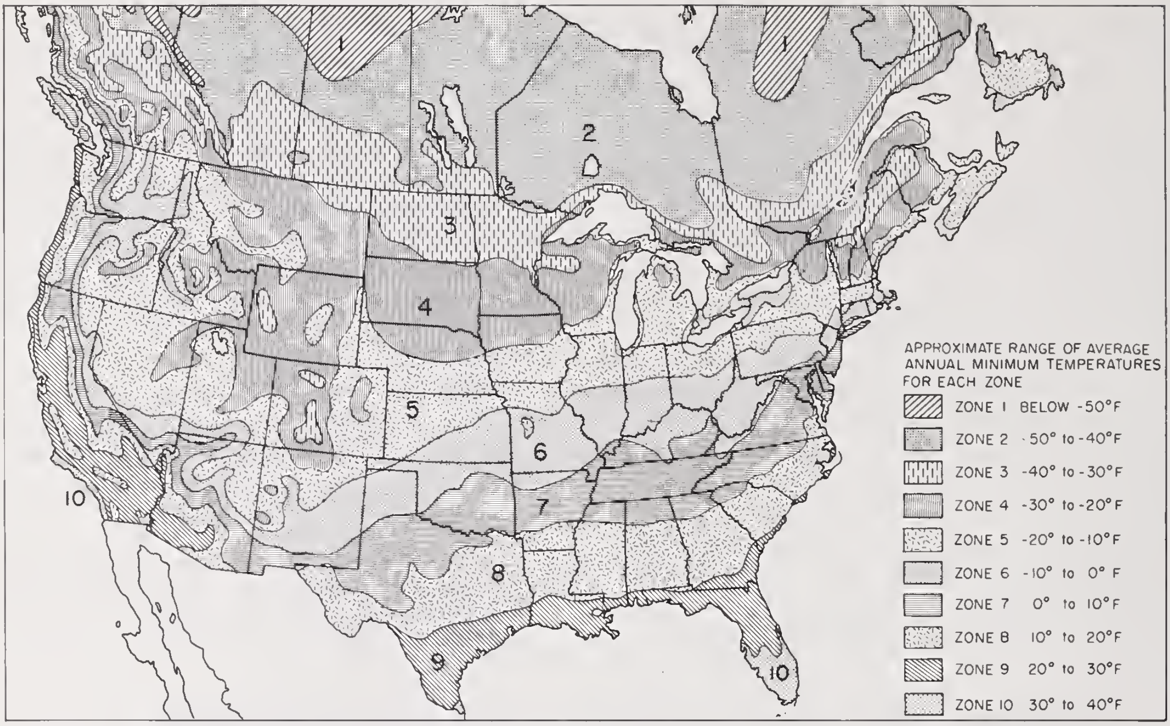
Limitations

In considering national hardiness zone maps, one should not overlook the intrinsic limitations of the whole concept of hardiness zones. Alfred Rehder was the first to point out these limitations in his 1927 *Manual*:

> There are, however, many other factors besides temperature in winter which will influence the hardiness and growth of certain plants, as soil, its physical as well as chemical composition, exposure, rainfall,



The Arnold Arboretum Hardiness Zone Map from 1967.



The USDA Hardiness Zone Map published in 1960.

> humidity of the air, shelter from cold winds. As a rule one may say that plants stand cold better in a drier situation than in a wet one, and that deciduous trees and shrubs prove hardier in a more exposed situation and in a climate with higher summer temperature, while evergreen plants prefer a sheltered situation, and like a more humid climate and less extreme summer and winter temperatures.

Indeed, as most gardeners have learned during the 1980s, taking "microclimate" variations into account often allows gardeners to grow plants that, according to the hardiness maps, should not survive in their area. At the Arnold Arboretum, for example, it is known that the fluctuating temperatures of early spring can be more damaging to some plants (particularly those from northeast Asia) than the minimum winter temperatures.

Taken with a hefty dose of skepticism, however, hardiness zone maps do provide gardeners with a useful guide to the plants they can grow safely in their area.

Availability

Copies of the new USDA Hardiness Zone Map are available through the Superintendent of Documents, Government Printing Office, Washington, DC 20402, for $6.50 (Misc. Publ. 1475); or from the Arnold Arboretum Bookshop, 125 Arborway, Jamaica Plain, MA 02130.

Peter Del Tredici is Editor of *Arnoldia*.

The *Dendrological Atlas:* A Legacy in the Making

An interview with Hungarian botanist Zsolt Debreczy on his life's work — a proposed fourteen-volume manual of trees and shrubs.

If one were to take literally the adage "one picture is worth a thousand words," then the *Dendrological Atlas* project, with its proposed 3,300 full-plate drawings and 20,000 photographs, is going to be worth millions. This monumental project is the dream of Hungarian botanist Zsolt Debreczy of the Museum of Natural History in Budapest, who has been working on it since 1971. Upon completion, the *Atlas* is projected to cover 6,500 species and 7,200 cultivars of cold-hardy, woody plants in fourteen volumes, with a grand total of 12,000 pages.

Working in collaboration with Debreczy is his wife, Gyöngyvér Biró, a microbiologist by training, who does the literature searches and helps with the writing and field work. Botanist-photographer István Rácz has been working with Debreczy since 1976, producing the photographic documentation for the project. In addition, several illustrators, including the late Vera Csapody, have worked with the team to produce pen and ink illustrations based on Debreczy's pencil sketches.

The *Dendrological Atlas* team has traveled extensively throughout the temperate zones including Asia, Europe, North America, and North Africa. They first came to the Arnold Arboretum for a brief visit in 1983, and in 1988, as recipients of a Mercer Fellowship from Harvard University, they were able to return.

The goal of the *Atlas* project is to create a comprehensive, beautifully illustrated work that includes all the trees and shrubs of the temperate climate zones of the world. The work builds upon the foundation laid by such authors as Alfred Rehder, W. J. Bean, and Gerd Krüssmann but adds totally original illustrations, visually oriented keys, and in-depth taxonomic descriptions.

According to plans, the *Atlas* will consist of two parts: Gymnosperms (Volumes 1 to 3) and Angiosperms (Volumes 4 to 12). The format of the work can be seen on the following pages. Debreczy, Rácz, and Biró hope to finish the project by the year 2000, almost thirty years after the the first drawings were made.

The following interview with Zsolt Debreczy addresses some of the questions frequently asked the *Dendrological Atlas* team regarding this ongoing project.

When did you start working on this project?

I started it in 1971 with Dr. Vera Csapody, the renowned Hungarian plant illustrator, who had published or illustrated almost 60 books before I started to work with her. Her first undertaking, with the great research botanist Sándor Jávorka, was on the Hungarian flora—with over 4,200 drawings of the plants native to the Carpatho-Pannonian region (historical Hungary), published in 1934. After I wrote a successful book on the winter-hardy evergreens with Vera Csapody's illustrations, we started the *Dendrological Atlas* project in 1971.

Was the project originally planned to be as large-scale as it now is?

Not at all! At first we planned simply to illustrate Rehder's *Manual*, the most widely used reference book for identification of temperate trees and shrubs. We started with small, twodimensional illustrations based mainly on herbarium specimens. Following my sketches, Vera Csapody immediately worked them out in black ink. As time went on, we used more and more living specimens for making the drawings and of course they looked different from those made from pressed specimens. It soon became clear that a consistent style, a "single voice," was needed to bridge this problem. Vera Csapody was in her eighties when we switched our format to produce full-page, three-dimensional illustrations. This happened in 1975, and it marks the beginning of the project in its present format. We also had to solve the problem of consistency in the photographs, which we resolved in 1976 when István Rácz joined the team. Later my wife Gyöngyvér Biró and some younger illustrators joined the group, and the *Atlas* became a major project of the Museum of Natural History in Budapest.

The collecting trips started in 1977. I organized them to cover most countries in Europe, North America, North Africa, the Caucasus, and Asia Minor. We worked in the best living collections of Europe, including many English parks and arboreta, and we studied in the best herbaria as well. We soon realized that if every major woody plant species in the temperate zones was to be illustrated with two pages, this would require at least five thousand pages of illustrations. That is when the *Atlas* became a whole series of books. To date, almost three thousand line drawings have been done, and our photo archive now contains more than sixty thousand pictures from which the photo plates will be assembled.

The scope of the project seems to invite collaboration. Are you working with scientists in other parts of the world?

We have already received tremendous help from many institutions, colleagues, private persons, and even family members. Without their help and generosity, our present status could never have been reached. In fact, this project is being supported by all those people who maintain the herbaria and living collections we use for study and for documenting specimens.

At first we worked with various Hungarian and Central European institutions and arboreta, and later with the excellent German, Dutch, Belgian, and English collections, such as Bedgebury Pinetum and Kew Gardens. And now we are particularly pleased to be able to work at the Arnold Arboretum, built by such greats as Sargent, Wilson, and Rehder. Today we are cooperating with numerous research fellows and scientists on a consulting basis, and we incorporate their comments and suggestions into our work.

Your project is as much art as it is science. How do you see these two often conflicting elements fitting together in your work?

Many of the illustrations may have artistic merit. The illustrator and photographer are limited by the accuracy requirements of science. The illustrations and photographs have to reflect the beauty of nature, but they do not have the same kind of freedom that art does. In the *Atlas*, the text and the pictures share the same pages; they transmit different information in complementary ways. We intend our work to be precise and correct in terms of science, but much of this information may be out-of-date after a few years, or decades. We believe the illustrations will retain their value long after some of the taxonomy has been revised.

In the same way, you try to fuse taxonomic botany and practical horticulture. Is this not also difficult?

We are botanists but feel we are part of both camps. While we "grew up" doing extensive herbarium and field work, we have spent far more time in living collections than most botanists. Horticulture can produce a tremendous amount of information regarding plant morphology and morphological diversity, but it is not always appreciated by botanists who find the data provided confusing or unreliable. The botanists, on the other hand, have the

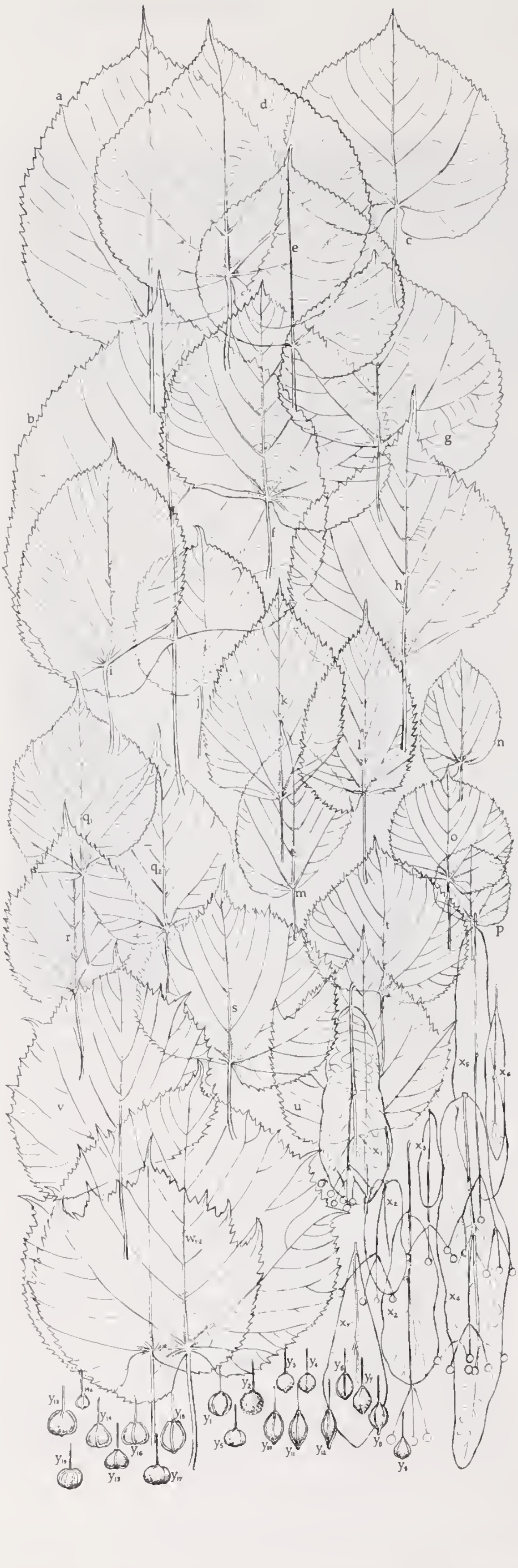
The Dendrological Atlas *team, from left: István Rácz, Gyöngyvér Biró, and Zsolt Debreczy. The film for this photograph, along with many of those taken for the* Dendrological Atlas *project, was generously donated by ORWO Filmfabrik in Wolfen, Germany. Photo by P. Del Tredici.*

necessary tools and experience to interpret the data and keep track of the proper classification.

A project of this magnitude seems overwhelming because it assumes that you know about all species of trees and that you will live long enough to complete it. Do you ever have doubts about your ability to finish this work?

I was thirty years old when I started this project and I was often told: "You are too young to start working on a project like this!" Now it would be too late for me to start a project on this scale. For the past nineteen years I have been working extensively on vegetation mapping and preparation of the *Atlas*. During this period I have not published anything in the field of taxonomy and I am glad that I did not. Rather, I worked with numerous colleagues and traveled as much I could, devoting most of my time and energy to *seeing* and *understanding* the problems of the whole temperate world dendroflora. As a

continued on page 28



Big-leaf Linden (Large-leaved Lime)

Tilia platyphyllos SCOPOLI (1772)

T. europaea LINNAEUS *in part (1753), T. officinarum* CRANTZ *in part (1762), T. grandifolia* EHRHART *(1790)*

Corresponding plates: ....

Chinese: 大叶椴
French: ***Tilleul a grandes feuilles, Tilleul femelle***
German: ***Sommerlinde, Grossblättrige Linde***
Hungarian: ***Nagylevelű hárs***
Italian: ***Tiglio nostrale, Tiglio d'estate, Tiglio a foglie grandi***
Polish: ***Lipa wielkolistna***
Russian: ***Липа Крупнолистная, Липа плосколистная***
('Lipa Krupnolistnaya', 'Lipa ploskolistnaya')
Spanish: ***Tilo, Teja, Tillera (Arag.); Tejo blanco (Burgos); Tell, Tey (Catal.); Tila (Serrania de Cuenca); T. de Holanda (Arg.)***

NATIVE TO: Europe, Asia Minor, West-Asia
VERTICAL RANGE: 10 to 1.900 m
CLIMATIC ZONE: VIII-VI-VII, X(VI-V-IV)
HARDINESS ZONE: 4
ECONOMIC IMPORTANCE: occasionally as timber; excellent bee-forage
HORTICULTURAL VALUE: good specimen tree; the first flowering among the lindens

MORPHOLOGY: **TREE** to 40 m; **CROWN** oval, **TRUNK** straight, often multi-stemmed, without swollen burrs; **BARK** smooth, gray when young with rows of lenticels; dark gray and deeply furrowed when old; main **BRANCHES** upright at first, later horizontally spreading, light gray to brownish-gray and smooth when young, dark gray with suberous lines of longitudinal rows by age; **BRANCHLETS** greenish to reddish-brown, sometimes red above, green below with dense or scattered, upright, straight, simple hairs, rarely glabrous; **BUDS** (4 mm) globose to subglobose with two-three outer scales, dark reddish-brown above and hairy with elate, straight, simple hairs; **LEAVES** (1.5-5 + [6-12] x [4-11] cm) typically orbicular-ovate, rarely oblongish or trilobate, abruptly acuminate at apex, cordate, obliquely cordate, sometimes truncate at base, sharply serrate; dull green and scattered pubescent above (rarely, except on the principal veins, glabrous), usually densely pubescent below with yellowish-white, straight, simple hairs; axillary tufts represented by dense, simple, straight, at first whitish, later grayish or yellowish-brown, non-tufted hairs, normally extended along the main ribs; **PETIOLE** (1.5-5 cm) normally pubescent, occasionally glabrous; **INFLORESCENCE** 3-7 flowered cyme with membranaceous, thinly veined, lanceolate **BRACT** (6-13 x 0.8-1.7 cm), usually obtuse at the end, more or less pubescent only along the venation above, glabrous below except for the midrib near the junction of the peduncle; **FLOWERS** 12-16 (20) mm in diameter, light yellow, of "open type": leaves of the perianth spread 180° or more; **SEPALS** (4-6 mm) imbricate, somewhat stellate tomentose at, and near the apex, long hairy at their margin and inside; **PETALS** (6-8 x 2-3 mm) oblanceolate, exceeding the sepals, light yellow; **STAMENS** (60; 8-10 mm) exserted: longer than petals; **PISTIL** (up to 12 mm) exserted; ovary subglobose, cordate in outline; **FRUIT** (8-10 x 6-8 mm) very variable in size, form and other features; typically 5 ribbed (rarely almost smooth and globose), thick shelled, densely tomentose or pubescent; **SEED** (3-4 x 2-3 mm) dark shiny brown.

HABITAT: *Tilia platyphyllos* is a common European linden, distributed north to Scandinavia, south to Hispania, to the Appenin- and Balkan Peninsula, and extending east to Asia Minor and West Asia.

Preferring a humid climate, this linden is a constant component of the beech, hornbeam, peduncle and sessile oak forests of Western and Central Europe (associating with *Fagus sylvatica, Carpinus betulus, Quercus robur, Q. petraea* etc.). This species is also one of the main components of the Central

◁ **Leaf- bract- and fruit variability within *Tilia platyphyllos***
(Scale 40 % here) This is the way that morphological variation, with the necessary data, will be presented in the *Atlas*. The big-leaf linden is a particularly variable species; normally, the interpretation of variation will require less space.
(A pencil drawing by Zs. Debreczy)

Europaean ravine forests where it usually grows on rocky, north facing slopes with *Acer platanoides*, *A. pseudoplatanus*, *Cornus mas*, *C. sanguinea*, *Corylus avellana*, *Fraxinus excelsior* and *Staphylea pinnata*.

In areas of low humidity and relatively little rainfall (less than 550 mm per year), *T. platyphyllos* tends to colonize narrow valleys and other level depressions that collect water. In dryer woodland areas such as the Turkey oak-sessile oak forests of southern C. Europe, it tends to form a small multi-stemmed tree or subcanopy shrub.

The distribution of *Tilia platyphyllos*

VARIABILITY and RELATIONSHIPS: Although there is great variability within the species, *T. platyphyllos* is easily recognized since it is the only linden with dense, simple hairs both on the branchlets and on the leaf surfaces. It is also one of the six European *Tilia* species that have no staminodes in their flowers.

Other distinguishing characteristics that separate this species from other European lindens are: 1) its prominent tertiary venation (except for *T. begonifolia*); 2) its axillary hairs (whitish at first, yellowish later) are simple and perpendicular to the corresponding veins, while *T. cordata*, *T. dasystyla* and *T. europaea* have tufts with tangled or curly hairs and in *T. begonifolia* and *T. euchlora* the hairs are perpendicular but tufted; 3) the fruit shell in *T. platyphyllos* is very hard and ribbed while that of the other European species is thin or medium-thick shelled and less or non-ribbed.

Mainly on the basis of the exceptionally variable leaf, inflorescence, flower and fruit characteristics, over one hundred varieties and more than thirty reputed hybrids had been described during the first decades of the century (see appendix) from both wild and cultivation. Recent studies show that these variants and "hybrids" are simply forms of the species, some of which, after a careful selection, could have horticultural merit.

CULTIVATION: In Europe, *T. platyphyllos* is often planted in large parks or along avenues. It performs best in areas with a humid, maritime climate. This tree has been known to live to be 900 - 1,000 years old. There are many old specimens growing in Europe, of which a famous one in Oldenburg, Germany exceeds 14 m in girth and is thought to have been planted around 950. This linden is an excellent lawn tree but not appropriate for use as street tree for it is not very resistant to pollution and is often attacked by aphids and sooty mold.

CULTIVARS:

'AUREA' *(T. platyphyllos var. Aurea [LOUDON] KIRCHNER, T. grandifolia var. aurantia HORT.)* [cultivated since 1838] Form with yellow branchlets and buds conspicuous in winter. There are numerous clones under this name; one has normal habit but slow growth with relatively small leaves, which are truncate or slightly cordate at base with strikingly white tufts below, later becoming brownish.

'BANGITA' [J. WAGNER, 1931, Hungary; prop. cv. nov.] Tree of normal growth, with very small (1 + [4-5.5]x1.3 cm) leaves most of which are somewhat roundish oblong-ovate, minutely serrate but deeply trilobed on the end of the shoot, reminding a tiny 'Vitifolia' leaf. The inflorescence is a short (5 x 3 cm) cyme with small bract (1 + 3 + 2 cm) and relatively large (ø 1.2 cm) flowers. It was found and has been cultivated at Eszterháza (Fertöd), W. Hungary, in the property of Count Eszterházy.

'BROWNII' *(=T. p. ssp. Braunii [SIMONKAI] C. K. SCHNEIDER ?)* Pyramidal tree with ascending branches and branchlets reaching 5 m in height and 3 m in width at about 15 yrs. The leaves are similar but somewhat smaller than those of the species.

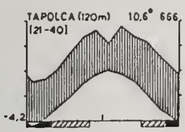
'COMPACTA' [known since about 1930] Slow-growing, bushy tree with globose, compact habit, reddish-brown hairy branchlets and smaller leaves (3 + 7x5 cm). The oldest known specimen was 2 m tall when 30 years old and 4 m 10 years later.

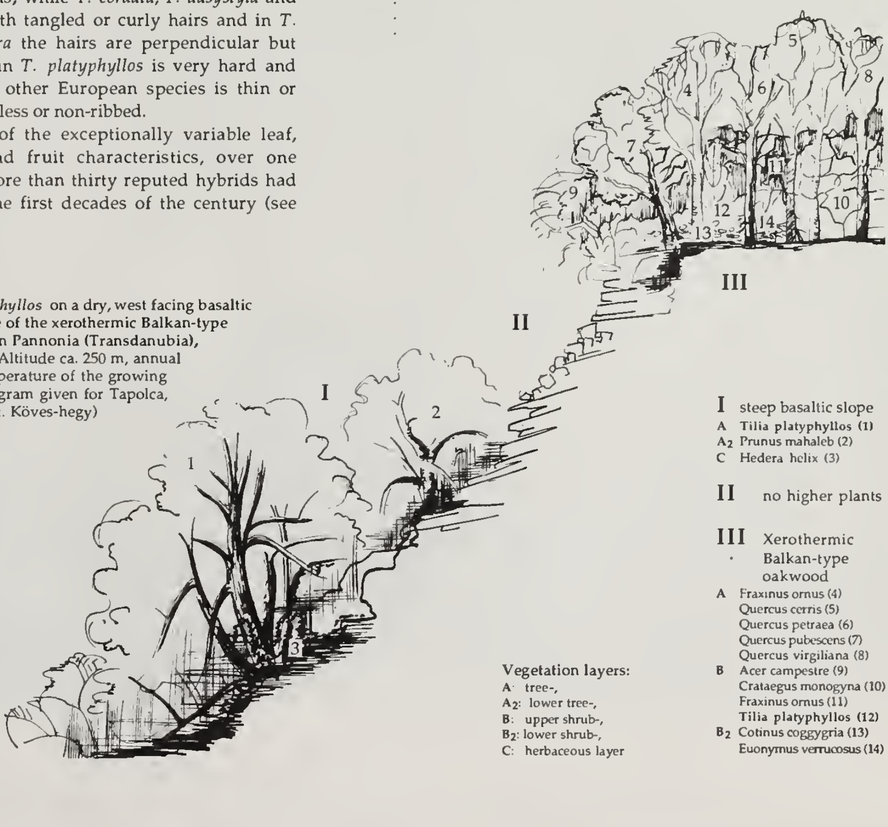
'FASTIGIATA' *(T. platyphyllos f. fastigiata REHDER, T. grandifolia pyramidalis BEISSNER)* [known since 1854] Pyramidal form of cuneate-oval habit with ascending branches and branchlets and normal vigor; about 6 m broad at a height of 18 m.

'FASTIGIATA LACINIATA'

(cont.)

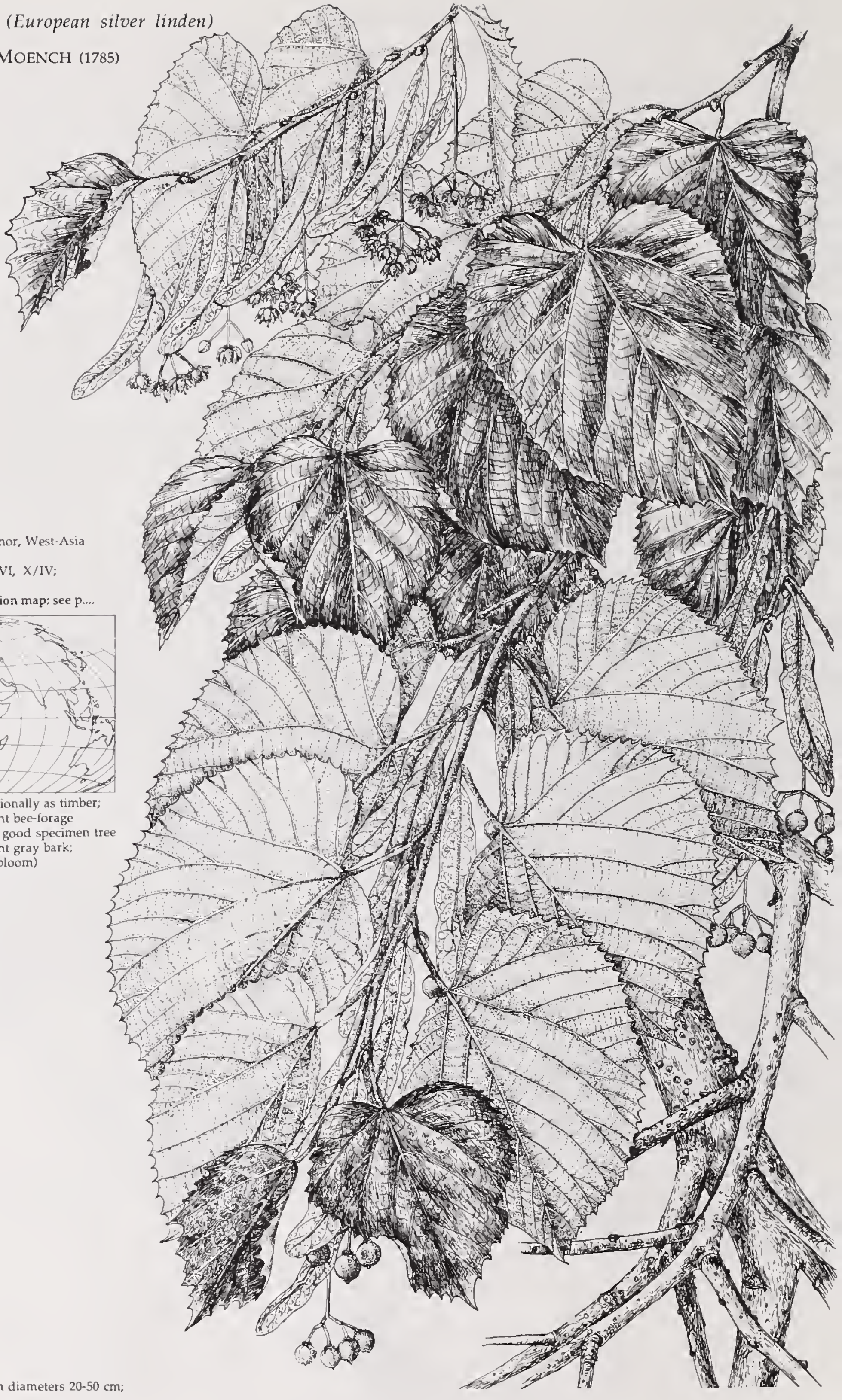
The occurrence of *Tilia platyphyllos* on a dry, west facing basaltic slope within the climate-zone of the xerothermic Balkan-type oakwood of Mt. *Köves-hegy* in Pannonia (Transdanubia), Hungary, Lake Balaton area. Altitude ca. 250 m, annual rainfall 680 mm, average temperature of the growing season 18°C. (The climate diagram given for Tapolca, within a 10 km distance of Mt. Köves-hegy)





Hungarian silver linden (European silver linden)

Tilia tomentosa MOENCH (1785)



NATIVE TO: SE. Europe, Asia Minor, West-Asia
VERTICAL RANGE: up to 1.500 m
CLIMATIC ZONES: VI/V-V, VII/VI, X/IV;
HARDINESS ZONE: 4
Description with detailed distribution map: see p....

ECONOMIC IMPORTANCE: occasionally as timber; local uses as handcrafts; excellent bee-forage
HORTICULTURAL VALUE: very good specimen tree (attractive winter habit with light gray bark; ornamental foliage; abundant bloom)
FL: Mid- to late July

Photo plate:
Specimen 90 yrs; height 22 m; stem diameters 20-50 cm;

Tilia tomentosa Moench

continued from page 23

result, I now have a deeper understanding of the diversity of this flora and a more solid basis on which to make taxonomic judgments than I would have had earlier in my career.

Undertaking a project like this does not necessarily mean that one knows everything about all kinds of trees. The value of this work, we believe, stands on its genuineness: while using others' work, the *Atlas* is intended to give our own summation of the temperate dendroflora.

Are you describing any new species or varieties in the *Atlas*, or are you working primarily with preexisiting taxonomies?

This work differs from those produced in the era of plant exploration during the early part of this century. Taxonomic revisions will be presented in the *Atlas*, but these will be new combinations rather than descriptions of new taxa. New treatments of selected groups will be published elsewhere.

How do you determine what species to include and what to exclude in the *Atlas*? Many on the proposed list of woody plants you include in your project are not very hardy. What makes them part of your geoflora?

We define the "hardy dendroflora" as the woody flora of the winter-cold areas of the world. The dominant part of this "geoflora" is growing in the Northern Hemisphere and is a remnant of the so-called Paleoarctic or Arcto-Tertiary flora. The species of this flora became established in their present locations during the cooler periods of the Tertiary period. In a sense, they were preadapted to survive the severe cold of the glaciations long before they occurred. Though this flora is an extratropical one, some of its members extend to subtropical-tropical high mountains as a result of recent migrations, and are therefore treated in our study. Our selection of plants is based on scientific considerations rather than on merely horticultural criteria regarding the hardiness of certain woody plants.

Whom do you envision as the audience for your work? In what ways do you think that it will be an improvement upon existing works?

In general, we believe that the book will be used by both professionals in botany, horticulture, and silviculture as well as by amateurs. Botanists will use the written keys and the illustrative discussion of the variability and relationships given for each species. Others may find more useful the visual keys, the morphological illustrations, or the accounts of the cultivars. We hope many people will be captivated by the beauty of the dendroflora. The work is intended to be an improvement in keys and in the discussion of the introduction of the woody plants. It will also be more consistent in its descriptions and more systematically illustrated than other works. Except for a few historical plates, all the illustrations are original.

What do you see as the major hurdles to finishing the project on schedule, time or money?

Time! If we had enough money . . . Of course more funds are needed for the *Atlas*, particularly for field trips, which is the only way to speed up the accumulation of data and photographs. It is also crucial to build a working relationship with some institution outside of Europe, perhaps in North America, to house our duplicate specimens, our working archives, and our reference materials. This would make it possible to have our scientific documentation preserved in more than one place and would allow other scientists easier access to our material.

Taxonomic Notes from the Arnold Arboretum

Stephen A. Spongberg

Recent name changes in two Arnold Arboretum introductions.

Two new volumes in the continuing *Flora of China* series (*Flora Reipublicae Popularis Sinicae,* Volumes 24 and 72) appeared in 1988; these contain treatments, respectively, of the Aristolochiaceae and Caprifoliaceae as they occur in the Chinese flora. Consequently, two studies from these volumes are now at hand that treat two plants recently featured in articles published in *Arnoldia.* And in both of these instances, changes in taxonomic interpretation by Chinese botanists require changes in nomenclature. This brief note is intended to alert readers of *Arnoldia* to these changes in the hope that the old names can be replaced before they become too entrenched in our memories as well as in the botanical and horticultural literature.

Heptacodium miconioides

The first change of name concerns the so-called seven-son flower, featured in an article by Gary Koller in the Fall, 1986, issue of *Arnoldia.* In his article Koller referred to this plant as *Heptacodium jasminoides* Airy Shaw, introduced into cultivation in the United States by the 1980 Sino-American Botanical Expedition. Koller mentioned that the genus *Heptacodium* had been established by Alfred Rehder in 1916 when that Arnold Arboretum taxonomist described *Heptacodium miconioides* Rehder, based on a collection made by E. H. Wilson early in this century. In 1952, thirty-six years after Rehder established the genus, the British botanist H. K. Airy Shaw described a second species, *Heptacodium jasminoides.*

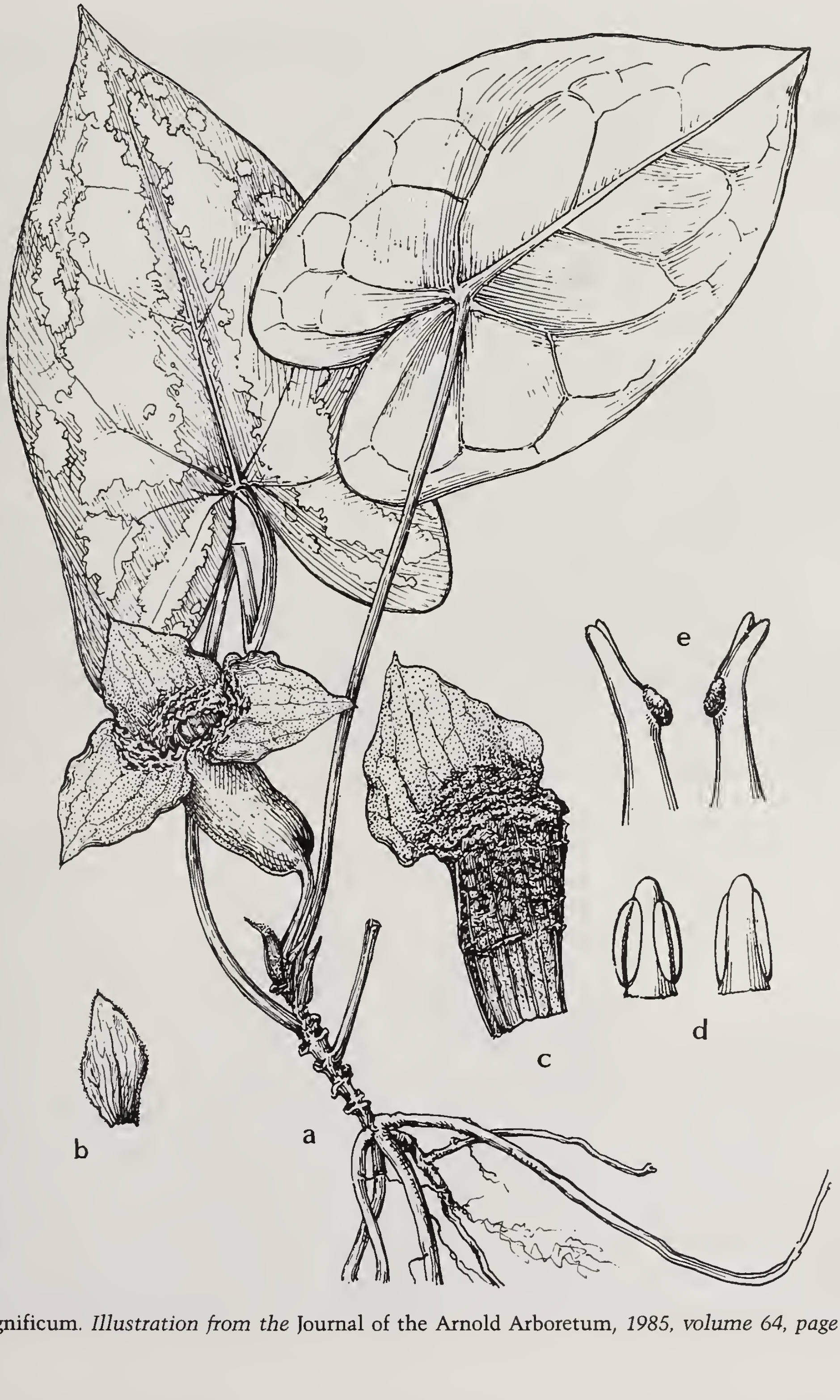
Now, after a careful comparison of materials reputedly representing both species, Professor Jia-qi Hu has determined that only one species can be defined, and consequently the name *Heptacodium miconioides* Rehder is the correct one for the solitary, highly ornamental shrub comprising this genus.

Asarum splendens

The second change of nomenclature concerns the identity and correct name of an *Asarum* introduced into cultivation in the West by Richard A. Howard, former director of the Arnold Arboretum. When visiting in China in 1978, Dr. Howard was given a living plant of an undescribed species of *Asarum* but was told that it represented *Asarum magnificum,* a species that was shortly thereafter described as new by two Chinese botanists, C. Y. Cheng and C. S. Yang, in the *Journal of the Arnold Arboretum* in 1983. In the same article these authors also described *Asarum chingchengense,* a species closely resembling *Asarum magnificum* in its leaf morphology but decidedly different in its floral structure. Once in cultivation, Dr. Howard's asarum was propagated and widely appreciated for its interesting mottled leaves. Details of its introduction, its history in cultivation, and its attributes as an ornamental plant were outlined in another article by Gary Koller that appeared in the Summer, 1989, issue of *Arnoldia.*

In that article, Koller referred to the plant as the magnificent ginger, *Asarum magnificum.* However, recently spotting a flowering

Asarum splendens. *Illustration from the* Journal of the Arnold Arboretum, *1985, volume 64, page 582, where it was labeled* A. chingchengense.



Asarum magnificum. *Illustration from the* Journal of the Arnold Arboretum, *1985, volume 64, page 594.*

specimen of this plant at a Philadelphia flower show, Barry Yinger, a keen student of Asiatic asarums, questioned the identity of the plant and suggested that it actually represented *Asarum splendens*, a plant originally described in 1982 by a Japanese botanist, Fumio Maekawa, as a species of the related genus *Heterotropa*.

Acting on this tip, we consulted the updated treatment of *Asarum* presented by Cheng and Yang in the *Flora of China*, and compared photographs of the flowers of the Arboretum asarum to all the others. Through these comparisons it became apparent that the asarum introduced by Dr. Howard was not *Asarum magnificum*. From the articles published by Cheng and Yang, it became evident that our plant corresponded to *Asarum chingchengense*, and the photographs of the Arboretum plant matched those of *Heterotropa splendens* published by Maekawa. But in the Chinese *Flora*, *Asarum chingchengense* was reduced to the synonymy of *Asarum splendens* (Maekawa) Cheng & Yang, which in turn was simultaneously transferred from the genus *Heterotropa* to *Asarum*. Consequently, in accord with Cheng and Yang's treatment, the plant introduced into cultivation into the West by Dr. Howard is correctly known as *Asarum splendens* if it is placed in the genus *Asarum* and not maintained in the genus *Heterotropa*. *Asarum magnificum*, to our knowledge, remains to be introduced into North America and European gardens.

The Arnold Arboretum records pertaining to both *Heptacodium miconioides* and *Asarum splendens* have been corrected to reflect these new names, and we hope that other growers will correct theirs as well.

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Abies bornmülleriana MATTFELD

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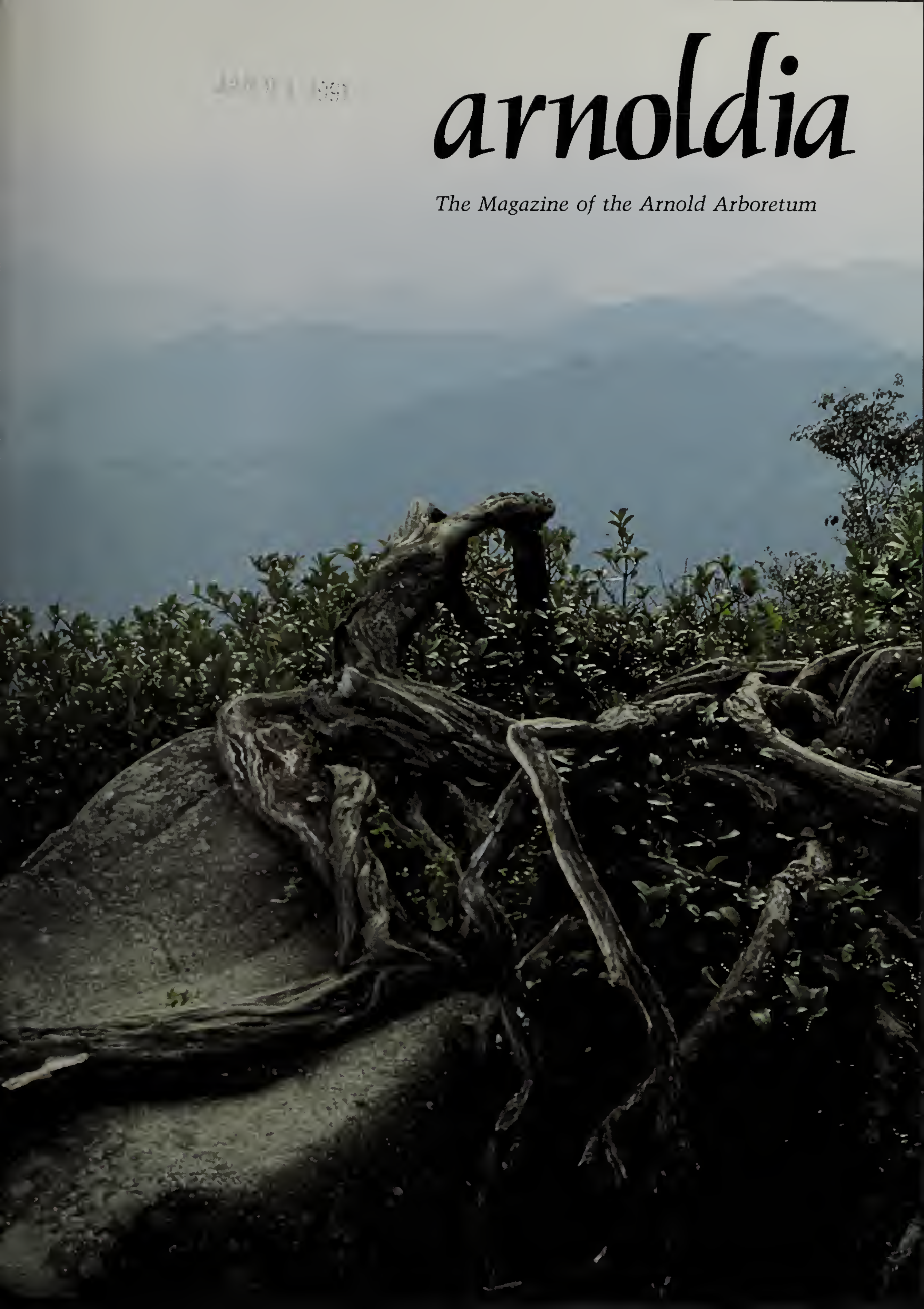
The Magazine of the Arnold Arboretum



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Volume 50 Number 4 1990

Arnoldia (ISSN 0004-2633; USPS 866-100) is published quarterly, in winter, spring, summer, and fall, by the Arnold Arboretum of Harvard University.

Subscriptions are $20.00 per calendar year domestic, $25.00 foreign, payable in advance. Single copies are $5.00. All remittances must be in U.S. dollars, by check drawn on a U.S. bank, or by international money order. Send subscription orders, remittances, change-of-address notices, and all other subscription-related communications to: Helen G. Shea, Circulation Manager, *Arnoldia*, the Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130-3519. Telephone (617) 524-1718.

Postmaster: Send address changes to:
Arnoldia, Circulation Manager
The Arnold Arboretum
125 Arborway
Jamaica Plain, MA 02130-3519

Peter Del Tredici, Editor
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Arnoldia is set in Trump Mediaeval typeface and printed by the Office of the University Publisher, Harvard University.

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Front cover: An ancient plant of *Euonymus fortunei* growing wild near the summit of Tian Mu Shan, Zhejiang Province, China. Photograph by Peter Del Tredici.

Back cover: *Chionanthus retusus* in fruit at the Arnold Arboretum. Photograph by Al Bussewitz.

Inside front cover: The highlands of Peru contain more than 1.5 million acres of terraces, most constructed in prehistoric times. Those shown here are located in Laraos, Peru, near Lima. Photograph by A. Cardich.

Inside back cover: *Chionanthus virginicus* in bloom at the Arnold Arboretum. From the Archives of the Arnold Arboretum.

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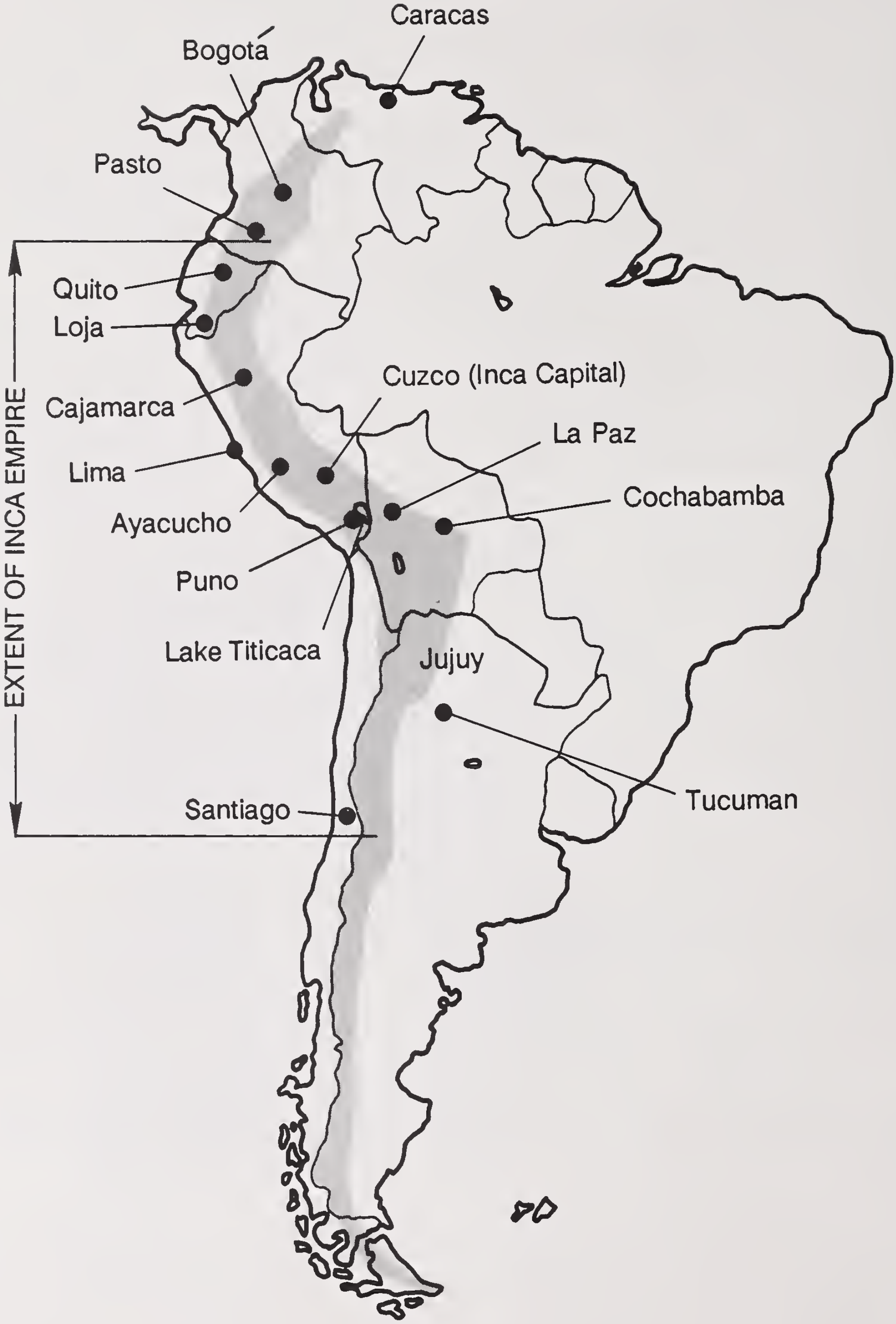
Caracas
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Jujuy
Tucuman
Santiago
EXTENT OF INCA EMPIRE

Lost Crops of the Incas

National Research Council Panel on Lost Crops of the Incas

These long-forgotten plants may play a key role in diversifying the world's food supply in years to come.

At the time of the Spanish conquest, the Incas cultivated almost as many species of plants as the farmers of all Asia or Europe. On mountainsides up to four kilometers high along the spine of a whole continent and in climates varying from tropical to polar, they grew a wealth of roots, grains, legumes, vegetables, fruits, and nuts.

Without iron, wheels, or work animals for plowing, the Indians terraced and irrigated and produced abundant food for 15 million or more people—roughly as many as inhabit the Andean highlands today. Throughout the vast Inca Empire, sprawling from southern Colombia to central Chile—an area as great as that governed by Rome at its zenith—storehouses overflowed with grains and dried tubers. Because of the Incas' productive agriculture and remarkable public organization, they were said to maintain three to seven years' supply of food in storage.

But Pizarro and most of the later Spaniards who conquered Peru repressed the Indians, suppressed their traditions, and destroyed much of the intricate agricultural system. They considered the natives to be backward and uncreative. Both Crown and Church prized silver and souls—not plants. Crops that had held honored positions in Indian society for thousands of years were deliberately replaced by European species (notably wheat, barley, carrots, and broad beans) that the conquerors demanded be grown.

Remaining in obscurity were at least a dozen native root crops, three grains, three legumes, and more than a dozen fruits. Domesticated plants such as oca, maca, tarwi, ñuñas, and lucuma have remained in the highlands during the almost five hundred years since Pizarro's conquest. Lacking a modern constituency, they have received little scientific respect, research, or commercial advancement. Yet they include some widely adaptable, extremely nutritious, and remarkably tasty foods.

This botanical colonialism closed off from the rest of the world a major center of crop diversity. Food plants of Asia, Mexico, and especially of Europe became prominent; those of the Andes were largely lost to the outside world.

It is not, however, too late to rescue these foods from oblivion. Although most have been hidden from outsiders, they did not become extinct. Today in the high Andes, the ancient influences still persist with rural peasants,

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The Inca Empire measured more than 4,000 kilometers from end to end. Superimposed on a map of modern South America, it would begin on Colombia's southern frontier, stretch southward along the coast and highlands of Ecuador and Peru, sprawl across highland Bolivia into northwestern Argentina, and reach down into central Chile to just below Santiago. This vast territory was probably the largest ever formed anywhere based on a "Bronze Age" level of technology.

who are largely pure-blooded Indian and continue to grow the crops of their forebears. Over the centuries, they have maintained the Incas' food crops in the face of neglect, and even scorn, by much of the society around them. In local markets, women in distinctive hats and homespun jackets (many incorporating vivid designs inspired by plant forms and prescribed by the Incas more than five hundred years ago) sit behind sacks of glowing grains, baskets of beans of every color, and bowls containing luscious fruits. At their feet are piles of strangely shaped tubers—red, yellow, purple, even candy-striped, some as round and bright as billiard balls, others long and thin and wrinkled. These are the "lost crops of the Incas."

That these traditional native crops have a possible role in future food production is indicated by the success of the few that escaped the colonial confines. Among the Incas' wealth of root crops, the domesticated potato, an ancient staple previously unknown outside the Andes, proved a convenient food for slaves in the Spanish silver mines and sailors on the Spanish galleons. Almost inadvertently, it was introduced to Spain, where, over several centuries, it spread out across Europe and was genetically transformed. Eventually, the new form rose to become the fourth-largest crop

*Harvesting quinoa grain (*Chenopodium quinoa*) in Ilave, Peru. Traveling through Colombia in the early 1800s, Alexander von Humboldt observed that quinoa was to the region what "wine was to the Greeks, wheat to the Romans, cotton to the Arabs." He was excited by the crop because at the time starvation was rampant all over the world, and he had gone to South America looking for new foods to combat it. Photo by M. Sayago, IAF.*

on earth. Other Andean crops that reached the outside world and enjoyed spectacular success were lima beans, peppers, and the tomato.

In light of this, it is surprising that more than thirty promising Inca staples remain largely restricted to their native lands and unappreciated elsewhere. Given research, these too could become important new contributors to the modern world's food supply.

The Andean Environment

The Andean region became an important center for domestication of crop species in large part because of its striking geographical contrasts. Along its western margin stretch narrow coastal deserts that are all but uninhabitable except where some forty small, fertile river valleys cross it. Behind this mostly barren plain towers the world's second-highest mountain range, the Andes, reaching an average of over 3,000 meters elevation. Its glacial heights were also uninhabitable, but intermontane valleys and basins are well suited to human occupation, and these became the home of the Inca rulers. Beyond the mountain valleys, on the eastern face of the Andes, are found subtropical cloud forests gently sloping into the Amazon jungle.

The Andean region was quite unlike the other regions where clusters of crops were domesticated. Here were no vast, unending plains of uniformly fertile, well-watered land as in Asia, Europe, or the Middle East. Instead, there was an almost total lack of flat, fertile, well-watered soil. Andean peoples grew their crops on millions of tiny plots scattered over a length of thousands of kilometers and perched one above another up mountainsides rising thousands of meters.

This complicated ecological mosaic created countless microclimates, including some of the driest and wettest, coldest and hottest, and lowest and highest found anywhere in the world. Perhaps no other contiguous region has such a broad range of environments as in the ancient Inca Empire. And the region is so fragmented that rainfall, frost, sunlight, and soil type can vary over distances less than a meter. For instance, a valley floor may have thick soils, abundant sunshine in the daytime, and severe frost at night, whereas immediately adjacent slopes may be thin-soiled, shaded, and frost-free.

To protect themselves against crop failure, ancient Andean farmers utilized all the microenvironments they could. Conditions causing poor harvests in one could produce bumper crops at another. Farmers deliberately maintained fields at different elevations, and this vertically diversified farming fostered the development of a cornucopia of crop varieties, each with slightly different tolerances to soil type, moisture, temperature, insolation, and other factors.

The resulting diversity of crops served as a form of farm insurance, but the differing growth cycles of different habitats also permitted work to be staggered and therefore more area to be cultivated.

*The zapallo (*Cucurbita maxima*) is only one of many squashes native to the Andes. This species, noted for its rich diversity, has given rise to numerous commercially successful squash varieties, including Acorn, Banana, Buttercup, and Hubbard.*

Inca Agriculture

Western South America's dramatic stage—coast, valleys, highlands, and cloud forest—formed the setting for the evolution of Andean civilization, which emerged some 4,500 years ago. On the semiarid coast, up the precipitous slopes, across the high plateaus, and down into the subtropical jungles of the eastern face of the Andes, dozens of cultures flourished and faded before the rise of the Incas about A.D. 1400.

The Incas inherited and built upon the products of thousands of years of organized human endeavor. It was they who, through military and diplomatic genius, first united a vast realm running the length of the Andes. Employing an inspired, if rigid, administration, they promulgated a social uniformity from their capital, Cuzco. The entire empire was a single nation, governed by the same laws, privileges, and customs.

The union within the Inca Empire was surprising because the various lands it covered were so vastly different: seared desert, saline flats, vertical valley walls, windswept barrens, triple-canopy jungle, glacial sands, floodplains,

Recreating Prehistoric Abundance

About 3,000 years ago, an ingenious form of agriculture was devised on the high plains of the Peruvian Andes. It employed platforms of soil surrounded by ditches filled with water. For centuries this method flourished because it produced bumper crops in the face of floods, droughts, and the killing frosts of those 3,800 meter altitudes. Around Lake Titicaca, remnants of over 80,000 hectares (200,000 acres) of these raised fields (*waru waru*) can still be found. Many date back at least 2000 years.

Now, in a dramatic resurrection, modern-day Peruvians working with archaeologists have reconstructed some of the ancient farms, and the results have been amazing. They have found, for instance, that this method can triple the yield of potatoes. In at least one experiment, potato yields outstripped those from nearby fields that were chemically fertilized. As a result of such observations, local farmers have begun restoring the ancient *waru waru* on their own. Government-sponsored restoration projects are also under way.

The combination of raised beds and canals has proved to have remarkably sophisticated environmental effects. For one thing, it reduces the impacts of extremes of moisture. During droughts, moisture from the canals slowly ascends to the roots by capillarity, and during floods, the furrows drain away excess runoff. For another, it reduces the impact of temperature extremes. Water in the canals absorbs the sun's heat by day and radiates it back by night, thereby keeping the air warm and helping protect crops against frost. On the raised beds, nighttime temperatures can be several degrees higher than in the surrounding region.

For a third, it maintains fertility in the soil. In the canals, silt, sediment, nitrogen-rich algae, and plant and animal remains decay into a nutrient-rich muck. Seasonal accumulation can be dug out of the furrows and added to the raised beds, providing nutrients to the plants.

The prehistoric technology has proved so productive and inexpensive that it is seen as a possible alternative for much of the Third World where scarce resources and harsh local conditions have frustrated the advance of modern agriculture. It requires no modern tools or fertilizers; the main expense is for labor to dig canals and build up the platforms with dirt held in by blocks of sod on the sides.

saline crusts, perpetual snow, and equatorial heat. This diversity is reflected in the Incas' own name for their empire: Tahuantinsuyu—Kingdom of the Four Corners—coast, plateau, mountain, and jungle. Yet the Incas learned to manage the desolation and the variety of these most demanding habitats, and they made these regions bloom.

This success was owing to several factors.

First, the Incas were master agriculturalists. They borrowed seeds and roots from their conquered neighbors and forcibly spread a wealth of food crops throughout their empire, even into regions where they were previously unknown. To enhance the chances of success, the Incas purposefully transplanted the plants with their farmers, thereby spreading both the species and the knowledge of how to cultivate them.

Second, the Incas created a vast infrastructure to support (or perhaps to enforce) the empire's agriculture. For example, they modified and conserved steeply sloping erodible terrain by constructing terraces and irrigation works, and by fostering the use of farming systems that attenuated the extremes of temper-

Water in the canals absorbs the sun's heat by day and radiates it back by night, helping protect crops against frost. The more fields cultivated this way, the bigger the effect on the microenvironment. The platforms are generally 4 to 10 meters wide, 10 to 100 meters long and about one meter high, built with soil dug from canals of similar size and depth. Sediment in the canals, nitrogen-rich algae, and plant and animal remains provide fertilizer for crops. Illustration by Narda Lebo.

ature and water. These included, for example, ridged fields and planting in small pits. In some areas, Inca terraces and irrigation systems covered thousands of hectares. Many are still in use.

Third, contributing to the infrastructure were roads and footpaths that provided an extensive system for transporting products to all corners of the realm. As a result, massive amounts of food could be moved on the backs of llamas and humans—for example, corn into the highlands, quinoa to the lowlands, and tropical fruits from the eastern jungles to the heights of Cuzco. To implement this superb organization without paper or a written language, a mathematical system was developed that used knots tied in strands of yarn (quipu). The code of the knots was memorized and so can never be solved. Today, they cannot be "read," but they resemble the digital system of computers; the Incas could maintain highly elaborate and complex records and accounts.

Further, the roads and footpaths made possible the exchange of information. Instructions and advice were carried quickly throughout the empire by an organized corps of runners. In this way, Inca sages sent predictions of the weather for the upcoming cropping season to and from all regions. The predictions were based on natural indicators such as the behavior of animals, the flowering of certain plants, and the patterns of the clouds and rainfall. The Incas were familiar, for example, with the phenomenon known as "El Nino" that periodically changes the ocean currents off the coasts of Peru and Ecuador, wreaking havoc with regional weather.

The Incas also developed methods for preserving their harvests for years, when necessary. It is estimated that in the central highlands of Peru alone there were tens of thousands of large, rock-walled silos and warehouses. Such stores were filled each year with dried and salted meat (called "charqui," the source of the English word "jerky"). They also contained roots preserved by freeze-drying. When potatoes, for example, had been harvested at the highest altitudes, they were spread out and left overnight in the freezing air. The next day, men, women, and children walked over the partly withered tubers, squeezing out the moisture that had been released by the freezing. The same process was repeated over several nights and days, after which the potatoes were completely dehydrated and could be stored safely.

The Incas' Descendents

For all its size and splendor, the Inca Empire endured for only a century, and it was crumbled by fewer than two hundred Spanish adventurers. Today the region of the empire—the highlands from Colombia through Chile—is one of the world's most depressed areas. The infant mortality rate is one of the highest on the South American continent—more than one-fourth of the children die before their first birthday, a rate more than twice that of Latin America at large and about fifty times that of Sweden. Only one in seven homes has potable water, and only one in forty has indoor plumbing. Add to this the disruption caused by guerrillas, who have launched an armed campaign of terror in the Peruvian highlands, and it is no surprise that massive migration from the countryside to the cities has occurred.

Exacerbating the highlands' difficulties are cultural and ethnic divisions. The Indians, who make up about half of the population, live a life apart from the modern sector. Most still speak Quechua, the *lingua franca* of the Incas; a few around Lake Titicaca on the Peru-Bolivia border speak Aymara, an even older language. The Indians' rural lives have not changed appreciably for generations.

On the other hand, the whites and mestizos (persons of mixed European and Indian ancestry), who make up the other half of the population, speak Spanish and live in a modern urban world that is undergoing rapid change.

The classes, therefore, are separate and unequal. And a concomitant notion is that their food plants are separate and unequal as well. It may seem irrational, but crops the world over are stigmatized by the prejudices held

*The giant Colombian blackberry (*Rubus macrocarpus*) is one of the biggest berries in the world, almost too large to be taken in a single mouthful. Photo by Wilson Popenoe © National Geographic Society, 1926.*

against the peoples who use them most.

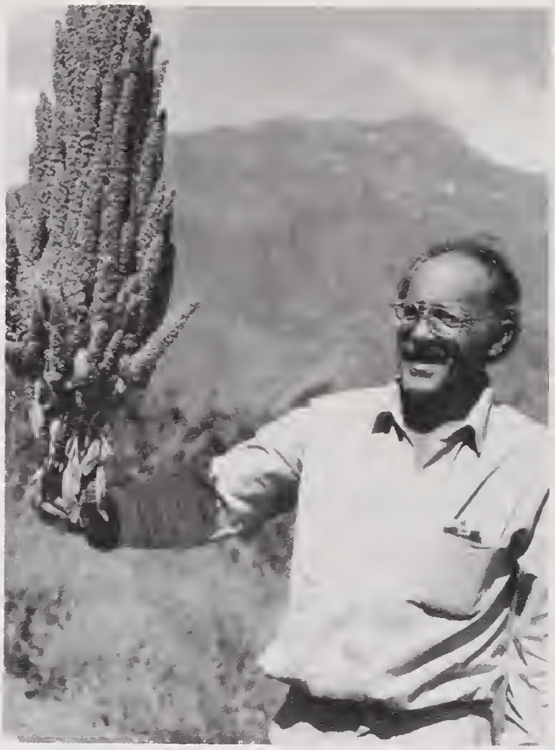
Over the centuries, the Spanish view that native crops are inferior to such European crops as wheat, barley, and broad beans has persisted. Indian foods are still equated with lower status. The conquistadores would undoubtedly be amazed to see potatoes, tomatoes, peppers, and limas contributing significantly to modern Spain's cuisine. But they would see that their prejudices against oca, tarwi, quinoa, and dozens of other Inca foods are still largely in place in South America.

Future Beyond the Andes

It is in the Andes that the plants have their greatest potential, especially for developing food products for malnourished segments of the population. However, they also promise to become useful new crops for other developing regions of the world, such as the tropical highlands of Asia, Central Africa, and Central America. In addition, they have notable promise for some industrialized regions, such as the United States, Europe, Japan, and Australasia. In fact, one country outside the Andes already has had considerable experience and success with them—New Zealand.

The reason these plants could have this wide ecological adaptation is that, although the Inca Empire stretched across the equator, a majority of its peoples actually dwelt more than three kilometers above sea level where bone-cracking cold descends at sunset, and the climate is more temperate than tropical. As a result, these crops in general have many

*Ahipa (*Pachyrhizus ahipa*) is one of the least known, but most interesting, of the plant kingdom's edible roots. The plants shown here were grown in Denmark, an indication that ahipa probably can be produced as a food crop in many places outside the Andes. Photo by F. Sarup.*



*Kiwicha "champion" Luis Sumar Kalinowski with a seedhead of one of his advanced lines of kiwicha (*Amaranthus caudatus*). Photo by Noel Vietmeyer.*

characteristics that have adapted them for cultivation in regions well outside the heat of the tropics. However, additional uncertainties exist when a crop is to be transplanted from one part of the world to another—for example, day length (photoperiod) dependence, which could be particularly troublesome.

Because the plants are native to latitudes near the equator (where the day and night lengths are equal year-round), some will not reach maturity during the long summer and fall days of the temperate zones. This difficulty has proved surmountable for potatoes, tomatoes, peppers, and lima beans, but it still could take growers some time to locate varieties or genes that can allow each of the crops described below to be grown as far from the equator as North America, Europe, Japan, and Australasia.

Difference in sensitivity to cold is another possible problem. Although the temperature variation in the Andean highlands often runs from a few degrees of frost at night to shirt-sleeve temperatures at midday, the frosts in the Andes are extremely dry, and they rarely form ice on the plants. Therefore, whether frost-tolerance data recorded in the Andes can be extrapolated to other areas is uncertain.

Nonetheless, the global promise of these plants is very high. In the last few centuries the tendency has been to focus on fewer and fewer species, but today many ancient fruits, vegetables, and grains are finding new life in world markets. This is heartening, because to keep agriculture healthy and dynamic, farmers everywhere need plenty of options, especially now when markets, climates, national policies, scientific understanding, and technologies are changing at a rapid pace.

The necessary next steps toward crop development and exploitation are often interdisciplinary, involving diverse interests such as genetics, processing, marketing, advertising, and technical development from the farm to the exporter.

Developing the lost crops of the Incas is the kind of research that scientists should undertake. In the process, they will rediscover the promise of these crops the Spanish left behind. The Inca Empire's grains, tubers, legumes, fruits, vegetables, and nuts are an enduring treasure for the Andes and for the rest of the world. Millions of people should quickly be introduced to these neglected foods of a remarkable people.

A summary follows of the "lost crops" of the Incas, selected by the National Research Council Ad Hoc Panel.

*Ulluco (*Ullucus tuberosus*) produces brightly colored tubers that are a staple food in many regions of the Andes.*

ROOT CROPS

Achira (*Canna edulis*, Cannaceae). Achira looks somewhat like a large-leaved lily. Its fleshy roots (actually rhizomes), sometimes as long as an adult's forearm, contain a shining starch whose unusually large grains are actually big enough to see with the naked eye. This starch is easily digested and is promising for both food and industrial purposes.

Ahipa (*Pachyrhizus ahipa*, Leguminosae). Ahipa is a legume, but unlike its relatives, the pea, bean, soybean, and peanut, it is grown for its swollen, fleshy roots. Inside, these tuberous roots are succulent, white, sweet, pleasantly flavored, and crisp like an apple. An attractive addition to green salads and fruit salads, they can also be steamed or boiled and have the unusual property of retaining their crunchy texture even after cooking.

Arracacha (*Arracacia xanthorrhiza*, Umbelliferae). Above ground, this plant resembles celery, to which it is related. Below ground, however, it produces smooth-skinned roots that look somewhat like white carrots. These roots have a crisp texture and a delicate flavor that combines the tastes of celery, cabbage, and roasted chestnut. They are served boiled or fried as a table vegetable or are added to stews.

Maca (*Lepidium meyenii*, Cruciferae). Maca is a plant that resembles a radish and is related to cress, the European salad vegetable. Although its edible leaves are eaten in salads and are used to fatten guinea pigs, it is most valued for its swollen roots. Resembling brown radishes, the roots are rich in sugars and starches and have a sweet, tangy flavor. Dried, they can be stored for years.

Mashua (*Tropaeolum tuberosum*, Tropaeolaceae). The well-known garden nasturtium was a favorite Inca ornamental, and at high altitudes in the Andes, its close relative, mashua, is a food staple. Farmers often prefer mashua to other tubers because it requires less labor and care to grow, and it can be stored in the ground and harvested when needed.

Mauka (*Mirabilis expansa*, Nyctaginaceae). Mauka has thick stems and yellow or salmon-colored fleshy roots that make it a sort of cassava of the highlands. The plant was unknown to science until "discovered" in Bolivia in the 1960s, and it now has also been found in remote mountain fields of Ecuador and Peru. If placed in the sun and then put in storage, the tubers turn very sweet, like sweet potatoes.

Oca (*Oxalis tuberosa*, Oxalidaceae). An exceptionally hardy plant that looks somewhat like clover, oca produces an abundance of wrinkled tubers in an array of interesting shapes, and in shades from pink to yellow. In the Andean highlands, it is second only to the potato in amounts consumed, and is still a staple for Peruvian and Bolivian Indians living at high altitudes. The firm white flesh has a pleasant, sometimes slightly acid taste.

Potatoes (*Solanum* species, Solanaceae). The common potato became one of the twenty or so staple crops that feed the whole world. Collectively, these are adapted to a wide array of climates and provide a genetic source of diversity, disease resistance, and new crops. Many have unusual and marketable properties. Some are golden yellow inside, a number have a decidedly nutty taste, and almost all have more concentrated nutrients than the common potato.

Ulluco (*Ullucus tuberosus*, Basellaceae). Some of the most striking-looking roots in Andean markets are ullucos. They are so brightly colored—yellow, pink, red, even candy-striped—that their waxy skins make them look almost like plastic imitations. Once a staple in the Inca diet, ulluco is one of the few indigenous crops that has increased its range over the last century. In some areas, it vies with the potato as a carbohydrate staple.

Yacon (*Polymnia sonchifolia*, Compositae). Yacon is a distant relative of the sunflower. Grown in temperate valleys from Colombia to northwestern Argentina, it produces tubers that on the inside are white, sweet, and juicy, but almost calorie-free. Because of their succulence, they are eaten raw and are pleasantly refreshing; they are also eaten cooked. In addition, the main stem is used like celery, and the plant shows promise as a fodder crop.

*Mashua tubers (*Tropaeolum tuberosum*) thrive in the high cold altitude of the Andes. The plant requires little care and can be stored in the ground for months. Photo by Wilson Popenoe © National Geographic Society, 1926.*

GRAINS

Kaniwa (*Chenopodium pallidicaule*, Chenopodiaceae). This broad-leaved plant produces one of the most nutritious of all grains, with a protein content of 16 to 19 percent and an unusually effective balance of essential amino acids. It flourishes in poor rocky soil at high elevations, usually surviving frosts that kill other grain crops, and outyielding them in droughts. Incredibly, it thrives where frosts occur nine months of the year.

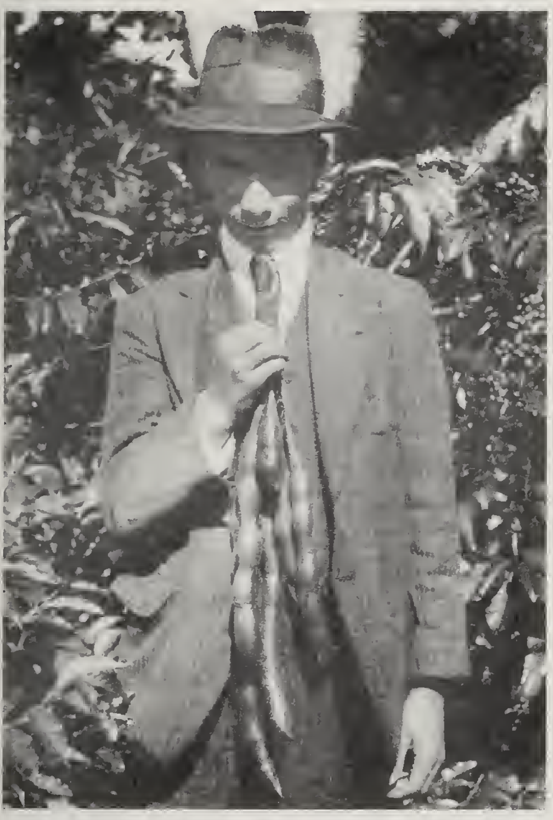
Kiwicha (*Amaranthus caudatus*, Amaranthaceae). The seeds of the amaranth, an almost totally neglected grain crop, have high levels of protein and the essential amino acid, lysine, which is usually lacking in plant protein. Kiwicha protein is almost comparable to milk protein (casein) in nutritional quality, and it complements the nutritional quality of foods that normally would be made from flours of corn, rice, or wheat. This makes kiwicha particularly beneficial for infants, children, and pregnant and lactating women.

Quinoa (*Chenopodium quinoa*, Chenopodiaceae). Although the seed of this tall herb is one of the best sources of protein in the vegetable kingdom, quinoa is hardly known in cultivation outside its upland Andean home. However, experience in the United States and England shows that the grain is readily accepted by people who have never tasted it before. Quinoa can be grown under particularly unfavorable conditions, at high elevation, on poorly drained lands, in cold regions, and under drought. Much has already been learned about this plant, which is becoming a commercial success outside the Andes.

LEGUMES

Basul (*Erythrina edulis*, Leguminosae). Basul is a common leguminous tree of the Andean highlands. It is unusual in that it produces large edible seeds and is one of the few trees that produces a basic food. Accordingly, it has promise as a perennial, high-protein crop for subtropical areas and tropical highlands. Beyond its use in food production, it is also a promising nitrogen-fixing tree for use in reforestation, beautification, erosion control, and forage production.

Nũnas (*Phaseolus vulgaris*, Leguminosae). The nũna is a variety of the common bean, but it is the bean counterpart of popcorn. Dropped into hot oil, nũnas burst out of their seed coats. The popping is much less dramatic than with popcorn but the product has delightful flavor and a consistency somewhat like roasted peanuts.



*Basul (*Erythrina edulis*) is a bean that grows on trees. Its extremely large seeds have a pleasant, slightly sweet flavor and are usually eaten like lima beans. They are also used in candies. Photo by Wilson Popenoe © National Geographic Society, 1926.*

Tarwi (*Lupinus mutabilis*, Leguminosae). This lupin is one of the most beautiful crops, and its seeds are as rich as, or richer in protein than peas, beans, soybeans, and peanuts—the world's premier plant-protein sources. Also, they contain about as much vegetable oil as soybeans. Tarwi has been held back mainly because its seeds are bitter. The Indians soak them in running water for a day or two, to wash out the bitterness. Geneticists in several countries have recently developed bitter-free varieties that need little or no washing.

VEGETABLES

Peppers (*Capsicum* species, Solanaceae). Chilies and sweet peppers have become the most widely used spices in the world, but hidden in the Andes are several more domesticated peppers as well as some wild species. All of these are employed by local people, and they promise to add new pungency, new tastes, and new variety to many of the world's cuisines.

Squashes and Their Relatives (*Cucurbita* species, Cucurbitaceae). Several of the fruits variously known as pumpkins, squashes, gourds, or vegetable marrows have their origins or greatest development in the Andes. These and some lesser-known botanical relatives are robust, productive crops, especially suitable for subsistence use. Many are little-known elsewhere and offer promise of new and better foods for scores of countries.

FRUITS

Berries. Along the length of the Andes are found several dozen localized berry fruits. These include relatives of raspberry and blackberry (*Rubus* species, Rosaceae), blueberry (*Vaccinium* species, Ericaceae), and some small berries (*Myrtus* species, Myrtaceae) that are rather like mini guavas.

Capuli Cherry (*Prunus capuli*, Rosaceae). The black cherries that are found throughout the Americas reach their best development in the Andes, where the capuli is a popular city and backyard tree. The cherrylike fruits are found in the markets three or four months of the year. Some are large, sweet, fleshy, and said to be at least as good as the traditional cherry.

Cherimoya (*Annona cherimola*, Annonaceae). Of all the Inca fruits, only the cherimoya is cultivated substantially outside the Andes. It is grown commercially in Spain, southern California, and a few other places. Such interest is understandable. Inside the thin greenish skin of the cherimoya is a delicious, sweet, and juicy flesh with a creamy, custardlike texture. Its unique flavor tastes like a subtle blend of papaya, pineapple, and banana.

Goldenberry (*Physalis peruviana*, Solanaceae). A relative of the North American husk tomato, the goldenberry is fresh-tasting and makes one of the world's finest jams. Growing under harsh conditions, it provides a wealth of yellow, marble-sized fruits that are beginning to attract international acclaim for their flavor and appearance.

Highland Papayas (*Carica* species, Caricaceae). Although the papaya is one of the premier fruits of the world, its botanical cousins of the Andes are all but unknown. They, too, have much promise, and they may extend the cultivation of papayalike fruits into cooler areas than is now possible.

*Although many species of wild berries are found in the Andes, the mora de Castilla (*Rubus glaucus*) is the most famous and popular. This Andean counterpart of the loganberry could have a bright future. Test samples of its high-quality, deep-red juice have been well received at a large U. S. fruit-drink corporation. This product might prove valuable for giving pallid juices a rich ruby red color. Photo by Wilson Popenoe © National Geographic Society, 1926.*

Lucuma (*Pouteria lucuma*, Sapotaceae). This fruit can be considered a "staple fruit." Unlike oranges or apples, its fruits are dry, rich in starch, and suitable for use as a basic, everyday carbohydrate. It has been said that a single tree can feed a family year-round. The fruits are often eaten fresh and are very popular in milkshakes, ice cream, and other treats. Dried, they store for years.

Naranjilla (*Solanum quitoense*, Solanaceae). Related to, but wholly unlike, tomatoes, this fruit is highly esteemed in Peru, Colombia, Ecuador, and Guatemala, but virtually unknown elsewhere. The delicious, refreshing juice of the naranjilla is one of the delights of the northern Andes, and it could become popular in African and Asian tropics, where the plant could conceivably flourish.

Pacay (*Inga* species, Leguminosae). Among the most unusual of all fruit trees, pacay produces long pods filled with soft white pulp. This pulp is so sweet that the pods have been called "ice-cream beans." Not only are the fruits attractive and popular, this nitrogen-fixing tree is extremely promising for reforestation, agroforestry, and the production of wood products.

Passion Fruits (*Passiflora* species, Passifloraceae). This exotic fruit is becoming popular in Europe, North America, and other places. With its concentrated perfume and flavoring ability, passion fruit "develops" the taste of bland drink bases, such as apple juice or white grape juice. So far, all commercial developments have been based on a single Brazilian species. In the Andes there are scores of other species, some of which are reputed to be superior to the Brazilian one.

Pepino (*Solanum muricatum*, Solanaceae). A large, conical, yellow fruit with jagged purple streaks, pepino's mellow flesh tastes like a sweet melon. It is beginning to enter international commerce. Already gaining popularity in New Zealand and Japan, the delicate pepino seems destined to become a benchmark for premium fruit production.

Tamarillo (*Cyphomandra betacea*, Solanaceae). Inca gardens high on the mountainsides contained small trees that bore large crops of egg-shaped "tomatoes." Today these tree tomatoes remain one of the most popular local fruits. They have bright, shiny, red or golden skins and can be eaten raw or cooked or added to cakes, fruit, salads, sauces, or ice cream. The succulent flesh looks somewhat like that of the tomato, but it is tart and tangy and has a piquancy quite its own.

NUTS

Quito Palm (*Parajubaea cocoides*, Palmae). The streets and parks of the city of Quito are lined with an elegant palm that seems out of place because Quito is one of the highest cities in the world and has a cool climate. The palm produces many fruits that look and taste like tiny coconuts. They are so popular that only early risers can find any left on the streets.

Walnuts (*Juglans neotropica*, Juglandaceae). While most walnut species are natives of the Northern Hemisphere, a few occur in the Andes. They are common backyard and wayside trees, and at least one of these is a promising timber and nut tree. In New Zealand, this species has grown unusually fast for a walnut, and its nuts have a fine flavor.

*The cherimoya (*Annona cherimola*), universally regarded as a premium fruit, has been called the "pearl of the Andes," and Mark Twain declared it to be "deliciousness itself!"*

This article was reprinted from *Lost Crops of the Incas: Little-Known Plants of the Andes with Promise for Worldwide Cultivation.* The book makes up the report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation Board on Science and Technology for International Development, established by the National Research Council. It was first published in 1989 by the National Academy Press, Washington, D. C. Copies of the book are available at the Arnold Arboretum Bookshop or can be obtained for $19.95, prepaid, from:

National Academy Press
2101 Constitution Ave., N. W.
Washington, D.C. 20418

The Trees of Tian Mu Shan: A Photo Essay

Peter Del Tredici

Tian Mu Mountain, located approximately 90 kilometers west of the city of Hangzhou, is the tallest mountain in Zhejiang Province, China. Rising 1506 meters above sea level, Tian Mu Shan is well known throughout China for its scenic beauty and for the diversity of its flora. It has a long and rich history, and has been visited by monks, herbalists, poets, botanists, and tourists for close to a thousand years. From a utilitarian point of view, the mountain is noted for exporting four comestible products: "cloud and fog tea," collected from *Camellia sinensis* growing wild on the cool slopes; "dried bamboo," derived from the young shoots of the locally abundant *Phyllostachys pubescens*; "hickory nuts," the sweet seeds of *Carya cathayensis*; and lastly the numerous medicinally important herbal plants that were once widely collected.

The most prominent symbol of Tian Mu Shan's long human history is Kaishan Temple, located two-thirds of the way up the mountain, at 1020 meters. Built by Buddhist monks in 1279, this small temple serves as a focal point for visitors, who often spend the night in order to view the sunrise the following morning. A second temple, Chanyuan, was built in 1665 and is located at the base of the mountain, at 330 meters.

The topography of Tian Mu Shan is diverse enough to support a wide variety of plant associations. The subtropical evergreen forests typical of south China commingle with the warm temperate deciduous forests of the north on the slopes of Tian Mu Shan, resulting in a flora of some 1530 species of vascular plants, one of the richest in the temperate world. Beginning in the 1920s, Chinese botanists, recognizing the uniqueness of the Tian Mu Shan flora, collected and described many distinct species from the area. Today at least three species are recognized as endemic to the mountain, and a total of thirty species growing within the reserve are included in Volume 1 of the *Plant Red Data Book* of rare, endangered, and threatened plants of China. In 1960, the Chinese government, recognizing the uniqueness of Tian Mu Shan flora, established a 1000-hectare reserve (400 acres) on the south-facing slope of the west peak, designed to preserve and protect the plants.

In addition to its high species diversity, Tian Mu Shan is also famous for its exceptionally large trees. Foremost among them is *Cryptomeria japonica* var. *fortunei*, the cryptomeria, of which there are 398 individuals with diameters greater than one meter. The golden larch, *Pseudolarix amabilis*, also grows wild on Tian Mu Shan, with some 98 individuals larger than half a meter in diameter. Most interesting of all are the large specimens of *Ginkgo biloba*, the ginkgo, growing in isolated valleys and on steep cliffs. According to the only published report on the population, 244 trees were located, with a mean diameter of 45 centimeters and a mean height of 18 meters. Whether these trees are truly wild or are the escaped offspring of trees cultivated by monks has been debated by botanists for years. Researchers have yet to reach a clear consensus on the answer to this question.

In addition to these three rare gymnosperms, exceptionally large specimens of *Torreya grandis, Liquidambar formosana, Nyssa sinensis, Cyclocaria paliurus, Litsea*

Ginkgo biloba *in silhouette at 980 meters elevation.*

auriculata, and *Emmenopterys henryi* are also common. In the fall of 1989, I had the good fortune to visit Tian Mu Shan in the company of two very able Chinese botanists, Professor Ling Hsieh of the Zhejiang Institute of Forestry and Mr. Yang Guang of the Jiangsu Institute of Botany. From October 6 to 15, the three of us tramped up and down the mountain mapping and measuring all the ginkgo trees we could find. It was a memorable time for me and one that I hope is captured in the following photographs.

Professor Ling and a large specimen of Pseudolarix amabilis, *the golden larch, 42 meters tall, with a diameter at breast height of 112 centimeters.*

Yang Guang with the "living fossil" ginkgo in the Tian Mu Shan reserve. This ancient ovulate tree occupies an area of approximately 20 square meters and consists of 15 stems greater than 10 centimeters in diameter. The largest trunk has a diameter of 110 centimeters. The Chinese describe this tree, perched on the edge of a steep cliff at 950 meters, as "an old dragon trying to fly." The fence protecting the tree was built in 1980.

Cryptomeria japonica *var.* fortunei *is the dominant tree on Tian Mu Shan. Here it is growing in association with a large specimen of* Magnolia denudata, *the yulan magnolia.*

Several Cryptomeria japonica *var.* fortunei *demarcate the stone path that leads to Kaishan Temple. About 300 years old, these trees may well have been planted for the purpose of erosion control.*

Very common on Tian Mu Shan, Liquidambar formosana, *the oriental sweet gum, is a very large tree. Here it is growing amidst a clump of* Phyllostachys pubescens, *a timber-producing species of bamboo.*

NEWS

FROM THE ARNOLD ARBORETUM

Master Planning: Looking Ahead to the Next Century

Why, the letter read, are you hiring fancy landscape architects when the original design of the Arboretum by Frederick Law Olmsted is doing just fine?

The writer of this letter was probably aware of our decision to seek an outside consultant to assist us in creating a master plan, the first long-range planning effort since the original Sargent/Olmsted collaboration. After interviewing a number of local firms with experience in planning and the preservation of historic landscapes, we chose Sasaki Associates of Watertown, Massachusetts.

So why are we hiring Sasaki? I can best answer this question by recounting a conversation I had recently over the phone. A woman called me to complain about the number of cars driving through the Arboretum to exit by the greenhouse; they were endangering the many mothers and children who walk the roads during the day. In fact, she said, a schoolbus, no less, had nearly run down her daughter.

She pointed out that drivers prefer to drive through the grounds because it is so difficult to leave by way of the primary entrance on the Arborway. Traffic lanes in the opposite directions are separated by a thin island of concrete and curbing, necessitating a complicated turnaround at the Forest Hills subway station which is further complicated by ongoing constructions. Why, she asked, don't we simply put a traffic light at our entrance and cut a passage through the concrete island to let cars exit in both directions?

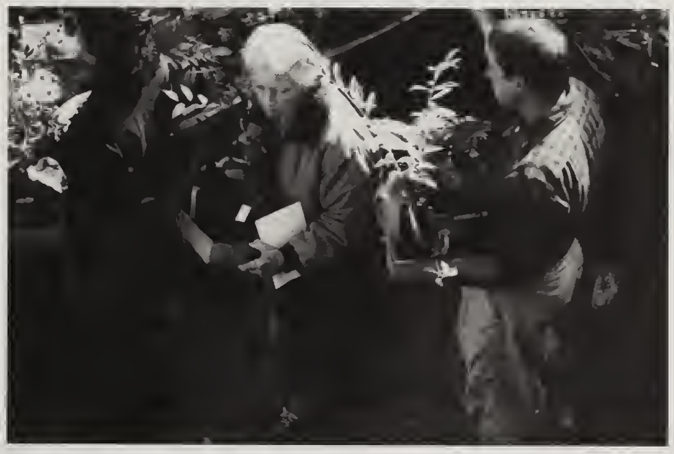
This sounds like a good idea, and it may well be one. But like most good ideas, it is likely to prove more complicated than it initially appears. Should left hand turns across traffic and into the Arboretum be permited as well? How would the light affect weekend parking that tends to cluster around the entrance? What about pedestrians? And who should pay for all this? Clearly the City of Boston, the Metropolitan District Commission and the Arboretum will all be involved.

Frederick Law Olmsted and Charles Sargent created the Arboretum in a day when the preferred mode of transportation was the horse and carriage. The original design and circulation system has been remarkably well preserved over the years. However, the urban realities of the late 20th century could come to threaten that preservation if we continue to operate without any comprehensive planning. So it is a master plan created with the experience of a firm like Sasaki Associates that will really allow the original Olmsted design to continue doing just fine well into the next century.

Bob Cook

Robert E. Cook, Director

PLANT SALE BETTER THAN EVER



Over 8,000 plants were sold and more than $50,000 raised as approximately 2,000 plant buyers and browsers strolled from tent to tent collecting new specimens for their gardens. The larger less crowded sales area in and around the barn and an increased number of cashiers enabled members to select their free plants without the congestion and waiting lines of previous years. Many thanks to the Arnold Arboretum Associates who organized this event and gathered the plants for the Rare and Silent Auctions.

SARGENT'S *SILVA*

Charles Sprague Sargent, the first director of the Arnold Arboretum, brought together a wealth of information about the known forest trees in the *The Silva of North America*. Undertaken for the Tenth Census of the United States, the fourteen volumes were published between 1890 and 1902. While changes in nomenclature and taxonomic perspective have occurred since its publication, Sargent's *Silva* remains today as the most authoritative and complete work of its kind.

Charles Faxon, botanical illustrator for the Arnold Arboretum at that time, created illustrations which were engraved by the celebrated Parisian firm of Philibert and Eugene Picart and printed by the Riverside Press in Cambridge for inclusion in *The Silva of North America*.

In addition to complete sets of this work in our library, the Arnold Arboretum has the printer's over-run copies of these 10" x 14" Faxon drawings which are suitable for framing. Beginning in January, 1991, members at the Benefactor level ($1,000 and up) will be offered one of these prints as an annual gift from the Director.

THE CONTRIBUTORY PORTION OF MEMBERSHIP DUES

Internal Revenue Service regulations require that in determining the tax deductible status of a charitable contribution, the "fair market value" of benefits received must be taken into account. Beyond the value of these benefits, your membership dues may be claimed as a charitable, tax deductible contribution.

Previously this contributory portion was determined by subtracting the "fair market value" of all benefits offered to each category of membership. This produced great complexity and confusion. Today only the value of *Arnoldia*, which is available to nonmembers for a yearly subscription rate of $20 ($25 foreign) must be considered "fair market value" of membership benefits and therefore not tax deductible. For members who elect not to receive *Arnoldia*, the total amount of membership dues is tax deductible. Payments for classes, symposia or Bookstore purchases are not tax deductible.

For more information call the Membership Department at 617-524-1718.

Faxon's drawing of Rhododendron Maximum, L., *an illustration from Sargent's* Silva.

NEW CASE ESTATES MAP

A new Case Estates information brochure and grounds map is available at the Case Estates and the Hunnewell Visitor Center. This brochure includes more information about the history of the Case Estates as well as descriptions of the new display areas.

The new map, adapted from an accurate and detailed base map drawn by Janis Wedmore and John Quinn, was created by Mapworks, Inc. of Norwell, MA. The attractive new representation of the grounds provides clear graphic orientation to the entire grounds.

If you haven't been to the Case Estates in recent months, please accept our invitation to use this new guide map for a winter walking tour of the new display areas and woodland paths.

Arnold Arboretum Logo

Created in 1980, our logo is an adaptation of the Chinese character for forest. The character contains three identical elements, each meaning tree. The slight variation in the three elements, permissable artistic liberty, is used to achieve a more esthetic overall character.

Although our logo has stylized the original Chinese character almost beyond recognition, it does carry on the tradition of graphic representation so important to the written Chinese language. Where as a reader of Chinese would recognize each of the three elements of the original character as a picture of a tree, untrained American eyes would not. The Arboretum logo recreates the basic elements of the original Chinese character within the more triangular graphic design which Americans have come to recognize as an evergreen tree. If you would like another logo window decal, please contact the Membership Department.

Al Fordham, formerly Chief Plant Propagator at the Arnold Arboretum, admires the restructured stream bank and new waterfall where the eroded stream bed had been.

THE
Linda J. Davison Rhododendron Path

As a result of a memorial trust given by Terence Colligan in memory of his wife Linda J. Davison, the portion of Bussey Brook at the foot of Hemlock Hill has been transformed into a beautiful dell where visitors may enjoy the sounds and sights of water rushing through the rocky stream bed. Boulders and tree trunks gathered from around the Arboretum have been woven into the landscape to stabilize and define the banks of the brook and create contemplative sitting areas and a bridge sensitive to Olmsted's design. Additional rhododendrons will be planted next spring to enhance the collections and the view.

Arnold Arboretum staff consult with Landscape Architect Julie Messervy and contractors. Maurice Sheehan, working Foreman of the grounds crew (second from left), designed the hen's tooth puddingstone wall which replaced the metal fence and supervised the project throughout.

The Donald B. Curran company of Ipswich, Ma. did a superb construction job. Standing on the bridge they built are from left: Front row: David Gordon, Stephen Talbot, Frank McLaughlin; Back row: Donald Curran, Sean Curran, Nobby Mawby, Jere Trask, Henry Vaillancourt.

Sheila Connor, Horticultural Research Archivist, examines the eroded stream bed prior to work on the project.

"THE ROMANTIC GARDEN"—A NEW SYMPOSIUM

Romance is in the air for gardeners in the bleak month of February, when the Arnold Arboretum presents the first symposium to focus on the new Romantic Design movement. Fashionable, fragrant, and luxuriant, the style is claiming the attention of gardeners throughout the country.

The all-day slide-lecture symposium is being presented in four cities: on Thursday, February 21, at the Chicago Botanic Garden, Glencoe, Illinois; on Saturday, February 23, at the Denver Botanic Gardens, Denver, Colorado; on Tuesday, February 26, at the New York Botanical Garden, Bronx, New York; and on Thursday, February 28, at the Arnold Arboretum, Jamaica Plain, Massachusetts. This is an opportunity for Arnoldia readers outside the Boston area to get up-to-date information on the history, philosophy, design elements, and color schemes of "The Romantic Garden." Registration fees are $106 for non-members, $96 for members of the participating institutions, and $53 for students with proof of full-time status. For further information or to receive a detailed brochure, call the Arnold Arboretum Education Department at 617-524-1718 or FAX your request to 617-524-1418.

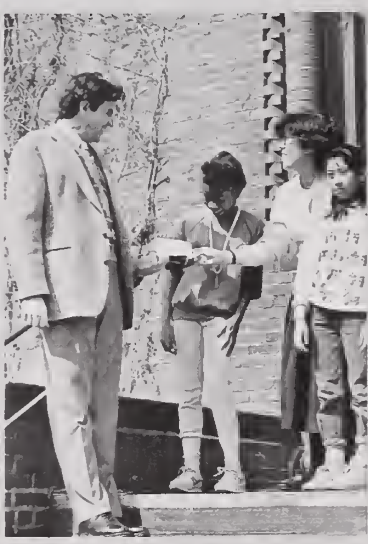
BECOME A DOCENT

If you would like to join our group of knowledgeable docents and have the opportunity to lead adults on tours of the Arnold Arboretum, consider attending the Docent Training Program this spring. The five three-hour sessions will be given on Wednesday mornings beginning on March 15th. Contact our Tour Coordinator, 524-1718, for more information.

School children learn about the ecosystems of the Arnold Arboretum during school curriculum-based Field Study Experiences. They delve into the structure of a flower with hand lenses, use compasses and maps to hunt for unusual trees from other parts of the world, observe the interplay of plants, animals and man, and feel they have had a wonderful adventure.

Children's Program Guides Needed

Renew your sense of adventure and learn to teach children as they explore the grounds of the Arnold Arboretum. Guide training for spring begins on Thursday, March 21 and continues for five consecutive weeks. Newly trained guides will join the program's staff of 39 volunteers in leading 3rd- to 6th-grade school groups through the Arboretum. Volunteers make their own schedules and teach during the morning.



Jim Gorman, Arnold Arboretum Committee president, presents a check for $4500 to Diane Syverson while visiting students from the Joyce Kilmer school look on. The committee's donation will provide scholarships for students from Boston Public Schools to participate in the Arboretum's Field Study Experiences.

Bookstore Offerings

WILDFLOWER CLASSICS:

Growing and Propagating Wild Flowers by Harry R. Phillips, $14.95. A complete and expert treatment of wild flower propagation and cultivation.

How To Know The Wild Flowers by Mrs. William Starr Dana. boxed edition, $19.95. A guide to the names, haunts and habits of our common wild flowers; richly illustrated.

The Natural Garden by Ken Druse, $35.00. This volume emphasizes low maintenance and natural beauty; filled with colorful photographs.

Visit the Bookstore daily 10 a.m. to 4 p.m. or call (617) 524-1718 to order these or other books.

At lower elevations on Tian Mu Shan, between 200 and 400 meters, Trachycarpus fortunei, *the widely cultivated windmill palm, commonly grows on dry soils in full sun.*

The Fringe Tree and Its Far-Flung Cousins

Rob Nicholson

The native *Chionanthus virginicus* and the Asiatic *C. retusus* add an element of drama to the spring garden.

If I had to construct a garden that would feature only one family of plants, the most promising choices would be the Ericaceae (Rhododendron), the Rosaceae (Rose), or the Leguminosae (Legume), all families that display great species diversity. My next choice would be the Oleaceae, the family of ash, lilac, privet, forsythia, and jasmine. In this predominantly spring-blooming garden, imagine a rectangle of high privet hedge encircling a mosaic of lilacs, a high stone wall at one end, topped with cascading hardy jasmine. A few ash trees could provide shade, and for the connoisseur of the unusual, we could include plants of *Abeliophyllum* (the Korean white forsythia), *Fontanesia*, *Parasyringa*, and *Chionanthus*, the fringe tree.

Hardy *Chionanthus*, the subject of this article, has long been appreciated by both oriental and western gardeners for its fleecy white floral display, but still remains relatively underutilized in northern gardens. For hundreds of years, botanists believed the genus *Chionanthus* consisted of two to four temperate species native to eastern North America and Asia. In 1976, William Stearn of the British Museum consolidated the genus *Chionanthus* with the genus *Linociera*, a large tropical evergreen group with about a hundred species. He felt that there were no clear-cut characteristics to distinguish the two genera, and it had become a mere convention to assign temperate species to *Chionanthus* and tropical ones to *Linociera*. The present taxonomic thinking is that the ornamental plants we know as fringe trees in the temperate zone are, in fact, a specialized branch of what is essentially a tropical genus.

The American Fringe Tree

Chionanthus virginicus, fringe tree or old-man's-beard, is native from southern Pennsylvania and New Jersey south to Central Florida, and west to eastern Texas, southern Arkansas, and Oklahoma. It can be found along the banks of streams and ponds, usually in a moist, rich soil, although some botanists have found it atop rocky sandstone bluffs in the Ozark Mountains of Arkansas. The species was cultivated in Dutch gardens as early as 1736, where it became known as "sneeuwboom" or snow tree. It was named *Chionanthus* (from the Greek *chion*, snow, and *anthus*, flower) by Linnaeus in his 1737 edition of *Genera Plantarum*.

Chionanthus virginicus is an extremely variable species and over the years numerous new species and varieties have been named, although few seem to retain validity over time. Old-man's-beard can take the form of a small, single-stemmed tree or a large, multi-stemmed shrub. Maximum height seems to be around 10 meters (33 feet), and the mature specimens I have seen are usually broader than they are tall. Its bark is similar to lilac, a smooth, brown-gray when young, becoming

Chionanthus retusus *at the Arnold Arboretum (AA #13051). Top, the tree in full bloom; bottom, the winter silhouette. Photos from the Arnold Arboretum Archives.*

fissured with streaks of reddish-brown when older. The leathery leaves are opposite, narrow elliptic to obovate-oblong, with entire margins, and are a shiny dark green above and pale dull green below. Fall color tends toward yellow, and the fruit is plum-like in color and shape, a half-inch drupe held singly or in clusters.

The flowers of *Chionanthus virginicus* are, without a doubt, its most ornamental feature. In Boston they are in full bloom in early June, making an effective spectacle for about two weeks. Flowers are held on elongated panicles 10 to 20 centimeters long (4 to 8 inches), and these panicles can vary in appearance from slightly upright to slightly drooping. Flower petals are pure white, narrow, and straplike, measuring 2 to 3 centimeters (1 inch), and usually number four. Individually they are only mildly interesting, but as they are produced in great number on each panicle, and the panicles in turn blanket the tree, the effect is astounding. Because flowering begins before the leaves are fully extended, the plant initially appears as a fleecy mass of white, punctuated by a few spots of fresh green. During the bloom period, the leaves become more developed and the plant gives a more dappled effect. Close up, the flowers impart a spicy privet-like scent, and from underneath it seems as though one is looking up through a cloud of mist. As one walks farther from the plant, the airy white panicles coalesce, and the plant reads as a solid white mass.

Chionanthus can be dioecious, with distinct male and female plants, or polygamo-dioecious, that is, individual plants have predominantly pollen-bearing or seed-producing flowers but may also have a few bisexual flowers or flowers of the opposite sex. Male plants of *C. virginicus*, some authors say, produce a more spectacular floral display, but no data have been published to support this, and I could not see significant differences in our few plants.

The greatest drawback to the use of the plant in New England is that it begins its spring performance long after others have hit the stage. The plants at the Arnold Arboretum, sited among the lilac collection, are almost always naked during "Lilac Sunday," usually the third week of May. Amidst the spectacle of color, they seem almost embarrassed, a gray suit at the Mardi Gras. But as lilac-blooming season begins to wind down, they come alive and are in full flower in early June.

Some horticulturists recommend using the American fringe tree as a focal point, a specimen tree for terraces or patios. In areas such as New England, however, the late appearance of its foliage and bloom makes it look awkward when featured, and I suggest using it as a lawn tree or along the edges of a property. As many members of the Oleaceae have been used for hedges, this might make an interest-

The American fringe tree is far hardier than its native range might suggest. The largest tree I know, 8 meters high (25 feet) by 10 meters broad (30 feet), grows on a lawn in Shelburne Falls, Massachusetts, a town just below the Vermont border, in USDA Zone 5. The owner of this specimen thought it was planted around the turn of the century and was proud to point out that, when in full flower, it has been known to stop busloads of Japanese tourists.

I have seen *Chionanthus viginicus* twice in the wild, in remarkably dissimilar habitats. In Stokes County, North Carolina, I was drawn to the banks of the Dan River, along with the local plant hunter Richard Schock. Our quarry was a purported population of *Stewartia malacodendron*, the silky stewartia, an unusual occurrence for the foothills of the Appalachians. As it turned out, the herbarium specimen that led us to this locale was a misidentified sheet of *Stewartia ovata*, which was the plant we found. On the moist, humusy slope grew a canopy of American beech and Canadian hemlock, with the understory a tangle of *Rhododendron maximum*. Both the *Stewartia* and *Chionanthus* were occasional small shrubs that managed to rise above the *Rhododendron* and persist in the fairly dense shade. In its autumn coloration, *Chionanthus* did not distinguish itself, and Richard actually had to point it out to me.

A few years later, while collecting *Torreya taxifolia* in the Apalachicola bluffs of northern Florida, I was surprised to find the fringe tree in much different circumstances. The bluffs are dissected by steep ravines harboring at their base a forest adapted to moist, humid conditions. The bluff tops, however, are quite dry and sunny, and are dominated by *Pinus palustris*, the longleaf pine. At the crest of the slope, I found *Chionanthus* along with *Quercus laurifolia*, the laurel oak, *Vaccinium arboreum, Oxydendron arboreum*, and *Callicarpa americana*.

A variant, variety *maritimus*, has been described on the basis of its more pubescent leaves, but perhaps the most intriguing form was described in 1812 by B. S. Barton: "I am assured that Mr. Clayton discovered in Virginia and cultivated in his garden, a species, or variety of Fringe-tree, with rose-colored blossoms. I presume it is nothing but a variety of common *Chionanthus virginica:* and it is said that similar specimens of this shrub have been observed in other parts of the United States." Unfortunately, this rosy mutation has been lost to horticulture.

The flowers of Chionanthus virginicus. *Photo by Rácz and Debreczy.*

The Pygmy Fringe Tree

The other North American species of *Chionanthus* about which there is general taxonomic agreement is *Chionanthus pygmaea*. This is native only to the sandy soils of central Florida and is listed nationally as endangered. It was first described by J. K. Small, an American botanist who collected the type specimens "on the ancient sand-dunes between Avon Park and Sebring, Florida, May 23, 1921 (flower) and August 30 and 31, 1922 (fruit)." Small reported that the shrub had an average height of about one-third of a meter (one foot), spread by underground stems, and was very floriferous. Though its flowers are only half the size of *Chionanthus virginicus*, its fruits are nearly twice as large, up to a monstrous 2 centimeters long (0.8 inches) on one herbarium specimen I saw. Another herbarium specimen collected by J. D. Ray describes the habitat of *C. pygmaea* as a "yellow sand dry ridge with open shrubby covering of *Quercus chapmanii, Quercus geminata, Sabal etonia, Befaria racemosa* and *Cyrilla arida*."

Sue Wallace of Florida's Bok Tower Gardens has worked on the propagation of the species and has seen the plant in its native environs. She has seen plants up to 2 meters tall (6 to 7 feet) and feels it is difficult to distinguish them from *C. viginicus*, except by their radically different habitats. She relates that *C. pygmaea* grows in almost desert-like conditions in deep sterile white sand.

Dr. Dick Lighty has experimented with cultivating the plant at the Mt. Cuba Center in Greenville, Delaware, and considers it a shrub with outstanding ornamental potential. For him, *C. pygmaea* grows to be a medium-sized shrub with heavy, waxy, magnolia-like leaves.

It bloomed at a very young age from seed and has withstood temperatures of −25 degrees C (−13 degrees F). Because the plant is endangered, it is illegal to collect specimens without permit, and because stocks of cultivated plants are still being increased, the plant is hard to find in nurseries. Clearly this rare southern gem is one of the plants of the future.

The Asiatic Fringe Trees

Chionanthus retusus, the Chinese fringe tree, is found in China, Japan, Korea, and Taiwan, and was introduced to the West by Robert Fortune in 1845. The cultivated Chinese fringe tree differs from our native fringe tree by its smaller, more leathery and elliptic leaves, its shorter, wider flower petals held in more upright panicles, and its later period of bloom. It flowers also on current season's growth rather than on previous season's growth, and the fruit, like that of the American fringe tree, is an oblong, blue-black drupe—but only two-thirds the size. It grows in both shrub and tree forms attaining a maximum height of 25 meters (80 feet). Like its North American relatives, it occurs in a variety of habitats producing a wide variety of leaf and floral forms.

In China, *Chionanthus retusus* is known to grow in a great many provinces, and can be found from near sea level to over 3,500 meters (11,000 feet). Our herbarium includes over sixty sheets of wild-collected material—a number that vividly demonstrates the baffling diversity contained in this species.

According to C. W. Wang, one example of a habitat in which *Chionanthus* is found is the deciduous oak forest of Hebei. The upper canopy is dominated by *Quercus aliena, Fraxinus chinensis,* and *Evodia danielii,* while Chinese fringetree, although rare, can be found in the subcanopy layer, along with *Acer mono, Tilia mandshurica, Tilia mongolica, Sorbus alnifolia, Celtis bungeana,* and *Ulmus japonica.*

In the coastal province of Zhejiang, the species has been reported on Tiantai Shan, a mountain with a mixed mesophytic forest,

Chionanthus retusus *in northern Henan, China. Photographed in 1919 by Joseph Hers.*

including *Sorbus alnifolia, Stewartia sinensis, Acer davidii, Acer palmatum, Cornus kousa, Betula luminifera, Nyssa sinensis, Magnolia officinalis,* and *Malus hupehensis.* In China, *Chionanthus* reaches its greatest altitude in the mountains of northwest Yunnan. Trees 10 to 13 meters high (30 to 40 feet) were found by Joseph Rock and George Forrest at altitudes between 2500 and 3000 meters (8000 and 9500 feet).

Among the specimens at the Grey Herbarium, the most illuminating were collected by Joseph Hers, a Belgian who lived in China in the early twenties. His collections include a dozen sheets from north Henan, south Shanxi, and north Jiangsu. He even photographed one specimen at Lushih, Henan, an upright 10-meter-tall (33 feet) specimen quite different in habit from the Arnold Arboretum's mature vase-shaped specimen. His collections help to show the diversity of leaf size, shape, and character found in just one province. Leaf tips can be acute, blunt, or notched (with two different leaf shapes on one branch), and leaf margins can be smooth or have quite large serrations. According to H.-F. Chow, the only economic use for *Chionanthus* in China is culinary. Young shoots and leaves are eaten and the young leaves are used as a substitute for tea, called lung-tsing.

In contrast to the situation in China, *Chionanthus retusus* in Japan is extremely localized, growing in just two areas. Between Korea and the main large island of Honshu lies a set of islands called the Tsushima Islands. It was here that E. H. Wilson found the plant while collecting for the Veitch Nursery in 1905. Of Japan's four main islands, the fringetree can only be found on Honshu, in the Mino-Mikawa floristic region, east of the metropolis of Nagoya. This is a region of botanical relics found nowhere else in Japan and includes among its rarities *Rhododendron makinoi, Acer pycnanthum* (a maple very similar to our *Acer rubrum*), *Magnolia stellata*, and *Chionanthus retusus.* Visiting the region for the Arnold Arboretum in 1986, I was able to find *Magnolia stellata* and *Acer pycnanthum*, but did not succeed in finding the fringe tree. According to S. Kurata, the plant prefers sunny and moist conditions in which it can attain a height of 25 meters (80 feet) and a girth of 70 centimeters (2 feet).

It came as a bit of a surprise, when checking the background sources of the Arboretum's *Chionanthus retusus*, that despite its prevalence in China and the all-star cast of collectors who found the plant there, all of our plants were from Japan, Taiwan, and most recently Korea. Our oldest plant (AA #13051), probably the oldest and best specimen in the country, was grown from seed from the

The beautiful trunk of Chionanthus retusus *(AA #13051). From the Arnold Arboretum archives.*

Imperial Botanic Gardens in Tokyo. Seed was received in 1901, and the resulting propagule now grows on the Chinese Path of Bussey Hill. It measures, after 89 years, 10 meters high (33 feet) with a spread of 11 meters (35 feet) and a circumference of 2 meters (6.5 feet) at its base. At about a meter from the ground, the trunk splits into nine sharply ascending trunks. This past severe winter seems to have inflicted some dieback on the newer branches (its first winter damage in memory), and no flowers were produced this spring.

Chionanthus retusus is also native to Taiwan and Korea where separate species and varieties have been described. From Taiwan, *C. serrulatus* was described by B. Hayata in 1913 and segregated on the basis of its serrate leaf margins and shorter petiole. More recently, H.-L. Li, former Director of the Morris Arboretum, downgraded this species to a variety, while T.-S. Liu reduced it to synonymy with *C. retusus*. Based on the herbarium specimens I've examined, it appears that serration is found throughout the range and not limited to Taiwan, or to immature plants, as some authors have claimed.

In Korea, the Forest Research Institute reports that *Chionanthus retusus* can be found growing from near sea level to over 900 meters (3000 feet). A separate species, *C. coreanus*, was described from herbarium specimens of J. Taquet by H. Leveille in 1910. It was found on Quelpart Island, a home to many endemics, at the Htepyang Falls, and is distinguished by its lanceolate foliage. Modern treatments reduce this form to a variety of *retusus*.

When one compares the two major species of *Chionanthus*, it is best to keep in mind the limited amount of germplasm of *C. retusus* in cultivation before making sweeping generalizations. But based on the few Chinese fringe trees I have seen, I would say I prefer it to its American cousin. The ninety-year-old specimen at the Arnold Arboretum is one of the outstanding ornamental trees in the country and almost every photo of *C. retusus* in publication depicts this tree. While in bloom, its slightly tiered, vase-shaped habit becomes covered in fleecy white blossoms, and it transforms itself to "the snow tree" that the Dutch so long ago called *Chionanthus*. I also find the naked architecture of *C. retusus* more interesting than the gangly, shrubbier *C. virginicus*.

Chionanthus retusus *near Peking, China. Photograph taken in 1915 by F. N. Meyer; the caption reads: "A large and old specimen of the Chinese fringe tree, about 30 feet high with a trunk over one foot in diameter at base. This tree was in full bloom and looked in the distance as if a white muslin cloth had been thrown over its head." From the Arnold Arboretum Archives.*

Propagation

Should a genus be highly ornamental, yet no cultivars exist, one has a sure signal that problems exist with vegetative propagation. This is indeed the case with *Chionanthus*, as few records of successful experiments with cutting propagation have been reported. One experiment set up by Arnold Arboretum Propagator Jack Alexander compared the rooting behavior of *C. retusus* and *C. virginicus* under mist using a medium consisting of half peat and half perlite. Although ten different lots of hormone treatment were tried, none of the *C. virginicus* cuttings rooted, and a 30 percent take was the best result with *C. retusus* (in a lot treated with 1 percent indolebutyric acid in a solution of 50 percent ethanol and 50 percent water).

Seed is the most dependable means of propagation, although this results in a plant of unpredictable characteristics. *C. virginicus* has seed that are doubly dormant and seem to require two warm/cold stratification cycles before germination occurs. After the first warm/cold cycle, a radicle will emerge from the hard seed coat and drive itself downward into the soil. Following the second warm/cold cycle, the shoot will emerge. Our records indicate that *C. retusus* will germinate in high percentages after a single cycle of warm/cold stratification.

The Arnold Arboretum is pleased to offer to our Friends plants of both *Chionanthus retusus* and *Chionanthus virginicus.* The *C. virginicus* seedlings are generally 6 to 12 inches tall, and the *C. retusus,* 8 to 24 inches. Donation, payable upon receipt of the two plants, is $35.00. Shipment will be in the spring of 1991.

Chionanthus Distribution
Dana Greenhouse
The Arnold Arboretum
125 Arborway
Jamaica Plain, MA 02130

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The Hunnewell Pinetum: A Long-Standing Family Tradition

Interview by Judith Leet

The collection of conifers begun by Horatio Hollis Hunnewell of Wellesley, Massachusetts, is now maintained by his great-grandson, Walter Hunnewell.

In 1866, Horatio Hollis Hunnewell mentions in his diary, where he recorded the ongoing improvements to his country property in Wellesley, Massachusetts, that he has prepared the ground for a Pinetum—for a collection of all the cone-bearing trees that he can make grow in New England.

Since he had already planted conifers on the grounds of his estate for fifteen years or so, one might argue that the Hunnewell arboretum was already well under way before it was officially started. Or one might date the beginning of the Pinetum as 1852, the year that Hunnewell's imposing white country house was completed and he and his family moved to Wellesley from Boston for long summer stays. Whether it is 125 or 140 years old, the Pinetum has been continuously maintained as a private arboretum by H. H. Hunnewell's family for four generations, and is now cared for knowledgeably by his great-grandson, Walter Hunnewell. In recognition of this contribution, the Massachusetts Horticultural Society recently awarded the "Hunnewell Family" its highest award, the 1990 George Robert White Medal of Honor.

The Pinetum was already a significant collection before the Arnold Arboretum was established in 1872, and Charles Sprague Sargent consulted with his older mentor H. H. Hunnewell and benefited from his experiences with the hardiness of plants in Massachusetts as Sargent made plans for what was to become the Arnold Arboretum.

A Simple Purpose

To learn more about the present condition of this unusual, if not unique, family arboretum, we went to Wellesley to speak to Walter Hunnewell, H. H. Hunnewell's great-grandson, on a sunny summer morning. A hands-on gardener, he greeted us from his perch on a one-seater power mower, after putting in a few early hours at work on the grounds—peaceful lawns enlivened by well-cultivated and mature specimen trees.

Entering the cool, spacious hallway of the main house, we were temporarily deflected from our purpose by a display of orchids too handsome to pass by unnoted; it turns out that Walter Hunnewell, a retired executive of the Gillette Company, now divides the year between his two major horticultural pursuits—indoors in winter with his orchids and outdoors in summer in the Pinetum. Whereas he has someone to help with the orchids in the greenhouse (some of which he collected in the wild as a young businessman traveling widely in Latin America), he almost single-handedly maintains the 360 or so towering conifers now growing in the Pinetum—with what he acknowledges as the

A view of the Pinetum at the turn of the century. Photo from The Life, Letters, and Diary of H. H. Hunnewell, *published in 1906.*

indispensable help of power rotary motors.

Until about ten years ago, Walter Hunnewell lived close to the family home overlooking Lake Waban and would stop by to help his aging mother care for the Pinetum. His father, Walter Hunnewell, Jr., who died in 1964, had assumed responsibility for the family Pinetum in 1921 and had maintained it attentively for forty years; but in the fifteen years that Walter's mother had lived on the property as a widow, the condition of the Pinetum had gradually declined. "She was interested in it because her husband had been interested, but she was not *personally* interested and she was already eighty when her husband died," Walter Hunnewell explained. "I lived next door and would come over to do some work, as did my brother Willard and sister Jane, who lived nearby; but basically the Pinetum went downhill. The grass wasn't cut as often, and weed trees sprouted up."

When Walter Hunnewell moved into the family home in 1980 upon the death of his mother, much restoration of the collection needed to be done. "We had to do relabeling, and Steve Spongberg of the Arnold Arboretum, starting about 1974, was very helpful in identifying trees where the labels had disappeared, as were Rich Warren and Zsolt Debreczy, later on.

"Identification is tricky because botanists can't seem to make up their minds: for example, *Picea bicolor* was renamed *Picea alcoqui-*

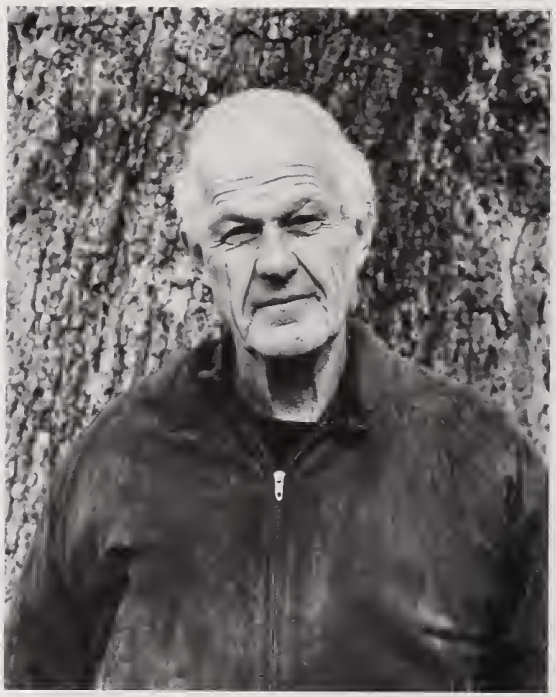
ana, but then was changed back to *P. bicolor.* And looking at the same tree, experts will have different opinions about what it is, so it's difficult to know whether to change a label or not.

"The simple objective of my great-grandfather, H. H. Hunnewell, was to find out what trees would grow in the climate of Massachusetts. At that time no one had any idea which trees would live here and which wouldn't. 'I'll make a collection of all the coniferous trees that I can find,' he wrote in his diary, 'and see what can grow here.' Of course he could do it on a scale I couldn't possibly do now," said Water Hunnewell. "He'd experiment with small seedlings, perhaps 50 plants of each species, setting out 2,000 plants at a time. He had a mammoth nursery and would plant them all out, employing perhaps thirty gardeners on his many projects."

Lessons in Hardiness

Though he had no formal training in horticulture, H. H. Hunnewell proceeded by observation, trial and error, and patience: if he lost fifty plants the first winter that he experimented with cone-bearing trees from New Zealand, he would plant fifty more the next year. He would continue to experiment doggedly and did not discourage easily. Those seedlings that survived in the sheltered nursery he would eventually plant in the Pinetum; when set out to face their first New England winters, many of the young trees would be winter-killed; over time these many losses narrowed down the selection of plants that he had hoped to introduce.

H. H. Hunnewell had many good growing years up to 1867 and confidently wrote, in the *American Journal of Horticulture,* that his efforts were worthwhile, despite the heavy labor and financial investments: "We have reason for congratulation, upwards of fifty new evergreen trees having been found adapted to our climate." But by the very next year, he recorded in his diary, "The past winter has been very destructive to evergreens—the most so of any I ever experienced." After listing the many species that had been browned or badly injured or killed, he added, "All this is very discouraging."



Walter Hunnewell next to "the old oak" on the front lawn, the only tree that predates H. H. Hunnewell's plantings. Photo by Peter Del Tredici.

Walter Hunnewell speaks feelingly of his great-grandfather's experiments and subsequent losses—sometimes of every single plant: "Eventually, it was found that plants chosen from the northernmost limit of their range—where they had adapted to snow and freezing conditions for many thousands of years—were more hardy, and H. H. Hunnewell began to bring those trees in. Although he tried and tried, he just couldn't grow the cedar of Lebanon, *Cedrus libani,* and wrote in his diary, 'it just isn't hardy here in Boston.' But later, around 1900, a hardier variety was found in the mountains of Turkey and introduced by the Arnold Arboretum. Some of these were planted here, one of which is now particularly

The main house built by H. H. Hunnewell in 1851. Photo by Peter Del Tredici.

fine—some say rather better than those in the Arnold Arboretum. The cedars of Lebanon grown in England and Europe have a much broader shape, with spreading branches; the branches dip and turn up—very picturesque; here ours are straight as a beanpole. One explanation is that the hardier ones come from high in the mountains where only straight ones could survive; the spreading ones are sitting ducks for heavy snow."

The Hunnewell family and the Arnold Arboretum have collaborated on plant-hunting projects over the years; the Hunnewells helped support E. H. Wilson's trips to Asia in the early 1900s, and in turn received plant materials for their collection, which now contains some of the oldest surviving examples of Asian introductions. "Our relationship with the Arnold Arboretum goes back to the beginning of the Arboretum," said Walter Hunnewell. "In the beginning, the Arboretum got a lot of good advice from my great-grandfather. He and Professor Sargent were good friends. My great-grandfather was the older of the two and had started first—but the two of them worked together for twenty years, and Hunnewell gave a lot of good advice to Sargent. Since 1900, it's been the other way: for twenty years we helped the Arnold Arboretum; for ninety years, they have helped us," said Walter Hunnewell, amused by the imbalance of favors.

"H. H. Hunnewell wasn't a botanist; he was an amateur who became knowledgeable. He lived to age ninety-three and had a wonderful full life—never was sick. He grew interested in horticulture in the 1840s when he was about thirty-five; he was fifty or so when he started the Pinetum. His life was more than usually interesting."

Horatio Hollis Hunnewell was born in 1810 in Watertown, Massachusetts, the son of Walter Hunnewell, a general doctor, and Susanna Cooke. Invited to Paris by relatives as a boy of fifteen to learn the banking business, Hunnewell labored for years at Welles & Company, a bank that exchanged currency for traveling Americans, and earned a considerable fortune. He fully expected to spend the rest of his life in France, but in the severe financial crisis of 1837, the bank, on the verge of failure, went out of business, and he lost everything. "All my brilliant prospects vanished, and the sleepless nights I passed in thinking what I had best do under these totally unexpected circumstances were many," he wrote in his old age. He returned to America dispirited, believing his productive life was all but over. In time he "drifted into railroads," as he put it, and moved on to far greater financial success than he had ever thought possible.

A Country Place

"H. H. Hunnewell did things very thoughtfully," said Walter Hunnewell. "When his prospects improved in Boston after the failure of the bank in Paris, he determined to build himself a nice house. Most of the land he planned to use for this country house was his wife Isabella's, that is, his father-in-law's land. Throughout the 1840s, he built the boundaries, put up a stone wall on Washington Street, and set out seedlings, thousands of seedlings of all kinds, forest trees, evergreens, fruit trees—apple, pear, cherry."

The house, built from 1851 to 1852, was singled out and illustrated in the 1859 edition of Downing's *Theory and Practice of Landscape Gardening*, edited by Henry Winthrop Sargent, a good friend and cousin. "H. H. Hunnewell had an idea," Walter Hunnewell said, "of what he wanted to do for the grounds—for the forty acres; and he did it himself, without a landscape architect. In time he bought an additional property of fourteen acres that became the Pinetum. This piece of ground was perfect for the Pinetum because of its gravelly, acid soil and interesting topography.

"The trees have no set arrangement; they are not laid out in rows. H. H. Hunnewell just planted trees of all different shapes and colors, mixed together. To me it looks better than, say, if he had grown all the hemlocks together. When Hunnewell planted an *Abies cilicica*, probably in 1860, he might have put out a ten-year-old tree. It is one of the older ones; we know that because it is one of the bigger trees. He didn't keep records; that was not his objective. He didn't particularly care where it came from, or when exactly it was planted, or whether it was a true type specimen—those things that interest us didn't make too much difference to him."

Maintaining the Pinetum

The precise number of trees living in the Pinetum has varied over the years. Walter Hunnewell's computerized printout, as of the summer of 1990, lists 354 trees. At one time the Pinetum had as many as 400 conifers. Some of the new plantings specifically replace trees damaged or destroyed by natural causes. "Back in June of 1988, a *Picea pungens* was hit by a bolt of lightning, which jumped to an *Abies veitchii*, and killed both. I planted new trees in the same spots. I let them live in the Pinetum for a year; if they survive, they then make the computerized list. I am horrified to see how small the young plants look in the Pinetum next to the full-grown trees. In the ground they seem minute, no higher than ten inches."

When he sets out new trees, Walter Hunnewell's attitude is much like that of his great-grandfather: "H. H. Hunnewell started the Pinetum when he was forty or fifty. It didn't bother him at all that he wouldn't live to see mature trees. He lived to see them grow for thirty or forty years, and he was planting small trees all the time. And I feel as he did; when I plant young trees, if they do well and grow nicely, it gives me a mammoth kick.

"There is a great temptation to plant them too close together when small. The branches

Abies cilicica, *planted in 1870, is the largest conifer in the Pinetum. Walter Hunnewell is standing at the base of the tree. Photo by Peter Del Tredici.*

eventually will go out twenty or more feet. I have planted some too close, but on the other hand, all won't grow to be nice trees, so I weed those out. If two particularly good trees are too close together, you have to make a sacrifice. Or let them grow close together. I differ here from H. H. Hunnewell and my father; they wanted a tree with open space all around it, but after all, these are forest trees. Why shouldn't they be close enough together so that, as in nature, they lose their lower branches?

"I don't like it when they grow—or so it seems to me—unnaturally when planted too far apart. That is, the lower branches hit the ground and root, and in twenty or thirty years, they reroot, distorting the normal appearance of that type of tree. Peter Ashton, the former director of the Arnold Arboretum, remarked on the way a Japanese *Chamaecyparis* had grown unnaturally when all alone. It had a mammoth jungle of young trunks growing around the original *Chamaecyparis*, and I don't like that. I prefer to plant them close enough so that the lower branches get shaded out and eventually die."

Clipping the Topiary

Introducing and collecting conifers was only a part of H. H. Hunnewell's Wellesley garden. He began to introduce many varieties of rhododendrons unknown in New England but widely used on English estates, and in addition to opening his own rhododendrons to the public, he sponsored an exhibition on the Boston Common in 1873 to popularize them. He took boundless pleasure in improving and beautifying his property over the years, creating fanciful gardens—an orangery, a grapery, orchid greenhouses, French- and English-style gardens, as well as lilac and azalea displays. His Italian garden of clipped trees on six terraces—stretching for two hundred yards along the lake below—was all built by hand shovels. "I hate to think," Walter Hunnewell paused, "of the effort involved. But he had plenty of labor to help; photos show him planting with six or eight men." For the Italian garden, H. H. Hunnewell experimented with clipping native American evergreens into formal geometric shapes; previously, European species had been used for such topiary effects.

To maintain this steeply terraced topiary garden, Walter Hunnewell's four grown children and a son-in-law now gather every year or two and, working as a team for an entire week, trim the trees. "I pick a week in August and hire a tree specialist with a cherry picker to trim the tallest. My children and I set to work on the middle-level trees—still quite tall—and do it the old-fashioned way with a tall ladder, which two or three of us hold upright with ropes twisted around our hips, while someone else is up on the ladder trimming. Those on the ground can move the ladder back and forth and maneuver it around.

There's lots of yelling back and forth—someone's pulling too hard or not hard enough. If the person on the ladder looks down, it's a long way to fall."

For the past fourteen or so years, the Hunnewells, including Walter's wife Maria Luisa, have pruned the topiary garden in this way. "My children have to take a week out of their vacations—but usually all come. One did not come the last time, and there were lots of comments about that. It's a certain amount of fun. They all in a way enjoy it; I get the most pleasure—partially because it gets the job done."

When asked if the succeeding generations had maintained the Pinetum to H. H. Hunnewell's standards, Walter Hunnewell replied, "Very much so. Up until 1929, there was plenty of labor; the workers basically cut the grass and weeds in the Pinetum with a horse-drawn mower or by hand with a scythe; it was labor-intensive and, because the land was steep, difficult work.

"My father struggled through the Depression, and there were times when he had an awful time. The staff was cut; my father, with the head gardener, put the children to work. All four children enjoyed working in the Pinetum, including my sister Jane. We removed the dead wood, trimmed out the dead branches, cut down trees, spread fertilizer, manure. It's fair to say, however, that, overall, the rhododendron were my father's primary interest."

Another Generation

Since he became responsible for the Pinetum, Walter Hunnewell has experimented with

"Italian garden and lake at Wellesley near Boston. Residence of H. H. Hunnewell, Esq." From the sixth edition (1859) of A. J. Downing's Theory and Practice of Landscape Gardening.

several innovative methods to facilitate caring for the property. "We tried grazing a horse or a cow—to see if that kept the grass down; it didn't work. Then I found a good mower that hydraulically lifts the rotary blade up and down. That mower has made an enormous difference. In a short time, I can do what it took three or four men all summer long to do. I also have a tractor that comes in with a bigger rotary mower to do the flat areas, and that too has made a great difference. For the steepest slopes, we use a rotary handmower that runs on the end of a rope. Someone can stand on flat ground above and, like a dog on the end of a leash, send it down the bank.

"I can handle the Pinetum with the help of my children; they are good about it although, sometimes, when they are busy with their work, it is difficult to make time. I now do a minimum amount of fertilizing and spraying, but basically the trees are very healthy. I always want to add trees I don't have; I put them out mainly in the month of April when I dig them out of the nursery and move them to the Pinetum." Walter Hunnewell consulted his computer printout of trees to determine how many new trees he now puts out each year. "In 1989, I planted eighteen trees—one that I planted out in April was dead by October; in 1990, I planted twelve trees."

The Pinetum now is very full and Walter Hunnewell will have to determine which trees to remove in the future. "Some are likely candidates, such as an *Abies concolor*, a white fir, about forty years old, that had its top blown out in a storm. With four leaders broken off, the fir ended up looking like a bush." Deciding it would never be what it should be, he

The "Italian Garden" at the Hunnewell estate. Photographed in 1990 by Peter Del Tredici.

cut it down without compunction. "You can always plant another," he added, summing up his very reasonable approach to gardening.

Asked about his own children—the fifth generation's future interest in caring for the Pinetum—Walter Hunnewell said: "All are in a way interested in the place, which is their home; they'd like to keep it going."

Unlike so many magnificent gardens, constructed with great care and labor, that are abandoned or neglected by later generations, the Hunnewells have carried on devotedly the legacy of Horatio Hollis Hunnewell. In late 1990, the condition of the Pinetum is flourishing and under the capable hands of the fourth generation of a family devoted to its well-being and to excellence in horticulture.

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*Numbers in parentheses refer to issues, those in **boldface** to illustrations of the entries.*

U.S. POSTAL SERVICE
STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION
(Required by 39 U.S.C. 3685)

1A, Title of publication: *Arnoldia*. 1B, Publication number: 00042633. 2, Date of filing: 28 September 1990. 3, Frequency of issue: Quarterly. 3A, Number of issues published annually: 4. 3B, Annual subscription price: $20.00 domestic, $25.00 foreign. 4, Complete mailing address of known office of publication: Arnold Arboretum, 125 Arborway, Jamaica Plain, Suffolk County, MA 02130-2795. 5, Complete mailing address of the headquarters of general business offices of the publisher: Arnold Arboretum, 125 Arborway, Jamaica Plain, Suffolk County, MA 02130-2795. 6, Full names and complete mailing address of publisher, editor, and managing editor: Arnold Arboretum, 125 Arborway, Jamaica Plain, Suffolk County, MA 02130-2795, publisher; Peter J. Del Tredici, Arnold Arboretum, 125 Arborway, Jamaica Plain, Suffolk County, MA 02130-2795, editor. 7, Owner: The Arnold Arboretum of Harvard University, 125 Arborway, Jamaica Plain, MA 02130-2795. 8, Known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities: none. 9, The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes have not changed during the preceding 12 months. 10, Extent and nature of circulation. A, Total number of copies. Average number of copies of each issue during preceding 12 months: 5,000. Actual number of copies of single issue published nearest to filing date: 5,000. B, Paid and/or requested circulation. 1, Sales through dealers and carriers, street vendors, and counter sales. Average number of copies of each issue during preceding 12 months: none. Actual number of copies of single issue published nearest to filing date: none. 2, Mail subscription. Average number of copies of each issue during preceding 12 months: 3,364. Actual number of copies of single issue published nearest to filing date: 3,525. C, Total paid and/or requested circulation. Average number of copies of each issue during preceding 12 months: 3,364. Actual number of copies of single issue published nearest to filing date: 3,525. D, Free distribution by mail, carrier, or other means (samples, complimentary, and other free copies). Average number of copies of each issue during preceding 12 months: 43. Actual number of copies of single issue published nearest to filing date: 31. E, Total distribution. Average number of copies of each issue during preceding 12 months: 3,407. Actual number of copies of single issue published nearest to filing date: 3,556. F, Copies not distributed. 1, Office use, left over, unaccounted, spoiled after printing. Average number of copies of each issue during preceding 12 months: 1,593. Actual number of copies of single issue published nearest to filing date: 1,444. 2, Return from news agents. Average number of copies of each issue during preceding 12 months: none. Actual number of copies of single issue published nearest to filing date: none. G, Total. Average number of copies of each issue during preceding 12 months: 5,000. Actual number of copies of single issue published nearest to filing date: 5,000. 11, I certify that the statements made by me are correct and complete. Peter Del Tredici, Editor.