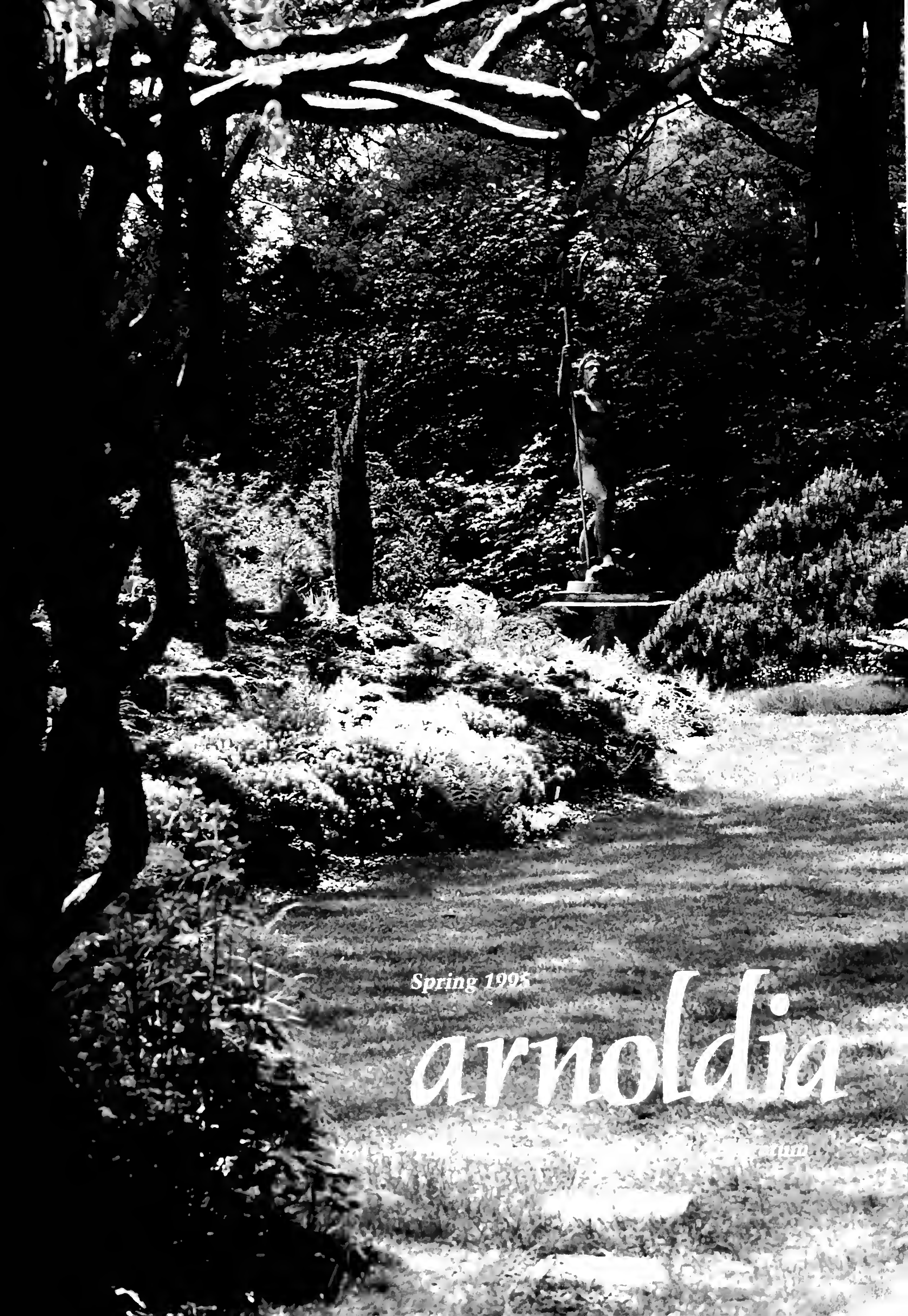
Spring 1995
arnoldia

arnoldia

Volume 55 Number 1 1995

Arnoldia (ISBN 004-2633; USPS 866-100) is published quarterly by the Arnold Arboretum of Harvard University. Second-class postage paid at Boston, Massachusetts.

Subscriptions are $20.00 per calendar year domestic, $25.00 foreign, payable in advance. Single copies of this issue are $10.00; copies of earlier issues 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 orders, remittances, change-of-address notices, and all other subscription-related communications to: Circulation Manager, *Arnoldia*, The Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130-3519. Telephone 617/524-1718.

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

Karen Madsen, *Editor*

Arnoldia is set in Trump Mediaeval typeface.

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Cover: Uplands. The wisteria arbor frames the tufa bed and statue of Neptune. Photograph by Saxon Holt.

Inside front cover: Richly diverse forests are often found around Buddhist temples on Wudang Shan, China. Photograph by Paul Meyer.

Inside back cover: The reflecting pool designed by Fletcher Steele at Uplands. Photograph by Karen Madsen.

Back cover: Guanshan, China, and a rice field beyond, is seen from the slopes of Wudang Shan. A China fir, *Cunninghamia lanceolata*, stands to the right. Photograph by Peter Del Tredici.

Uplands: Life Among the Alpines

Catherine Hull

Rock gardening is a spell—if you succumb to it there is seldom any turning aside from the passionate love of small wild things. There is no point pontificating or preaching—it swoops you up or it leaves you cold.

Do you choose gardening or does it choose you? I thought I had chosen to make a perennial garden, first in a suburb of Washington, D.C., and later in a small town north of Boston. Then one day I saw from a friend's window a wild mountain poppy growing in a crevice of rock, the orange flower moving gracefully with every breath of air, no bigger than a small butterfly. Instantly I dropped the idea of a lush herbaceous border and began a love affair with wild things, especially those that grow high in the mountains, called alpines. Soon I joined the North American Rock Garden Society. At my very first meeting, which was held at the foot of Mt. Washington, the principal speaker was Lincoln Foster, the guru of all rock gardeners. Then and there my gardening life changed forever. A very strenuous future stretched before me.

Happily, my conversion followed closely the purchase of our new home. The property is on a hill a hundred feet above sea level looking out to Massachusetts Bay. The landscape architect Fletcher Steele had designed a small upland garden here in the 1930s. He made a wisteria arbor with stone columns, a border of hybrid tea rose and clematis along a narrow lawn, a goldfish pool with a full-size statue of Neptune presiding at one end, and a long border of rhododendron and laurel.

My only previous gardening experience had been in backyards, where I had struggled with double digging to incorporate better soil and compost. But here, one thrust of a shovel and CLANG!—a rock! It was soon obvious that the hill was literally solid granite with only a thin skin of soil. No hole deeper than four inches could be dug except in the middle of the lawn. (We later learned that Steele had had to import truckloads of loam to create that lawn.) But at last there was a reason for rock—a wonderful reason—rock plants.

My first efforts began on an island in the driveway where a granite ledge underlies a rather thick growth of trees—pines, hemlocks, oaks, and some Japanese maples planted in Steele's time. By clearing a section of ledge and filling depressions and pockets with the basic rock garden mix of leaf mold, topsoil, and sharp sand, I made a setting for a small rock garden. It was intensely satisfying to have my first love, alpine poppies, grow from seed and do well in the company of some other easy-to-please low plants such as *Dianthus* and *Iberis*.

This early success led me next to the long-overgrown border of rhododendron and laurel near the lawn. Lincoln Foster had said that if he had to create a space to grow rock plants, nothing could compare to the planted wall. It seemed wise to follow his advice, all the more because a rock wall was available: it supported the rhododendron bed that lay along a walk Steele had planted with flowering dogwood. The trees could provide the high dappled shade needed for the wall's southern exposure. I felt no compunction about removing the old laurel and rhododendron; they had been aging unhappily for reasons that became evident when they were dug. The soil they lived in was desiccated and pale, with no possibility of moisture retention, hardly deserving the name of earth.

JOHN FURLONG

Neptune, rescued from a water tower in Needham by Fletcher Steele, stands over the reflecting pool at Uplands. Two colonies of Steele's signature plant, the large-leaved butterbur, Petasites hybridus, *can be seen to the right of the pool; the Atlantic Ocean is beyond.*

The stones in the existing wall were round and unattractive; it was a bonanza to find a tumbling wall of well-weathered granite fieldstones at the foot of the hill. I must have been the despair of the skilled masons doing the job, insisting as I did that the lichened side of any rock be turned outward and that they pack between the stones the special mix I had prepared. They were able to fill the whole depth of the old laurel-rhododendron bed with newly mixed soil suitable, we hoped, for a stony scree for mountain plants. In nature, scree is the loose rock debris found at the base of large rock masses or left behind on slopes by the movement of glaciers. To create it artificially in a raised bed one needs deep underpinnings of small stones or rubble. We put in well over a foot, then sandwiched in some leaves or hay to prevent the finer soil mix on top from sifting down.

I had been gathering small plants from specialist nurseries and from friends' coldframes, and I had also grown some from seed. Many of the smallest were inserted between the stones on the face of the wall; others were placed on top in the prepared scree bed. The plants were mulched with at least two inches of gravel or stone chips to keep the roots cool and protect the leaves from soil spattering.

Soon after the granite wall and raised bed were completed, plants were flourishing. The backbone was provided by small conifers and shrubs, such as *Daphne*, both *cneorum* 'Eximia' and *alpina*, *Leiophyllum buxifolium* var. *prostratum*, and the nearly prostrate *Vaccinium macrocarpon* 'Hamilton'. The loveliest of all was *Kalmiopsis leachiana* 'Umpqua Valley' propagated by Alfred Fordham at the Arnold Arboretum. *Lewisia* were soon thriving, as were small saxifrages and an *Asperula nitida* ssp. *hirtella* (or *A. n. puberula*, as it is often known) recently collected by an explorer in Turkey; *Androsace* sowed themselves—in short, it was

PAMELA HARPER

Kalmiopsis leachiana *'Umpqua Valley'*

KAREN MADSEN

Glaucidium palmatum

KAREN MADSEN

Primula x *'Frances P. K.'*

KAREN MADSEN

Dodecatheon maedia *'Album'*

gorgeous. So much so that I wanted more wild plants, not only from mountain peaks but from bogs and woodlands as well.

With a book in one hand and shovel in the other, I tried to dig a bog, succeeding in getting down only about four or five inches before striking granite. I dutifully followed the book's instructions to line the designated bog space with several layers of plastic and to fill it with dampened peat laced with a small amount of sand, although as the years go on I realize that the layer of ledge alone would undoubtedly have kept the moisture in. Not everything in that spot is a bog plant, but *Helonias bullata, Saxifraga pensylvanica, Primula denticulata,* and *Cardamine pentaphyllos* do well.

Along paths Fletcher Steele must have planned many years ago, we added woodland plants, among them both the single and double *Trillium* and *Sanguinaria, Clintonia, Primula, Erythronium, Arisaema,* and ferns. In a fairly

KAREN MADSEN

Trillium recurvatum

KAREN MADSEN

Trillium grandiflorum *'Flore Plenum'*

open area near an old hemlock we planted *Glaucidium palmatum,* which has become one of the showiest early spring bloomers and an enormous favorite. Below a low rocky cliff by the lawn we planted one of my best-loved ferns, a maidenhair, *Adiantum venustum,* and above on the level shelf of rock a single *Dodecatheon maedia* 'Album', which has selfsown and created a community. *Gentiana scabra,* the Japanese fall gentian, behaved the same way, colonizing the cliff. A few *Claytonia virginica* planted early on have made a wonderful white spring carpet for the shooting stars—a serendipitous result.

Euonymus and ivy groundcovers, thoroughly entrenched, had been planted by Steele as "maintenance free" for his client in the 1930s. When we pulled them away, some good natives appeared as if released from jail. The most exciting was *Erythronium americanum,* which continues to spread, with considerable bloom in early spring. A few patches of *Anemone quinquefolia* came to life and have been hopping about ever since.

Little by little, the garden was being extended. We made a dwarf rhododendron collection on raised islands—homes for cuttings from Polly Hill's North Tisbury hybrid azaleas and for a few crosses made by Lincoln Foster at his garden, Millstream, in Falls Village, Connecticut. Other ericaceous plants came back with us from trips to England and Scotland, along with many plants for the rock garden's scree.

Not all the effort was expended on the upland garden. We had been in the house only a few weeks in the fall of 1967 when one night we heard the sound of rushing water outside. Early the next day we thrashed our way downhill through the dense growth of brush and trees and found a stream struggling through thickets of alders. Had the gods read my wish list? A stream had always been near the top, but neither the real estate agent nor the former owner had ever mentioned one. Our discovery triggered vast effort to clear the alders, deepen the channel, accentuate the rocky waterfalls, and create a few pockets to hold water even in summer.

The desire to see the stream from the house helped us confront the forty years' growth of briars, poison ivy, nettles, wild grape, and unwanted trees on the hillside—the growth that comes after land has once been cleared and is reverting to its natural woodland state. Oak, beech, and ash had been strangled and stunted by the competition. In these days of raised ecological consciousness, it is considered wicked to call any natural state a horticultural nightmare, but we had to come to terms with this tangled wilderness in order to let in more air and light, to widen the view of the ocean at the upper level, and to make paths down the hill and up again.

For several years, my husband and a succession of college students pulled and cut. I followed with salt-marsh hay and piles of newspapers (we haven't thrown one out for twenty-eight years). There may be better ways to discourage unwanted vegetation, but I can only report on what we did here. The biodegradable paper and hay are adding a richer, deeper soil quite rapidly. Of course, much that is unwanted gladly seeds in, but so do more welcome volunteers.

I still needed more space for my growing collection of alpines. Where could I make another bed with sufficient light, away from the shade and the drip of trees, preferably with a northern exposure? The answer was the ailing rose and clematis border. My attempts to make those plants happy had been a complete failure. The roses were leggy and had blackspot. The clematis were supposed to climb only sixteen inches to the top of the dressed-slate retaining wall, then lie down flat and show glad faces to an admiring audience sipping tea on the terrace above. But it didn't work that way for me. In spite of my teasing and training the vines along a horizontal trellis on top of the wall, there was more wilt than bloom. Once again, plants were dug out for anyone wishing to take them.

I had been hearing more and more about tufa—that calcareous rock, very porous, pocked with holes and narrow tubes. It was our great good fortune to learn of an estate where a cache of tufa—treasure to rock gardeners—was unwanted by the owners. They let several of us take away all we could carry. With that unexpected windfall we soon had an Aladdin's supply in all shapes and sizes.

Fortunately the rose and clematis bed was at the edge of the long lawn Fletcher Steele had made with imported soil, so it was possible to dig. At about two feet down we poured in bags of vermiculite, as I had read of its ability to hold moisture under a large raised bed. Next we added lavish loads of gravel and sand; then assorted-sized pieces of tufa were embedded in a long series of mounds of prepared soil. Soon after this pudding was completed and some plants put in, the elements took a hand. The result was a sunken soufflé: I had made the mix too humus-y, with too much peat and leaf mold. So I began again and belatedly listened to advice from others. We buried cinder blocks along the edge near the lawn to support the largest, base pieces of tufa and instead of a soil mixture used only coarse sand to position the other pieces, with occasional chunks of granite wedged underneath to hold them in place. A four-inch layer of the regular rock garden soil mix was topped with two inches of stone mulch to give the plants a start. They responded with the usual euphoria of young plants in fresh soil in settings to their liking.

Soon alpine poppies blazed over the long bed, *Saxifraga* settled in, *Androsace, Hutchinsia alpina, Aethionema oppositifolium,* some *Penstemon, Dianthus,* and *Erinus*—a pleasant mosaic of small plants colorful in May and early June. Many of the small ferns took gladly to the tufa, and I have had much better luck with *Adiantum pedatum* var. *subpumilum* (often known as *A. p.* var. *aleuticum)* and *Asplenium trichomanes* in that porous rock than in the granite. *Cystopteris bulbifera* f. *crispa* has taken a very determined and welcome hold. The happiest combination may have been a small pink *Erigeron compositus* endemic to the Wallawa Mountains in Oregon and *Gentiana acaulis* grown from seed. The past tense applies to that companionship as the large gentian gave up after a season of twenty-four blossoms; young gentians have been planted to see if they can recreate the good years. There are small shrubs: *Salix arbuscula* and *S. hylematica, Tsusiophyllum tanakae, Daphne arbuscula* indigenous to the Tatra Mountains, *Ulmus parviflora, Ptilotrichum spinosum* 'Purpureum', and others to provide a different interest and change of texture. Certainly some plants selfsow too vigorously and others fade quietly away, but on the whole the tufa bed still gives us great pleasure.

You seldom see a rock garden without dwarf conifers. The high mountains have only occasional windbent stems or twisted trunks above

KAREN MADSEN

Drifts of the white Hutchinsia alpinum, *the ever-faithful of the tufa bed, remain constant while other plants come and go. In the upland garden, spring's color gives way in summer to various greens and the interest of differing textures while meadow plants flower on the lower hill. Notwithstanding the blaze of the New England woods, fall in the garden is a quieter season, when the plants begin to collect themselves and prepare to return to their beginnings.*

the treeline, but in a garden landscape more persistent punctuation is needed, some backbone for small plants. A little difference in eye level is welcome as one looks at the scree, raised bed, or wall, and a conifer's dark green shape helps accentuate the plants around it. *Juniperus, Abies, Picea, Tsuga, Chamaecyparis,* all are useful and present in various sizes in our tufa and granite beds. Many of these so-called dwarf conifers proved eager to become giants and had to be moved down the hill, where they are now anchors of dark green or steel blue in all seasons.

My education as a rock gardener has proceeded slowly over the years. It is curious to see what remains constant in one's affections and what begins to pall. And startling how hard some lessons are to learn. It is painful to realize that not all the plants you love will stay with you long. Enormous help came to me from courses at the Arnold Arboretum, and I wish I could have taken others at the New England Wild Flower Society. One acquires books along the way—I started out reading them like detective stories—and there are answers from the experts who lecture at seminars, clubs, and plant societies. For a rock gardener the North American Rock Garden Society is a constant source of help, of plant sales and swaps, and of seeds. The contagious zeal of all plantspeople is a never-ending propellant.

One of the ABC lessons I have been shamefully slow in absorbing is the continually changing nature of a garden. Some plants have a tendency to move out from the place where they have performed beautifully and seek new ground. I am thinking, for instance, of *Primula kisoana,* the special color form that Dr. Rokujo


KAREN MADSEN

Papaver alpina


CATHERINE HULL

Saxifraga longifolia


CATHERINE HULL

Lewisia brachycalyx *with* Viola variegata


CATHERINE HULL

Adiantum pedatum

in Japan sent to Lincoln Foster. It made a striking splash over a yard wide by a woodland path for several years, then began to meander all over, leaving a blank space behind. Many plants that don't wander away or die simply become weak images of their former selves.

The scree bed in the granite wall has been in need of rejuvenation for several years, and piecemeal efforts have not produced much improvement. I am seeking solutions to avoid the upheaval a total rebuilding would require. I have allowed some biennials too much license: *Symphyandra hofmannii* has been a lusty invader, *Scabiosa lucida* another. For a while *Phyteuma orbiculare* was a threat. Honesty and rocket are all over the place. After battling briars and poison ivy, such comely takeovers seemed almost welcome, but the day of reckon-

KAREN MADSEN

The author down the hill in her "wilderness."

ing comes relentlessly: digging and renewing the soil and replanting are urgently needed.

When I tire of working with tiny seedlings in a small corner of the granite scree or tufa bed, I plunge downhill. There I can thrash around, cutting back dock, overzealous daisies, and exuberant goldenrod; plant some of the taller *Penstemon, Perovskia, Anemone,* different forms of *Digitalis,* varieties of *Cimicifuga* and *Rodgersia,* and other plants I like. I am not sure yet whether I regret introducing some of the ornamental grasses. Many of them can become monstrously large and difficult to move.

Scattered over the hillside are shrubs such as *Fothergilla,* both *major* and *gardenii, Viburnum, Daphne, Syringa meyeri* 'Palibin', *Heptacodium miconioides, Vaccinium, Lespedeza thunbergii,* and others. We are planting only small trees and individual specimens, among them *Acer triflorum, A. griseum, Cornus kousa,* various forms of *Stewartia,* and a *Chionanthus retusus* collected by members of the Arnold Arboretum staff on the Sino-American Expedition in 1980.

In spite of the clearing and cutting of our early years here, only about one-third of the hill is in full sunshine. The most shaded areas are being encouraged to grow different species of ferns as well as lots of *Cimicifuga, Epimedium, Vancouveria hexandra, Alchemilla mollis, Aruncus,* and much else. Some of the ferns—the ostrich *(Matteucia struthiopteris)* is one—are adopting a belligerent tone and marching fiercely up the hill. *Asarum europaeum* and *Waldsteinia ternata* are taking hold along the edges of paths, and many other plants have been moved down from the woodland garden where they had multiplied beyond their space.

Schools of thought on gardening are continually changing, just as gardens themselves do. One of the most observant writers, Mac Griswold, has said that gardeners want to know if it's possible to restore the environment and have a garden, too. There is even an outcry in some places against doing battle with slugs, chipmunks, and woodchucks. It takes a tremendous mental wrench to perceive their presence as anything but invasive; in fact, it is more than I can do in parts of the garden. Is a favorite plant


SAXON HOLT

Symphyandra wanneri *with* Anemonella thalictroides.


KAREN MADSEN

Korean stone lantern obscured by Trillium grandiflorum *and* Arisaema sikokianum.

to be lost because it is caviar to a chipmunk or just what the slug was waiting for? Is it to be struck from our list because it is not native? I am sorry that the ecological crisis has thrust guilt on some gardeners. Can it be lifted where plants are concerned and channeled instead onto overspraying with pesticides and herbicides and the overuse of chemical fertilizers?

One ecological theme can hardly be contested—the one praising compost. For lack of loam and soil on our property we have turned compost-making into a homescale industry with cinder block bins in an out-of-the-way spot and a shredder to speed up the process when there is time to use it. Every fall and spring the shredder is in heavy use chopping up the autumn crop of leaves and coping with those left behind in spring as well. These leaves are used for surfacing the paths, for mulch, for compost. The bins are like the cannisters on a kitchen shelf in which flour, sugar, and salt are stored; here there are bins for leaves, horse manure, sand, gravel, weeds, seaweed, and sheep and cow manure when we can get it. When shredding time or strength runs out in the fall, we pile unshredded leaves in a large wire bin, the first of three, so that in three years there is compost of a rough sort for general use in the woodland and on the hillside. This has been done unscientifically, without additional inoculants, letting nature do the work.

Wheelbarrows and trash barrels are indispensable parts of our gardening efforts—a wheelbarrow is taken to the various bins and individual ingredients put in by the bucketful, the choice of which bin and how much depending on whether the mix is for woodland plants in shade or for plants on the open hillside. For the rock garden the mix is made more fastidiously with only leaf mold (mainly oak since that is our principal tree) and helpings of peat, occasionally manure, and ample amounts of sand and bags of granite chick grit to provide good drainage.

Why do gardeners garden? Especially, why try so hard to grow temperamental plants with fussy requirements and unpredictable personalities? And what makes a plant a favorite? Summon the poets—let me count the ways. It is as irrational, personal, and idiosyncratic as the gardener's genes. Often I think I would give up a large section of a rock bed if I could have one perfect specimen of *Androsace* 'Millstream' or *Physoplexis comosa,* or have a fern return and flourish as *Asplenium ceterach* once did. For rock gardeners it has to do with delicacy, the structure of leaf and flower fitting together with a clock's perfection of parts, far too rigid a comparison for shapes so fragile. But contradiction leaps with every word: there is nothing visibly fragile about the cushion of a saxifrage—often a sturdy community of minute rosettes—but the flowers that open on the nearly invisible stems above that cushion are as thin in petal as silk, their very stature and texture speak of crystal air, high places, freedom, uniqueness. Nothing humdrum, nothing overdone or blowsy, or repeated too often. We wait for the blossoms, are enraptured by them, and then wait again for another season—fleeting, evanescent—all the qualities that are hard to capture or tame.

Plants from all the wild places—meadows, swamps, bogs, woodlands, as well as alpines—are there to satisfy the yearning for flowers that are slender rather than fat; unusual rather than commonplace; elegant and graceful rather than bulky. When an alpine is well grown, it is said to be "in character," conforming to the ideal in the wild. Fertilizers, overwatering, too much cosseting, can change the height, the size of the flowers, the very look of the plant. An alpine generally needs to be only a few inches high; a woodland plant graceful, not heavy.

Plants from the wild are my weakness, it's true, but I also garden just for the feel and the smell of it. Mere earth in spring can summon the heart as imperatively as the fragrance of any familiar flower. But the moment is at hand to reconcile the urge to grow plants with the need to spend more hours on other pursuits. Adjusting expectations, refocusing goals, coming to terms with what *is* rather than what is wished for—these are lessons I need to learn. No sooner said than the thought of a new planting of *Arisaema sikokianum* pops up or a bank of species azaleas to transform a boring corner. How not answer the challenge of convincing *Primula japonica* to settle in permanently by the stream? Who would willingly shun the prospect of more shrubs whose fragrance in season can suffuse the whole garden, or forego a recently discovered plant that quickens the blood? Did I just imply *moderation*? Or use the word *reconcile*? As long as there's life, let spring come and let me at the trowel!

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Catherine Hull is a gardener and a lecturer on horticulture specializing in alpines, rock plants, and woodland wildflowers. She is a member of the North American Rock Garden Society and other plant societies. As a trustee of The Trustees of Reservations she is particularly interested in the Sedgewick Gardens at Long Hill. She has served on Harvard's Visiting Committee to the Arnold Arboretum, where she has also worked as a volunteer.

Plant Collecting on Wudang Shan

Peter Del Tredici, Paul Meyer, Hao Riming, Mao Cailiang, Kevin Conrad, and R. William Thomas

American and Chinese botanists describe the locales and vegetation encountered during a few key days of their expedition to China's Northern Hubei Province.

From September 4 to October 11, 1994, representatives from four botanical gardens in the United States, together with botanists from the Nanjing Botanical Garden, participated in a collecting expedition on Wudang Shan *(shan=mountain)* in Northern Hubei Province, China. The American participants were from member institutions of the North American-China Plant Exploration Consortium (NACPEC), a group established in 1991 to facilitate the exchange of both plant germplasm and scientific information between Chinese and North American botanical institutions.

Paul Meyer, director of the Morris Arboretum, led the expedition. He was joined by Kevin Conrad from the U.S. National Arboretum, Peter Del Tredici from the Arnold Arboretum, and Bill Thomas from Longwood Gardens. The Nanjing Botanical Garden was represented by two botanists, Mao Cailiang and Hao Riming, assisted by Lü Yi and Zang Qifa. Deng Zhidong, director of the Science and Technology Committee of Dang Jiang Kou City, was in charge of logistical arrangements, assisted by Zen Jiafu.

Wudang Shan was selected for its exceptionally diverse flora, among the richest in the temperate world. Ernest Henry Wilson, the English plant explorer who collected in China first for the Veitch Nursery and later for the Arnold Arboretum, spent considerable time in Hubei Province (then known as Hupeh) in the late 1800s and early 1900s but never went as far north as Wudang Shan. He did, however, visit the town of Fang Xian, about fifty kilometers to the southwest.* The first systematic study of the flora of Wudang Shan was done in 1980 by a team of botanists from Wuhan University, who made extensive herbarium collections. In the spring of 1983, the British plant collector Roy Lancaster visited the region with a group of tourists, making him the first Western botanist to explore the mountain (Lancaster, 1983, 1989).

Wudang Shan is famous throughout China as an important center of Ming Dynasty Taoism. Over five hundred years ago, about three hundred thousand workers were employed on the mountain building some forty-six temples, seventy-two shrines, thirty-nine bridges, and twelve pavilions, many of which are still standing. A modern paved road takes visitors up to about 900 meters, where a hotel and several small inns are located. Beyond this point a steep stone path leads up to the summit, the Pillar-of-Heaven Peak, which is crowned with the small but spectacular Golden Temple. Hundreds of thousands of Chinese tourists and pilgrims visit the mountain throughout the year, but their impact is generally confined to the immediate vicinity of this main path. While the vegetation adjacent to the path shows signs of wear and tear, one finds well-preserved forest very close by as well as on all the secondary trails.

Remnants of ancient forest in China are typically found only in the vicinity of Buddhist or

* The old *Acer griseum* (paperbark maple) growing along Chinese Path at the Arnold Arboretum (AA# 12488-B) was collected by Wilson at Fang Xian in 1907 (EHW # 719).

PASSERBY

Members of the Wudang Shan expedition pose for a group photo at the summit of the Pillar-of-Heaven Peak. From left are Mr. Zeng, Lü Yi, Zen Jiafu, Kevin Conrad, Peter Del Tredici, Mao Cailiang, Paul Meyer, Hao Riming, Zang Qifa. Not shown are Bill Thomas and Deng Zhidong.

PETER DEL TREDICI

All supplies must be carried on foot up an ancient stone path to the summit of Wudang Shan.

Taoist temples, a fact that explains the relatively good condition of the forests surrounding the main peak of Wudang Shan. At lower elevations, below about 600 meters, the forests have either been replaced by field crops or are being intensively managed for fuelwood production. The only relatively undisturbed forest that we found was above 900 meters on slopes punctuated by inaccessible peaks, steep cliff faces, and boulder-strewn valleys.

The Wudang Shan Range, which is located in the northwestern corner of Hubei Province, extends for a distance of about 400 kilometers along a southeast/northwest axis (from 110°57' to 111°14' east longitude and 32°23' to 33' north latitude). It is bordered by two large rivers: the Han, which flows about 30 kilometers to the north, and the Yangtse, about 150 kilometers to the south. The upper slopes of Wudang Shan consist of a series of seventy-two jagged peaks, the highest being 1,612 meters in elevation. Above 1,000 meters, the terrain is dominated by steep cliffs and deep, moist ravines. The soil is well-drained, having been formed mainly by erosion of sedimentary limestone and sandstone, and is classified by the Chinese as "mountain yellow-sandy loam." Soil pH ranges between 5.5 and 7.5, with the top of the mountain more acid, between 4.5 and 6. The mean annual temperature is 8.5 degrees Centigrade; the mean annual precipitation of 963 millimeters is quite evenly distributed throughout the year.

Our goal in this article is not to describe all the plants encountered on Wudang Shan but rather to give the reader a sense of the locale and its vegetation, as well as of the plant-hunting process, by outlining the observations we made during a few key days of the expedition.

PETER DEL TREDICI

An ancient specimen of Quercus variabilis *that has been repeatedly cut back for firewood production. Farmers have coppiced most of the trees on the lower slopes of Wudang Shan in similar fashion.*

September 21: Hubei Horticultural Heaven

The weather was alternately foggy and rainy, creating a mysterious mood in the forest. Shortly after leaving the main trail leading to the summit, we entered a forest dominated by large specimens of pine and oak, *Pinus tabulaeformis*, the tabletop pine, and *Quercus aliena*, an oak similar to our native chestnut oak. Continuing along the path, we came upon a rustic stone house built into the side of a vertical cliff. A little way beyond this cottage, a bend in the road looped back on itself as it followed the contours of a ravine. The conditions were moist, shady, and steep, with an oak overstory. Our guide, Mr. Zeng, a collector of medicinal plants, pointed out two specimens of *Stewartia sinensis*, the Chinese stewartia, both with beautiful, smooth cinnamon-red bark, a wonder to behold and to touch. Growing nearby were several kousa dogwoods, *Cornus kousa*, and a small specimen of the paperbark maple, *Acer griseum*. The Americans in the group could hardly contain their excitement, as though they had died and gone to horticultural heaven. The only thing missing, sadly, was seed on any of the plants, probably due to the previous summer's drought. The understory of this exquisite tableau consisted of the beautiful

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Epimedium *sp. growing on the slopes of Wudang Shan. Because it was lacking both fruit and flowers, its identity is uncertain. Based on a newly published report by Roy Lancaster, it could well be* Epimedium stellatum.

evergreen holly, *Ilex pernyi*; the ubiquitous Chinese spicebush, *Lindera glauca*; and *Lyonia ovalifolia*. As on much of Wudang Shan, the forest floor was carpeted with a bewildering array of ferns and herbaceous perennials, including species of *Aconitum*, *Ligularia*, and *Cimicifuga*, all in flower. Jack-in-the-pulpits *(Arisaema)* were everywhere, their stalks heavy with seed, along with unidentified species of *Epimedium* and *Rodgersia*.

Shortly after passing through the *Stewartia* ravine, we stopped for lunch in a small cave where Mr. Zeng, who had gone on ahead of us, had built a fire to warm us. Just outside the mouth of the cave was a large specimen of the somewhat weedy glory bower, *Clerodendrum trichotomum*. After lunch we continued on, collecting seeds of *Zanthoxylum molle*, *Acer mono*, and a snake-barked maple, *Acer davidii*. As we emerged from the dense forest into a more open area, we came across a straggling specimen of *Decaisnea fargesii*, bearing several of its unusual long, blue fruits, and several multistemmed specimens of a maple, *Acer henryi*, that resembles our native box elder.

We also saw an ancient specimen of *Zelkova sinica* growing on a cliff face that may once have housed some kind of shrine. Its exfoliating orange bark made it stand out clearly in the thick mist. As noted earlier, *Cornus kousa* was quite common in the woods, represented by several old specimens a third of a meter or more in diameter, along with large specimens of *Cornus controversa*, the Chinese pagoda dogwood. A little way beyond the *Zelkova* shrine, we found several plants of Chinese witch hazel, *Hamamelis mollis*, loaded with unopened seed capsules. We were particularly pleased to collect this winter-blooming species, which has recently been gaining popularity in American gardens. After seeing so many plants without seed, it was a treat to find one in fruit, and we greedily collected every seed capsule we could find. The plants were growing on a dry, shady hillside near another plant in the witch hazel family, *Sinowilsonia henryi*; a large specimen of the beautiful broadleaf evergreen tree, *Phoebe bournei* (Lauraceae); and a few small plants of *Cephalotaxus sinensis*, growing in dense shade. As the path became more open, we found ourselves surrounded by flowering specimens of *Elaeagnus pungens* in full fragrancy, growing together with *Forsythia giraldiana*, in seed.

September 30: The Paperbark Maple

At about 900 meters on a steep northwest-facing slope, we found two large specimens of *Acer griseum*, covered with seed. One specimen was about 6 meters tall and had three large trunks emerging from a swollen base; the other, about 7 meters tall, had a single trunk about 15 centimeters in diameter. Throughout this area of mature forest, we saw numerous saplings and seedlings of this species growing in dense shade on very steep, well-drained terrain. Ecologically speaking, *A. griseum* appears to be late successional, clearly able to persist under conditions of deep shade, periodic drought, and intense root competition. When a gap in the forest canopy develops, the tree is perfectly positioned to expand into the newly available space.

Our excitement at finding *Acer griseum* was exceeded only when we noticed two trees with bright orange bark farther up the slope. More *Stewartia sinensis,* we thought at first, but on closer examination we discovered them to be specimens of *Zelkova sinica.* This outstanding tree is rare in cultivation in North America and deserves thorough testing to determine whether its potential as a street tree matches that of its more common cousin, *Z. serrata.* On the slopes of Wudang Shan, the orange bark of *Z. sinica,* which exfoliates in discrete plates like pieces of a jigsaw puzzle, was every bit as spectacular as that of *Acer griseum.*

In this area alone we found five large paperbark maples with diameters of 10 centimeters or more and ten smaller trees with diameters between 3 and 6 centimeters. There were ten juveniles between 30 and 200 centimeters tall, and about fifteen seedlings less than 30 centimeters tall. This makes for a mixed-age population of approximately forty plants. The three largest trees were situated at the base of a steep cliff, and we nearly killed ourselves trying to reach them.

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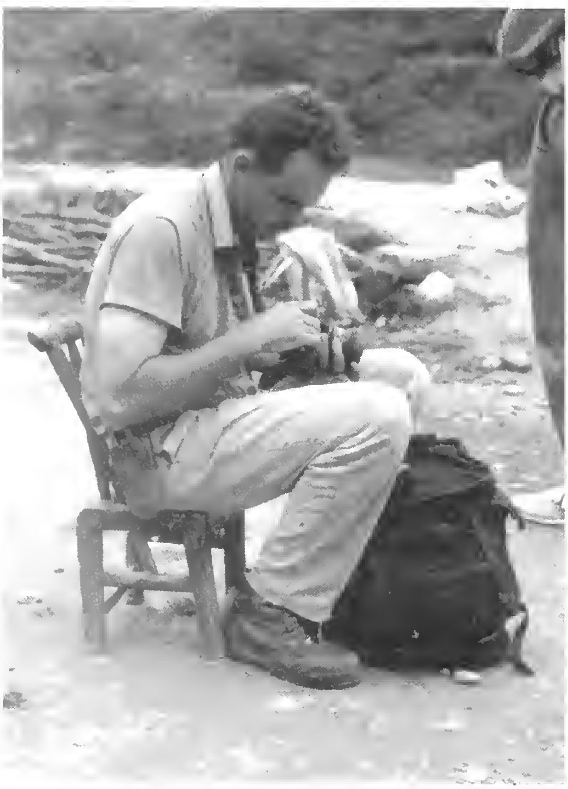

Kevin Conrad reloading his camera at the end of a long day of collecting.

Some horticulturists have suggested that the slow growth of *Acer griseum* in cultivation might be symptomatic of inbreeding that has occurred as a result of its genetically limited introduction by Wilson at the turn of the century. However, our field observations suggested that its slow growth is probably an adaptation to the ecological niche it occupies in the forest understory. Most of the specimens we saw were spindly and gnarled, with light, airy crowns.

About 95% of the *Acer griseum* seed we collected was hollow. Why this should occur within a healthy, mixed-aged population is not readily apparent, but the scant rainfall in the area since late spring may be one explanation. The fact that fertility problems have been widely reported in cultivated paperbark maples suggests a possible biological cause: it may be that the broad, green wings of the seeds are performing a photosynthetic function in addition to their more obvious dispersal function. If this is the case, the "seeds" may be persisting on the tree in order to produce carbohydrates, regardless of whether or not they contain an embryo. However, we found numerous paperbark maple seedlings growing in the understory, clearly indicating that not all *A. griseum* seeds are hollow and that the species is capable of reproducing even in dense shade.

October 1: The Ravine Trail

Leaving the main tourist trail behind, we started climbing a steep, moist ravine. In the distance we could hear the loud cries of a troop of rhesus monkeys *(Macac mulatta)* as they moved through the forest on the slopes across the valley. Almost immediately we were in the midst of numerous herbaceous plants, many in full flower. They included two species of annual *Impatiens,* one yellow, the other pink; the Chinese bugbane, *Cimicifuga simplex,* with its meter-long flowering spike; the toad lily, *Tricertis macropoda;* the stately, yellow-flowered *Ligularia dentata;* and three species of monkshood (*Aconitum* spp.). In addition, a large number of perennials in the seedpod stage were present, including *Cardiocrinum cathayanum,* the giant lily, with fruiting stems up to a meter tall; two jack-in-the-pulpits, *Arisaema consanguinium* and another as yet unidentified; and a second bugbane, *Cimicifuga acerina.* We also collected spores from at least four different species of ferns that abounded in the moist, shady understory. We can only imagine how spectacular this area is in the spring.

Climbing farther up the moist ravine, to about 1,000 meters, we came upon a cluster of stone terraces. According to Mr. Zeng, they were built around 1962, during the Cultural Revolution. They had been planted with corn and soybeans, but were abandoned five years later because they were too far from people's homes. Numerous sun-loving plants had invaded the terraces, chief among them *Pueraria lobata,* the dreaded kudzu vine. It was amazing to see this plant behaving in its homeland much the way it does as an introduced species in North America—that is, swarming up and over everything in its path. Indeed, large areas on the lower slopes of Wudang Shan were completely covered with kudzu.

The Chinese kiwi vine, *Actinidia chinensis,* was also common throughout the woods, easily recognized by its coiling stems hanging languidly from the branches of canopy trees. The fruits of this species, which is a parent of most commercially available varieties, are moderately sized, about 3 to 5 centimeters long, and very tasty. The local residents do a brisk business selling them to tourists setting out for the top of the mountain. As in the case of kudzu, the kiwi vine seemed to require some form of disturbance (usually human) in order to establish itself. Rounding out a triumvirate of weedy vines that sprawled over the lower slopes of Wudang Shan was *Akebia quinata,* with its clusters of banana-shaped, purple fruits filled with a sweet, white pulp and numerous hard, black seeds. More than once these fruits proved a pleasant snack for the collecting team.

Farther up the slope, at about 1,200 meters in elevation, we came upon a particularly exciting find—a giant specimen of *Emmenopterys henryi* (Rubiaceae, or madder family), some 18 to 20 meters tall and 48 centimeters in diameter. The tree is listed in the Chinese *Red Data Book* (1992) of endangered plants and is classified as "vulnerable." It produces showy, white flower clusters with subtending bracts that persist into mid-autumn, taking on a rose-to-tan color as the small fruits ripen. Mr. Zeng showed no hesitation about climbing the tree barefoot in order to collect some seed. For the Americans, it was a thrill to find what E. H. Wilson considered "one of the most strikingly beautiful trees of the Chinese forests" (Sargent, 1917). Growing nearby was a large specimen of *Acer mono,* along with numerous specimens of *Pteroceltis tartinowii,* literally clinging to a rocky cliff face. A beautiful shrub, *Mahonia bealii,* was also common in the understory; Mr. Zeng, a practitioner of traditional Chinese medicine, collected a fair number of its stems, which when taken internally "put out the fire within the body."

Other Highlights of the Forest

Not more than 20 meters from the main path, at about 1,100 meters in elevation, we found an absolutely spectacular specimen of *Stewartia sinensis,* 15 meters tall and 55 centimeters in diameter at breast height. The bark was perfectly smooth and a cream-pink in color, unlike the reddish bark of younger plants. W. J. Bean captured the essence of the tree when he described the bark as being "smooth as alabaster and the colour of weathered sandstone" (1981). Our specimen had no branches below 8 meters, making it impossible to collect either seeds or specimens. According to local legends, this is a sacred tree; Taoist pilgrims typically burn sacred paper, symbolizing money, as an offering at its base. Unfortunately, the area around the tree is used as a refuse dump, spoiling an otherwise sublime setting. Growing in the shady understory near the giant *Stewartia,* we found a peony in fruit, *Paeonia obovata* var. *willmottiae.* The three-valved pod was reddish-purple on the inside and filled with a mixture of viable steel-blue seeds and red, aril-like structures. The species produces beautiful white flowers in the spring. It was originally collected by E. H. Wilson in Fang Xian.

At higher elevations we collected seed of *Sinowilsonia henryi* and *Fortunaria sinensis,*

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A spectacular specimen of Stewartia sinensis, *15 meters tall and 55 centimeters at breast height, growing at an elevation of 1,100 meters on Wudang Shan.*

both in the family Hamamelidaceae. The former reached tree-size proportions on Wudang Shan, upwards of 10 meters, while the latter was decidedly shrubby. At lower elevations we encountered the marginally hardy but very beautiful *Loropetalum chinense*, growing up to 4 meters tall. This plant produces large masses of beautiful white flowers in late winter, but unfortunately can be grown out-of-doors only in the southern portions of the United States.

Maples were well represented on Wudang Shan, including the aforementioned *Acer henryi, A. davidii,* and *A. mono*. We also came across a small-seeded chestnut, *Castanea henryi;* the wild persimmon, *Diospyros lotus;* and a large tree-form redbud, *Cercis glabra*. The canopy was dominated by several species of oaks, most notably *Quercus variabilis* and *Q. serrata*, remarkable for their ability to thrive in poor, eroded soils and to sprout back after being cut down. At other locations on the mountain, farmers used logs of both these species as substrates for cultivating a wide variety of woodear-type fungi.

Among the shrubs, the genus *Euonymus* was particularly well represented on Wudang Shan. We found at least five different species, including the aptly named *E. elegantissima*, with gracefully pendant four-angled fruits. We were particularly pleased to find seeds of the beauty bush, *Kolkwitzia amabilis*, growing in moist ravines. This species, which has beautiful pink and white flowers and a graceful growth habit, was first collected by Wilson in 1901. It achieved great popularity in the 1920s and 1930s but is now, sadly, out of fashion. Other shrubs of note included three species of small-leafed *Rhododendron;* the beauty berry, *Callicarpa japonica;* and the Chinese sweetleaf, *Symplocos chinensis*. The evergreen spicebush, *Lindera glauca*, was ubiquitous in the understory, reaching heights of 4 to 5 meters. We also found species in the familiar genera *Lonicera, Hypericum, Photinia,* and *Spiraea*.

Conclusions

All told, the Wudang Shan expedition yielded 185 collections of seeds and cuttings. For each collection the exact location (latitude, longitude, elevation) was determined by a battery-

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Paul Meyer checking latitude and longitude using a Global Positioning Device.

powered Global Positioning Device and carefully recorded, along with a detailed description of the surrounding habitat. In addition, each collection was documented with five replicate herbarium specimens, to be filed in both Chinese and North American herbaria. These will function as the permanent record of the trip that will allow future generations of botanists to study the nature of vegetation change in the Wudang Shan area. They were also essential to the success of our trip in allowing us to check our field identifications against documented material in the herbarium of the Nanjing Botanical Garden. Indeed, without herbarium vouchers, the scientific value of the expedition would have been minimal.

When recounting the excitement of collecting plants, one often forgets the more mundane aspects of the plant-hunting process, namely seed cleaning and packaging, which occupied almost as much of our time as the plant collecting itself. As tedious as these tasks sometimes seemed, they are necessary in order to ensure that insect and/or microbial pests are not inadvertently introduced into the United States. Shortlived seeds, such as those of oaks, maples, and chestnuts, had to be carefully packed in moist sphagnum moss to keep them from drying out during transit.

Upon our arrival in San Francisco, the seeds were inspected by officials from the U.S. Department of Agriculture before being released for entry. Later, they were divided among the various NACPEC institutions for cultivation. At the Arnold Arboretum, those seeds requiring a chilling period in order to germinate were immediately placed in the refrigerator, while those lacking embryo dormancy were sown directly in the greenhouse. Even as this article is going to press, many of them have already germinated. Surplus seedlings, should there be any, will be distributed to other botanical gardens as well

PAUL MEYER

One of the many buildings clinging to the cliffs near the top of the Pillar-of-Heaven Peak.

as to commercial nurseries. Over time, young plants will be put in the ground and evaluated for performance under a variety of field conditions. In the grand scheme of things, seed collection is only the first step of a lengthy process that includes propagation, cultivation, evaluation, and selection.

After all the work is done, the question remains, "Was it worth the effort?" In the case of our Wudang Shan trip, the answer is an unequivocal "Yes." As regards the plants, we have succeeded in bringing in new germplasm of species already in cultivation in North America but represented by only one or two prior collections that may or may not include the hardiest ecotype available. We also made a contribution to the *ex situ* conservation of several rare Chinese plants that are threatened by extinction due to widespread habitat destruction. And finally, we introduced into cultivation several species that have never been grown in the United States. On the human side of the equation, the trip produced lasting friendships among all the expedition participants and strengthened the ties among a number of U.S. and Chinese botanical institutions.

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The Arnold Arboretum

SPRING • NEWS • 1995

The Visiting Committee Visits

Robert E. Cook, Director

Reading the history of Charles Sprague Sargent's directorship, which spanned the period from 1872 to 1927, one gains the distinct impression that he reported to no one in particular at Harvard University. Although he was appointed by the president of the University and submitted an annual report each year, he managed the Arboretum with a great deal of autonomy from the Cambridge administration.

In these more democratic times, I retain a considerable amount of this autonomy, although a good third of my time is spent addressing administrative and University matters in Cambridge. In this capacity, I report to the Vice President for Administration at Harvard, Sally Zeckhauser, who manages much of the physical plant and personnel side of the University on behalf of the seven-member Harvard Corporation. However, like other schools and institutes at the University, the Arboretum has a Visiting Committee, a group of individuals appointed to review the workings of the Arboretum and report back to the Board of Overseers, an elected body that governs alongside the Corporation. Our Visiting Committee includes horticultural and botanical scientists, educators, and long-time friends of the Arboretum.

Corliss Engle

Peter Del Tredici, Assistant Director for Living Collections, guides members of the Visiting Committee on a tour of Chinese Path. From left are Donna F. Hartman, Christopher T. Bayley, chair, Elizabeth C. Sluder, and W. Hardy Eshbaugh. Committee members not shown are Gregory J. Anderson, Robert A. Bartlett, Jr., William B. Coughlin, Caroline G. Donnelly, Jane C. Edmonds, Thomas S. Elias, Corliss Knapp Engle, Francis O. Hunnewell, Joan M. Hutchins, Matthew J. Kiefer, Ellen West Lovejoy, Janine Evnin Luke, Edith N. K. Meyer, and Robert Ornduff.

In early May the Visiting Committee visited for a day and a half, focussing their attention particularly on the quality of care we bring to the maintenance and curation of the living collections here in Jamaica Plain. I am pleased to report that they were extremely supportive and very impressed with the appearance of our landscapes, the richness of our holdings, and the extra lengths to which we go to maintain accurate records of all our shrubs and trees. We feel confident that we are setting the standard for what for serious scientific arboreta, and that we have the best documented collection of trees in the country.

A Day to Celebrate Trees

On Saturday, May 6, the Arboretum held its first Celebrate Trees Day. It featured talks on urban forests and street trees, tours of the landscape, a children's storyteller, and giveaways of spruce trees and yellowwood seeds. By the end of the day we had distributed almost 200 spruce and over 100 pots sown with yellowwood. Despite a rather blustery and cool spring day, the volunteers and staff enjoyed the opportunity to spread the word about the importance of trees.

• *see pictures on page 7*

Location by Location—Mapping 265 Acres of Plants

Susan Kelley, Curatorial Associate

Since its establishment in 1872, the Arboretum has continuously developed and maintained a living collection of trees, shrubs, and vines from around the world, plants that now number nearly 14,000. The collections are a resource for resident and visiting scientists and graduate students of botany, horticulture, and landscape studies, all of whom rely upon the Arboretum's maps and the extensive records that are maintained for each plant in the collection. At the time a specimen is planted on the grounds, its record is opened with its unique identifying accession number and its botanical and common names; the plant's provenance (whether collected from the wild or obtained from a nursery or other botanical institution); how it was received (as a seed, a graft, an individual plant, etc.); and the region(s) of the world to which the species is native. Yet this information is of little value unless the plant in question can be readily located on the grounds, and since 1937 the Arboretum has maintained hand-drawn, finely detailed maps that enable Arboretum curators and visiting scientists to find and study individual specimens.

To improve the accuracy and efficiency of plant records and mapping, the staff of the Arboretum made a commitment in the mid-1980's to convert to computerized systems the existing plant data (until then maintained on 3" x 5" index cards) and hand-drawn maps. With improved records management an immediate goal, a database was designed specifically for the maintenance of botanical garden and arboretum plant records. The system, called BG-BASE, is based on the Arnold Arboretum's documentation methods and is now in use not only at the Arboretum but at fifty-five other botanical institutions around the world. (The Winter 1989 issue of *Arnoldia* [49:1] was devoted to the whys and hows of curating the living collection.)

The first step toward the new mapping system was to contract Swissair Photo + Surveys, Ltd. (Zurich) to survey the Arboretum grounds. From aerial photography, Swissair Photo provided the Arboretum with a base map, compatible with a CAD (computer aided design) format, that shows topographic contour lines at intervals of 10 feet and roads, paths, water features, and buildings. A grid system overlaid onto the base map divides the property into 64 individual maps, each 400 feet by 600 feet, and each map is further divided into four quadrants labeled NW, NE, SW, or SE.

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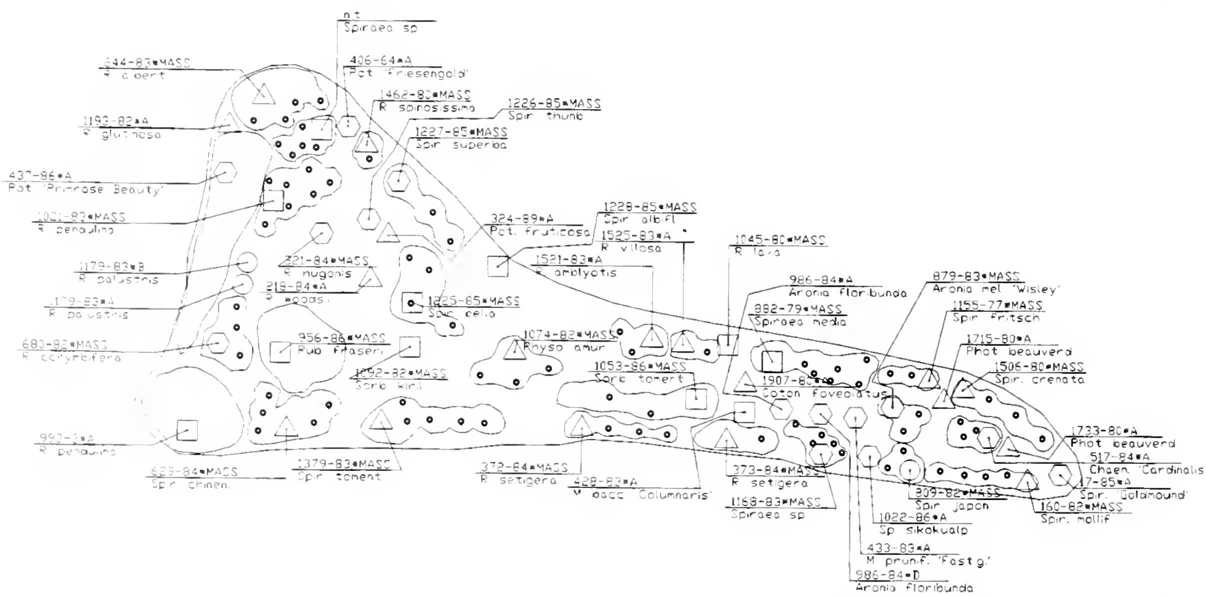

The map for bed 7A in the Bradley Collection of Rosaceous Plants showing symbols denoting provenance type, accession number, and an abbreviated form of the botanical name. The dark circles denote multiple plants within a specific accession.

A New Face for Chinese Path: A Gallery of Asian Plants

Richard Schulhof, Assistant Director for Education and Public Affairs

The Chinese fringe tree, one of many Asian species to be enjoyed along Chinese Path.

In a landscape known for trees of historical significance, the Arboretum's Chinese Path stands alone as a place where history is written in plants. Roughly a hundred years ago, a series of events made possible the creation of a gallery of trees and shrubs near the summit of Bussey Hill that exists today as a magnificent living record of Asian plant explorations and introductions to the North American continent. This spring, work resumed on a project to enhance Chinese Path both aesthetically and as an interpretive display for Arboretum visitors.

The site of Chinese Path, the 198–foot Bussey Hill, has long held significance for the people of Boston. During the Revolutionary War, Colonel Eleazer Weld, ancestor of Governor William Weld, owned "Weld Hill" as part of a larger property that included much of the present-day Arboretum. At that time, the summit's commanding views of the Boston basin gave strategic importance to Weld Hill, the site of an earthen fortification. In 1806, gentlemen farmer Benjamin Bussey acquired the property and made the hill the centerpiece of one of Boston's finest country estates. In addition to a mansion on the hill's south-facing slope, Bussey constructed an observatory at its summit where evenings of study included star gazing with fellow Bostonians who shared his scientific interests. By the time Bussey bequeathed the property to Harvard and the Arboretum was founded, the name "Bussey Hill" was firmly affixed to the property.

When Charles Sprague Sargent and Frederick Law Olmsted negotiated for the inclusion of the Arnold Arboretum in the Boston park system, Bussey Hill's outstanding views were to once again determine its use and development. As part of its agreement with Harvard, the City of Boston at first specified that eleven acres near the summit of Bussey Hill be left unplanted for a picnic area. The picnic area was never realized, however, and in 1895 the City of Boston released the reservation area so that it could become part of the Arboretum proper.

The timing of the City's decision was truly fortunate, as it provided space for an unprecedented influx of new species for the Arboretum collections. Beginning in 1892 with Charles Sargent's trip to Japan, the Arboretum launched a series of expeditions to eastern Asia that resulted in the addition of over 1,000 species and varieties to the living collections in Jamaica Plain. With space elsewhere already planted, the new Asian collections found a home on the former city property on the southwest side of Bussey Hill. The area, initially named Azalea Path, featured an extensive planting of the Royal azalea *(Rhododendron schlippenbachii)*, collected by John G. Jack in Korea in 1905. Over the next twenty years, specimens of other Asian species collected by Sargent, Jack, and most notably, the great plant explorer Ernest H. Wilson, filled adjacent beds called the "Collection of Chinese Shrubs." Eventually this area expanded to form the broad horseshoe-shaped gallery known today as Chinese Path.

This spring the Arboretum continued its efforts to transform Chinese Path into an interpretive exhibit that will trace the history of plant exploration and the

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introduction of new plants from East Asia. The redesign, prepared by Gail Wittwer, a student at the Harvard Graduate School of Design, aims to better guide circulation through the area and to update the collection with specimens obtained through recent plant explorations.

The path's defining feature is the botanical legacy of E. H. Wilson and other Arboretum explorers. Magnificent specimens from turn-of-the-century explorations—the dove tree *(Davidia involucrata)*, Japanese stewartia *(Stewartia pseudocamelia)*, and a paperbark maple *(Acer griseum)* that many believe to be North America's most outstanding specimen—are now joined by plantings of *Sorbus yuana, Ilex fargesii, Rhododendron fargesii*, and other shrubs collected by the 1980 Sino-American botanical expedition, the first cooperative venture between American and Chinese botanists since 1947. The crowning glory of the area's new plantings will be a grove of more than a dozen wild-collected dawn redwoods *(Metasequoia glyptostroboides)* that will soon mark the southern terminus of the path. It is hoped that these historic specimens, together with pamphlets, story labels, and other exhibit materials to be provided through a grant from the National Endowment for the Humanities, will reveal to visitors the story of over a century of plant exploration and its impact on botanical science, horticulture, and the North American landscape.

Kim E. Tripp

The Arboretum's Pat Willoughby and Don Garrick (from left) plant a *Cornus kousa* that was collected by the 1980 Sino-American botanical expedition.

Karen Madsen

Dawn redwoods propagated at the Dana Greenhouses await planting on the grounds. A grove planting of these trees will define the southern end of Chinese Path.

Susan Hardy Brown Honored

Karen Madsen

Susan Hardy Brown, herbarium curatorial assistant, has been honored in a new program that recognizes outstanding employees at Harvard University. Over the years, Susan has done an exceptional job in mobilizing and leading an active group of volunteers to help her and other plant mounters assemble dried plant material into labeled specimens for the collections in Jamaica Plain as well as those in the Harvard University Herbaria in Cambridge. Last year, 18,217 specimens were created in all.

Many of the specimens constitute works of art as well as tools for research. Once mounted, they become critical material in support of our efforts in botanical systematics and biodiversity conservation. In nominating Susan for this recognition, Bob Cook applauded the energy and intelligence she brings to her work and the great cheer and good spirits with which she accomplishes it.

Karen Madsen

Candace Julyan has joined the Arboretum staff as project director for the Community Science Connection, a new science education project funded by the National Science Foundation. Candace earned her doctorate at the Harvard Graduate School of Education where she investigated students' understanding of seasonal change in trees. Before coming to the Arboretum she developed and directed the National Geographic Kid's Network, a science education project in which students share experimental data about local environmental conditions across a national computer network. In addition to her work with the Community Science Connection, Candace is the developer and host of an interactive television program on MCET entitled "The Changing Nature of Trees."

Computer Networks, Local Schools, and the Living Collection

Candace L. Julyan, Project Director, Community Science Connection

What role can or should the Arnold Arboretum play in providing science learning opportunities to teachers and students in the surrounding communities? How might computer technology be used to support students' understanding of science? How can the Arboretum serve as a resource for parents interested in supporting their children's science education? Over the next four years, many people at the Arboretum and in local schools will be grappling with these three questions as part of the NSF-funded project, Community Science Connection. As described in Bob Cook's recent Director's Report, this project has evolved from the Arboretum's continuing work with area schools, led by Diane Syverson, while introducing computer technology as a new element in this work.

The $1.2 million grant will allow the Arboretum to work with teachers in the Boston, Brookline, and Newton schools to develop a series of investigations that students can conduct in their schoolyards, in neighborhood natural areas, and on the Arboretum grounds. By exchanging letters and data on a computer network, students will be able to share their ideas with one another and interact with Arboretum scientists as they consider the implications of their findings. In addition, the project will develop ways for parents to support their children's learning through science investigations conducted at home and through special science activities for families on the Arboretum grounds.

The initial goal of the project, which began in February 1995, has been to create a community among the twenty-six teachers who will serve as the early pioneers in this effort. These teachers are from nine schools within a three-mile radius of the Arboretum: in Boston, the Agassiz School, the John F. Kennedy School, the Joseph P. Manning School, the Ellis Mendell School, the Richard J. Murphy School, and the John Winthrop School; in Newton, the Mason-Rice and Memorial-Spaulding schools; in Newton and in Brookline, the Lawrence School.

This spring, the twenty-six teachers have been exploring their own understanding of the changing nature of trees through direct observations. In addition, they have been mastering the computer technology that they will be using with their students in the fall. This summer these teachers and Arboretum staff will develop the investigations that will serve as the foundation of the project's work. Some of these will involve observations of seasonal changes; others may include working with Arboretum scientists. One possibility suggested by Peter Del Tredici, Assistant Director of Living Collections, is to have students conduct some experiments for him on animal feeding preferences by collecting data about which fruit squirrels select first when offered a selection that

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• • *from page 2*

Different features within the landscape are assigned to different layers within the CAD system, so not only has the ease of managing the plants (which can be seen on their own layer) been greatly improved, but information about landscape elements such as irrigation lines, utility lines, and abutting properties can now be readily obtained.

Changes made in the collections are noted in the database and are reflected on the maps via a utilities program that links the mapping system to BG-BASE. The locations of new plantings on the grounds are determined by measuring the distance to nearby plants already on the maps. Individual plants are then digitized onto the maps, with the exact location marked with a symbol that denotes a plant's provenance type (wild or garden collected). Linked to each symbol is the plant's accession number and an abbreviated form of its botanical name. All of this information is gathered directly from the database and is accessed from an active list within AutoCAD. Maps are then printed at a map book size of 11 inches x 17 inches for the Arboretum staff who use them daily to locate individual plants for pruning, horticultural review, making herbarium specimens, or labeling. Each plant in the Arboretum's collection is labeled with a dog tag of sorts, a credit card-sized aluminum strip on which is printed the specimen's accession number, botanical name, provenance information, a common name, and a map location. These labels serve staff and visiting researchers as well as students and the some 250,000 visitors who explore the Arboretum each year.

New Staff

Karen Madsen

Kirsten Thornton, Landscape Preservation Assistant, joined the Arboretum staff in January. Kirsten is participating in our collaboration with the Olmsted Center for Landscape Preservation of the National Park Service. With the help of the Arboretum's nursery staff she is in charge of establishing and maintaining a historical plant nursery in our south nursery area. The nursery will be a holding area for approximately 250 plants propagated from historically significant trees and shrubs from National Park Service sites. When the plants reach an appropriate size, they will be returned to their respective sites as a genetically identical replacement for a plant that has been lost or is in imminent danger. We are currently nurturing propagules from the Olmsted elm at Fairsted, in Brookline; from the yellowwood planted by the Adams family at their Quincy homestead; and from a number of historic apple trees from the home of Franklin Delano Roosevelt in Hyde Park, New York. Kirsten is a 1994 graduate of the University of Rhode Island with a degree in plant science. She was a 1994 Arnold Arboretum summer intern.

• • • • *from page 5*

includes the gingko and other tree species.

In September 1995 the first group of students will begin to communicate with one another and with the Arboretum staff about their findings. At the end of the school year, they will be invited to the Arboretum for a conference at which they will present their findings to each other and meet their electronic colleagues face-to-face. In the 1996–1997 school year, we will invite additional teachers and schools to join the project.

The CSC approach to science education is in keeping with many of the science education reform initiatives taking place in the state and in the nation. The unusual aspect of the project is its base in an institution like the Arnold Arboretum. We feel that our position as a community resource and a scientific research community makes us uniquely qualified to explore new possibilities for collaborations among schools and informal science institutions. Throughout the project we will document our experiences in order to encourage and support other arboreta and botanical gardens interested in replicating our work. By the end of the project we hope to have answers to our questions about the role of the Arboretum in school science programs, about the role of computer technology in supporting meaningful science activities, and about the role that parents can play in their children's education.

A Day to Celebrate Trees:

Events to Promote the Appreciation and Enjoyment of Trees

Karen Madsen

A pot of yellowwood seeds (in the bag) and a young spruce tree head for a new home.

Karen Madsen

Jim Gorman, second from left, led visitors to some of the highlights among the spring-flowering trees and shrubs.

Karen Madsen

Magnolia 'Elizabeth' was the cynosure of all eyes and several cameras.

Karen Madsen

Richard Schulhof, right, discusses the ideas behind the design of the Arboretum on a walking tour.

Karen Madsen

Gary Koller, not seen, led an informal forum on street trees on the Arborway as well as within the grounds. Among participants were (from left) Sydelle Pearl; Dave Bloniarz of the University of Massachusetts; Anne Joseph; Jim Gorman, Arboretum staff; and Corliss Engle, Arboretum volunteer and member of the Visiting Committee.

Dr. Dwight Celebrates 92nd Birthday

Karen Madsen

Richard Dwight, MD, has been a volunteer at the Dana Greenhouse for seventeen years. On April 30 of this year, he celebrated his 92nd birthday, making him our oldest volunteer. A graduate of Harvard Medical School, he is a retired surgeon. In addition to being an avid gardener, he is a gourmet cook, plays the flute, and supports the Boston Symphony Orchestra. He played competitive tennis until age 91 and plans to start again soon. Commenting on the tasks he has been asked to do in the greenhouse, Doctor Dwight says simply, "I like to be useful."

PROGRAMS & EVENTS

In summer, the Arnold Arboretum designs many of its courses, workshops, lectures, and special events to fit into vacation schedules. A small sampling follows. Please note that fees printed in **boldface** are for Arboretum members.

WAL137 A Visit to Cricket Hill Herb Farm

Judith Kehs, Owner and Herb Expert

Our visit to Cricket Hill will begin with an introductory talk on herbs by herb professional Judith Kehs. We will tour the greenhouse and specialized gardens in which Cricket Hill produces the many varieties of herbs they market. Our visit will conclude with refreshments in the garden.

Friday, July 7/ 12:30–3:30 pm (TBA, Rowley, MA).

Fee: **$18**, $21

HOR 134 Summer Flowering Shrubs

Richard Stomberg, Manager, Harvard University Herbaria Glasshouses

The hot humid days of midsummer bring a wide variety of color and texture to the shrub border. This class will focus on the culture of a range of mid- and late-summer flowering shrubs, including *Aesculus*, dwarf buckeye; *Vitex*, chaste tree; *Buddleia*, butterfly bush; *Genista*, dyer's greenweed; *Clethra*, summersweet; *Clerodendrum*, glorybower; *Calluna*, heather; and many others. This is an outdoor walking course held rain or shine.

2 Thursdays, July 20, 27/ 4:00–6:00 pm (Dana Greenhouses).

Fee: **$40**, $46

New Staff

Irina Kadis, a graduate of Leningrad State University with a degree in plant ecology, is dividing her time at the Arboretum between greenhouse work with manager Tom Ward and assisting Putnam Fellow Kim Tripp with data collection and analysis for several ongoing experiments. In that capacity, she is also contributing to a review article on genotypic variability in woody plant

Karen Madsen

performance in managed environments, a task that involves extensive literature searches and records management. For intensive work on the genus *Alnus*, she is translating key Russian texts.

Irina brings to the Arboretum a wealth of botanical experience. In the course of her study of relationships of plants in forest environments, she has held a teaching assistantship at her alma mater and a research assistantship at the Biological Research Institute in St. Petersburg (Leningrad).

Rehder's Ceanothus: *Ceanothus* x *pallidus* 'Roseus'

Gary Koller

Drought resistance in a plant is not only admirable but in many cases a necessity. Add to its profile toughness, persistence with minimal care, longevity, pest resistance, compact size, and adaptability to soils of low fertility, and you have a plant of merit independent of ornamental characteristics.

Ceanothus x *pallidus* 'Roseus' offers all of the above plus ornamental quality. These attributes are common to the entire genus *Ceanothus,* which is well known to West Coast gardeners but is rarely seen in eastern gardens. Muted in color, it is easily integrated with stronger floral colors and is equally suited to formal landscapes as well as the more casual. Its pale rose-colored flowers appear in mid-June, well after the great spring rush of flowers, and remain for several weeks. If spent blossoms are removed immediately, some recurrent flowering will occur. If allowed to mature, flowers give way to light green fruits that mature into small wine-colored spheres scattered throughout the foliar green like small jewels. These fruits provide a strong visual attraction for several weeks in late summer, especially when set against plants with pink flowers or backed by burgundy foliage. With final ripening, the capsules turn beige-brown and split open along three suture lines, remaining on the plant well into the winter months.

Summer foliage is a medium green and, in my experience, entirely pest-free. The leaves remain in good condition until late October, then fall away with no significant color change. The new season's stems remain thin and supple all summer long. Those on the side exposed to the sun take on a dull burgundy color while on the shady or protected side they remain a light green.

The plant forms a mound, flat-topped to dome-shaped. If completely cut to the ground in spring, just as new growth begins, plants achieve a height of three feet and a spread of three to five feet by early June. Unpruned plants will be slightly taller but more open and rangy. Their consistently tight habit makes them useful in restricted spaces; they are not likely to exceed their allocated space. Individual plants spaced thirty inches apart in good light will coalesce into a continuous, dense surface from soil level to the upper tips, with no thinning or dieback where the plants merge. 'Roseus' is therefore useful both as a specimen plant or in a small hedge or mass planting.

Ceanothus, a member of the buckthorn family (Rhamnaceae), is exceptionally drought tolerant; indeed, it will not thrive in heavy or wet soils but instead prefers a soil with very good drainage. The ability to thrive with little water makes it ideal for the sandy soils of seacoast areas as well as inland on poorer, rocky soils. In poorly drained or frequently irrigated soils, *Ceanothus* becomes highly susceptible to root rots. They should never be planted where excess moisture is a problem, especially near irrigation systems.

Ceanothus comes from the Greek, *Keanothus,* and was first applied to prickly plants. Linnaeus reassigned the name to this genus in 1753 when he described *Ceanothus americanus* in the *Species Plantarum.* The genus, which has fifty to sixty species, is entirely North American, with representatives in Canada, the United States, and Mexico. The majority of the species and natural hybrids are native to California. Four species are native east of the Mississippi River: *C. microphyllus* in parts of Florida, Alabama,

ETHAN JOHNSON

Ceanothus x pallidus *'Roseus'*

and Georgia; *C. serpyllifolius* in a few scattered areas of Florida and Georgia; *C. americanus* from Maine to North Dakota, south to Florida and Texas, and in southern Canada from Ontario to Manitoba; and *C. ovatus* in eastern and central states. *C. americanus* was the first species introduced from the American colonies to Europe in 1713, but it never became popular in gardens. A century later, *C. coeruleus*, with its showy panicles of sky blue flowers, was discovered in Mexico, and its introduction to Europe paved the way for a number of garden hybrids developed in French and Belgian nurseries before 1830. *C.* x *pallidus* 'Roseus' was one of these hybrids.

The parentage of *Ceanothus* x *pallidus* 'Roseus' combines stock that thrives in the alkaline soils of the West as well as in the acid soils of the East. (Plants at the Arnold Arboretum grow in an acid pH.) This tolerance of poor soils and salts extends the plant's range to include highway use. Sunlight exposure can range from full sun, which is preferable, to light shade, which causes some reduction of vigor and flowering as well as a more sparse overall effect.

At the Arnold Arboretum this *Ceanothus* dies back when temperatures dip to about zero degrees Fahrenheit with no snow cover. This requires removal of all dead and injured stems just before the new growing season, but at the same time it allows the plant to renew its aboveground parts. Even after dieback, plants with strong well-established root systems will produce a quick new flush of growth that remains full and robust. Annual dieback may in fact contribute to greater longevity. *Ceanothus* is often regarded as short-lived, persisting for no more than ten or twenty years, but the Arboretum's original plant, acquired in 1889 from the nursery of Victor Lemoine in Nancy, France, still thrives after more than a century. In milder climates there is no need to cut back the plant annually, but doing so every few years may help to keep plants tight and bushy. Major shearing should be limited to once a year to maintain a mound that is relaxed and informal, rather than tight and sheared.

The Arboretum's original plant found its way to the old shrub collection where for the first ninety-five years or so it received no exceptional care or, for that matter, much interest. I remember it in 1976 as a sad little plant with a great deal of old deadwood, invaded and nearly swamped by switch grasses. In 1986, as part of the renovation of the Eleanor Bradley Collection of Rosaceous Plants, it was lifted and divided into five or six parts. A group of four was placed in the Dwarf Conifer Garden just below the Bonsai House, on top of a stone wall in very dry soil with excellent drainage and no irrigation. During 1994, from late June until mid-September, several thousand cuttings were taken from this planting to be propagated for this year's spring distribution to Friends of the Arnold Arboretum. Steve Effner, propagator at Quonset Nursery in South Dartmouth, Massachusetts, where the plants were grown, had the best results with cuttings taken just as the plant begins to harden up. Treated with mormodin #3 and stuck individually into #72 pots, a high proportion rooted within three to four weeks. They seemed to be adversely affected only by excess moisture.

Rehder, in his *Manual of Cultivated Trees and Shrubs*, reports that the hybrid complex known as *Ceanothus* x *pallidus* originated before 1830, thought to be the result of a cross between *C. ovatus*, which is native from New England to Texas, and *Ceanothus* x *delilianus*, itself a hybrid of the eastern *C. americanus* and the Mexican *C. coeruleus*. Thus, *C.* x *pallidus* 'Roseus' represents a mix of plants from warm and cold climates.

On receipt in 1889, our plant carried the name *Ceanothus* "hyb. flore Alba Pleno." It was Alfred Rehder who applied the name *C.* x *pallidus* 'Roseus', a name that appears to be unique to the Arnold Arboretum; I cannot find it listed elsewhere. It may well exist in the European nursery trade under another name. Could it be the same as the plant 'Marie Simon'? Perhaps not, for I suspect that 'Marie Simon' blooms slightly later. Problems of nomenclature aside, *C.* x *pallidus* 'Roseus' has thrived for well over a century at the Arnold Arboretum.

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Terminal panicles of pale rose-colored flowers appear in mid-June, at the end of the current season's growth, well after the great spring rush of flowers, and remain over several weeks.

The wonderful forms of *Ceanothus* seen in European gardens offer an incentive to further hybridization work. *Ceanothus* x *pallidus* 'Roseus', while among the hardiest, might be improved still more. Recombination with more garden-worthy forms selected for flower and leaf color and other desirable characteristics could enrich the palette of *Ceanothus* cultivars for northern landscapes.

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KIM E. TRIPP

Cephalotaxus: The Plum Yews

Kim E. Tripp

***The largest [Japanese plum yews] I saw grow in the rich forests at the foot of Higashi-Kirishima . . . I saw many trees from 8 to 10 m tall with . . . wide-spreading branches forming broad rounded crowns. Such trees, with their dark-green leaves pale or glaucescent on the under side, are very beautiful. . . .* E. H. Wilson, *The Conifers and Taxads of Japan,* 1916[1]**

Wilson was describing the surprisingly large specimens of *Cephalotaxus harringtonia* he had seen growing in Kyushu, Japan. Although it was Wilson who introduced the plant into cultivation in the United States, he was not the first Western plant explorer to collect it and extoll its beauties. Long before, around 1829, the prominent plant collector and principal author of *Flora Japonica,* Philipp Franz von Siebold, had sent *Cephalotaxus* to Europe where it was received with interest and appreciation.[2] Siebold grew five different *Cephalotaxus* in his own garden in Japan, along with many other plants he had discovered, cultivating them for their beauty and for evaluation as garden plants.

Today, although plum yews are widely considered some of the most beautiful and useful of evergreen conifers, their potential as ornamental and medicinal plants has yet to be fully explored and utilized. The endangered status of *Cephalotaxus* in the wild—particularly in China, its "distribution center and refuge,"[3] where it is vulnerable to the increasing demands of an exploding human population—lends a sense of urgency to efforts to learn more about this fascinating genus. At the Arnold Arboretum, we are working to help conserve *Cephalotaxus* while continuing to study and propagate the genus for use in cultivation.

Cephalotaxus

The modern natural range of *Cephalotaxus* has diminished considerably from that of its early antecedents. Now the genus is restricted to southern and eastern Asia—Japan, Korea, south, central, and eastern China, Hainan, Taiwan, India, Burma, Laos, and parts of Vietnam.[4] *Cephalotaxus* was also found in Europe and northwestern North America in the Miocene and Pliocene eras; moreover, during the Jurassic era its antecedents extended into what is now Greenland.[5]

Because Japanese plum yew has been in cultivation in Europe and the United States for close to a century, many modern horticulturists are familiar with the Japanese species *Cephalotaxus harringtonia,* named in honor of the Earl of Harrington, one of the first to grow the plant in a European garden. Far fewer are aware of other equally beautiful members of the genus that were not found by Western explorers until the turn of the century. Six to twelve species and botanical varieties, depending on the taxonomist consulted, comprise an elegant genus with an inelegant name.

While today *Cephalotaxus* is most often considered the single genus of the coniferous Cephalotaxaceae, it was earlier included in the Taxaceae with taxads like *Torreya, Taxus,* and *Pseudotaxus.*[6] Distinctive aspects of the embryogeny and development of *Cephalotaxus* set it apart from this group, however, in spite of shared adult morphological characteristics like fleshy seed coats, two-ranked needles of similar shape, and low shrub to small tree habits.[7] A few modern authors include *Amentotaxus* in the

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Cephalotaxus sinensis, *seen here "à la mode" in last winter's ice storm, is one of the most cold hardy of the Chinese plum-yew species.*

KIM E TRIPP

The mature fruits of Cephalotaxus *(*C. sinensis *is shown here) resemble olives or small plums.*

Cephalotaxaceae, resulting in occasional references in the literature to two genera in the Cephalotaxaceae.[8]

Plum yew's botanical name is apt. "Cephalotaxus" means "head-yew," from the Greek "kephale" for head and the botanical name "taxus" for the yew genus. "Head-yew" refers to the flowering structures that are borne in tight clusters or "heads" and to its needles, which resemble those of yew. Another, more appealing common name, plum yew, refers to the plum-like shape and color of the ripened fleshy "cone."

Cephalotaxus is most often found growing as shrubs or small trees in soils rich in humus in moist subtropical or warm-temperate forests, generally as understory plants in at least light shade. They are primarily low- to mid-altitude plants, but a few variant types are found at higher elevations and on chalky gravel cliffs. The entire range of the genus, however, extends from tropical to cool temperate climates, and cold hardiness of cultivated taxa corresponds to provenance.

While the foliage of plum yews generally resembles that of true yews, the reproductive strobili are quite distinct. Most of us are familiar with the bright red (or occasionally yellow), fleshy, nonpoisonous "aril" that incompletely surrounds the yew's very poisonous, small, rounded seed. Fewer are likely to be familiar with the seed of plum yew, which is significantly larger than that of yew, being about the size and shape of an olive or very small plum (0.75 to 1.25 inches long and 0.25 to 0.75 inches wide) and completely enclosed by a thin, hard shell and an outer fleshy coat. As the seed ripens, the fleshy coat changes color, maturing from an attractive, glaucous blue-green, through a warm cinnamon-red (hence "plum yew"), and finally to a dull tan or purple-brown before abscission of the entire "cone" and/or degradation of the fleshy tissue.

Male and female plum yew strobili are borne on separate plants. Male strobili develop in flattened heads of numerous small clusters of anthers, about 0.25 inches in diameter, regularly arranged in the axils of the needles along the length of the branchlets. Female strobili develop as clusters of six to twelve ovules in pairs held on an odd-looking, oval, initially mauve-colored head (or "cone"), that expands from about 0.5 inches in length at first visibility to the mature length of 0.5–1.25 inches (depending on the species). Usually only one seed matures per head.[9] Three to five female heads are borne on stalks at or near the end of the current or previous year's branchlets.[10] Female cones are wind pollinated.

Seeds of *Cephalotaxus* have a relatively long period of development. Depending on species and region, pollen cones require nine to eleven months to mature (from initiation to pollen dispersal), while female cones can take as long as twenty-one months, generally maturing at the end of the second growing season after initiation.[11]

Cephalotaxus is now rare and endangered in significant areas of its range.[12] Its lengthy seed maturation period, combined with a dioecious reproductive habit and an often sparse natural distribution throughout much of its range, may contribute to the seemingly low frequency of regeneration for the genus in the wild. According to Huang, animals and birds may also eat the seed.[13] There is also pressure on *Cephalotaxus* from human activity. It is harvested for timber in various parts of its range as well as used for firewood and for medicinal purposes. The female cones are sometimes collected for the oil expressed from the seed.[14]

Ironically, increasing awareness of the endangered status of *Cephalotaxus* comes at a time when its potential value has expanded beyond horticultural uses to include anticancer compounds found in its seed and vegetative tissues. Experimental work with the ester alkaloids cephalotaxine, harringtonine, and allied chemicals has shown promise, although apparently no widespread therapeutic applications have yet been introduced.[15] Sadly, two of the three species that are especially rich sources of these alkaloids, *C. hainanensis* and *C. oliveri*, are currently endangered, although the third, *C. fortunei*, is less vulnerable.[16]

Cephalotaxus as a Garden Plant

The various taxa of *Cephalotaxus* are of interest and value not only as endangered sources of useful materials, but as exquisitely beautiful evergreens for a variety of modern landscapes, combining graceful habits and foliage with the tough stress resistance and ease of maintenance required by modern gardeners and landscape contractors.

Cephalotaxus are slow-growing conifers with dark olive to black-green foliage. Because their habits range from upright and shrubby to low and informally mounding, they can serve as hedges, masses, groundcovers, specimens, and foundation or container plants. They thrive in a variety of soils, including extremely dense clays. They are not only tolerant of shade but—with only one exception—perform well even in heavy shade, an unusual trait for a needled evergreen. Indeed, most *Cephalotaxus* produce the best foliage when given at least some shade, although some maintain excellent foliage color in either full sun or shade.

Plum yews are extraordinarily heat tolerant in humid climates, another unusual trait for a needled evergreen. For this reason, they have been called "the yew of the south," although they can serve as excellent landscape plants in an area extending far beyond the Southeast. Once established, they are tolerant of extended dry periods such as those experienced during most of our eastern summers. However, they are not good choices for hot, dry climates like those in much of the southwestern United States.

Cephalotaxus are relatively deer resistant (I have come to believe that no evergreen is totally deerproof). Deer feeding on plum yews have been reported in areas with very heavy deer populations (for example, central New Jersey and Pennsylvania). Even in these cases, however, with only one exception, deer turned to *Cephalotaxus* foliage only as a last resort.

Nomenclature and Taxonomy

Unfortunately, there is no current monograph on *Cephalotaxus* available. This is especially troublesome since the nomenclature of this genus is particularly confusing and is likely to remain a challenge for the foreseeable future; to the best of my knowledge, no taxonomic monograph of the entire genus is currently underway. Hence, one must simply dive in and make a first attempt at creating some order out of the chaos.

Key characters listed in the literature have rarely been useful to me when dealing with plum yews. I have observed that widely cited key characters such as stomatal band whiteness, length and shape of needle, and bark color can vary with age of the plant and the microenvironment in which it is grown.[17] Full sun, cool temperatures, and leaf maturity, for example, appear to promote whiteness of the stomatal bands on plants of the four species now grown in North America. In another case, an oft-cited, characteristic V-shaped trough formed by the angle at which needles are held—which has been used to separate what is now called *C. harringtonia* var. *drupaceae* from the rest of the species[18]—can frequently be seen on plants of various species.

What this translates to on a practical basis is that confirmed provenances and commercial sources are critical when working both with species and with cultivars. In the case of species, identifying individual plants is especially challenging because the key characters are mostly morphological intergrades. Therefore, knowledge of geographic origin is important, and even when armed with such knowledge only the morphological extremes of the genus (e.g., *C. fortunei* with very long needles versus the shorter-needled *C. harringtonia*) can be reliably and consistently separated from each other *ex situ*. Judging from what I have observed on diverse live plants and herbarium specimens, a pragmatic taxonomist might argue for including much of the genus in a single species, at least for plants found on the Asian mainland. The fol-

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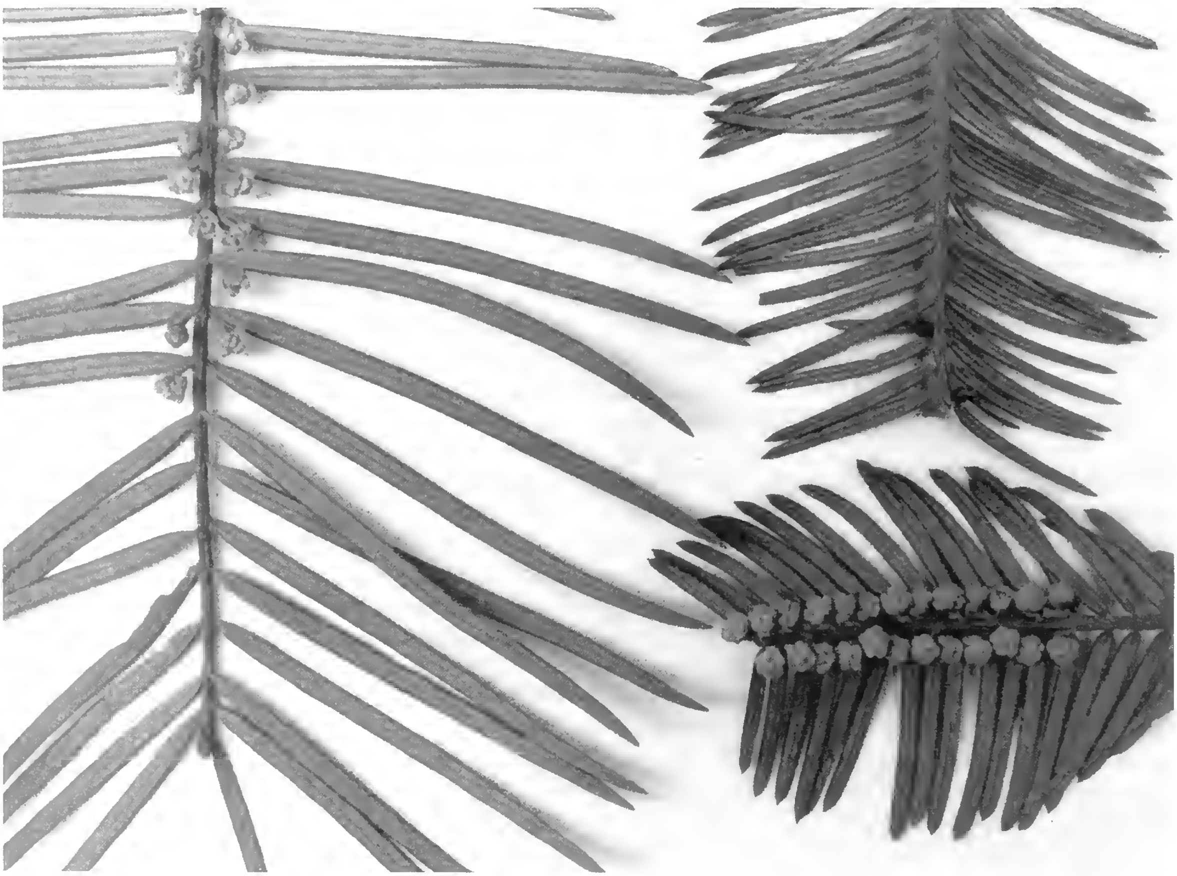

Needle length varies widely among plum yew species. Cephalotaxus fortunei *(left) has the longest needles, while* C. harringtonia *(lower right), in general, has the shortest. Other species, like* C. sinensis *(upper right), are intermediate.*

lowing discussion of forms offers a brief introduction to the diversity of plum yews.

Cephalotaxus fortunei Hooker (Fortune's plum yew, San-chien-shan, Lo-han-shu, three-pointed fir)

Fortune's plum yew is native to China, where in addition to wild populations, it is found planted near shrines and temples. This species has a widespread range in central and eastern China south of the Yellow River and has been collected in Shui-sa-pa (the "Water Fir Grove" near the border of Hubei and Sichuan provinces) as part of the *Metasequoia* flora.[19] It was introduced to both Europe (around 1849) and the United States (around 1858) by Robert Fortune, who collected it in China.[20]

The needles of *Cephalotaxus fortunei* are the longest of the genus, varying from two to over four inches; the most dramatically long-needled plants are the most elegant. Needle diameter ranges from extremely slender (1/16th inch) to nearly as wide as that of other species (1/6th inch), with color of the stomatal bands on the undersides of the needles varying from bright white to green. Bark is reddish-brown to dark brown and peels in plates as plants age. Mature female cones are longer (one-and-a-half to two inches) and often narrower than those of other species.

Cephalotaxus fortunei is a multistemmed shrub or small tree with an open, loosely rounded habit and slightly pendant branchlets. Height and spread will vary with provenance of seedlings and the climate in which the plants are grown. In China, depending on locale, *C. fortunei* is found as a shrub or as a small to medium-sized, multitrunked tree reaching heights in the range of thirty feet.

In Europe and North America, warmer regions give faster, more upright growth, while cooler temperatures lead to shrubbier, slower-growing plants. All of the *C. fortunei* selections I have seen do best in shade, which results in a more open habit than is found in sunny situations; in North America, full sun usually causes at least some winter burn on the foliage. They prefer moist, loamy soil, but will also stand up to heavy clays if grown in light shade. They are reliably cold hardy through zone 7, and in sheltered, shaded sites, into the warmer parts of zone 6.

Cephalotaxus fortunei var. *alpina* Li is a low form found in the mountainous forests of northwestern Yunnan and western Sichuan. *C. fortunei* 'Grandis' is an especially long-needled female form, originally from Hillier Nurseries. *C. fortunei* 'Lion's Plume' is yet another long-needled cultivar, originally received in the 1950s at the Willowwood Arboretum in New Jersey but no longer in the collections there. *C. fortunei* 'Prostrate Spreader' ('Prostrata') is a long-needled, low, mounding form, also from Hillier Nurseries, with lovely dark-green foliage; several other prostrate selections available in the United States may or may not be clones of the Hillier Nurseries plant.

Cephalotaxus griffithii Hooker (Griffith's plum yew)

Griffith's plum yew is one of the species found in India, specifically in the Mishmi Hills of Assam (at about 6000 feet) where it is a small tree fifteen to thirty feet in height. It is also found in western Sichuan, China. Needles are two to three inches long by 1/8th inch wide. Herbarium specimens of this species appear similar to those of the geographically overlapping species *C. mannii*, *C. oliveri*, and *C. sinensis*.[21] In the past, *C. griffithii* was cultivated at Kew, which received specimens from the Calcutta Botanical Garden sometime before 1890,[22] but Kew's inventory does not currently list this species. I have not seen it in cultivation anywhere in the United States. Cold hardiness of this species outside of Asia is unknown.

Cephalotaxus hainanensis Li (Hainan plum yew)

Hainan plum yew is a tropical species found on the island of Hainan, China. Some authors include this taxon as part of *C. mannii*, which appears to be its closest relative. On Hainan, it can grow to tree size, reaching fifty to seventy feet in height. Needles are long and slender (two or three inches by 1/8th inch); most herbarium specimens appear nearly identical to those of *C. mannii* except for a greater variability in needle length. Because of timbering and bark stripping, Hainan plum yew is seriously threatened in its natural range; it is also one of the species rich in anticarcinogenic alkaloids. It is not in cultivation in this country but is likely to be cold hardy only into zone 9.

Cephalotaxus harringtonia (Forbes) Koch (Harrington's plum yew, Japanese plum yew, Inugaya)

This was the first plum yew to be collected by Westerners and has been longest in Western cultivation. It is widespread in Japan from Kyushu north to Hokkaido and is also found in areas of northeastern China and Korea. In the warmer parts of its range it is usually seen as a small tree; in colder areas it most often appears as a rounded shrub of low to medium height. It is this latter habit that most frequently develops in cultivation in Europe and North America. Its needles are relatively short and often wider than those of mainland taxa (one-to-two inches long and 1/6th inch wide), and its fruits are rounded-ovoid. The numerous cultivars have a variety of shapes, sizes, and foliage variegations.

Siebold first sent this plant to the Leiden Botanical Garden in 1829 as *Cephalotaxus drupaceae*. Most modern authors separate *C. harringtonia* var. *drupaceae* from typical *C. harringtonia*. The primary difference appears to lie in the arrangement of the needles on the stem. In the literature, both historical and modern, the foliage of *C. harringtonia* var. *drupaceae* is repeatedly described as distinctive in its upright V-formation, but I have seen this characteristic on any number of *Cephalotaxus* species and cultivars in diverse sites. In North America (and in a brief survey of southern England), the V-shaped character appears to be more closely related to cultural conditions and to the stage of development of the needles and plants than to any consistent taxon-specific morphological trait. This V-shaped characteristic becomes especially pronounced on the flowering branches of many male *Cephalotaxus*, regardless of species or variety, as pollen-bearing strobili expand in the needle axils and appear to promote "lifting" of the two-ranked needles into a V-shaped trough. The degree of "V" also increases somewhat throughout the season on all plants of various species as leaves mature and in response to dry periods. I have

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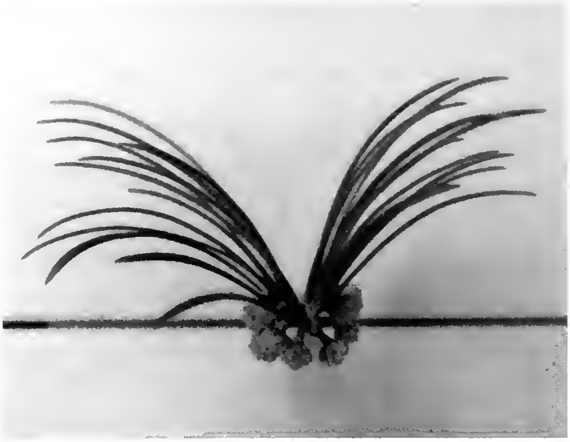

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The V-shaped foliage that is attributed to Cephalotaxus harringtonia *var.* drupaceae *can actually be seen in other species as well. Seen here in profile, from top to bottom,* C. koreana, C. fortunei, *and* C. sinensis *exhibit varying degrees of this same characteristic.*

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A mass of nine Cephalotaxus koreana *seedlings at the Arnold Arboretum has proven itself to be exceptionally handsome and durable.*

had no success separating what is called *C. harringtonia* var. *drupaceae* from *C. harringtonia* in North America by relying on these morphological characteristics. Cold hardiness and landscape performance of *C. harringtonia* vary with cultivar and botanical variety as noted below.

Cephalotaxus harringtonia var. *nana* Nakai (Hai-inugaya) is the variety found growing on seaside cliffs and mountainous areas of Hokkaido and eastern Honshu.[23] Its needles are shorter and more slender than those of *C. harringtonia*, and the plants themselves are shorter, with a more upright, suckering habit. Its fruits are also smaller. In the wild, *C. harringtonia* var. *nana* spreads by layering; it does the same in cultivation, albeit slowly. Overall it is more compact and more finely textured than the species and retains this habit in cultivation. Plants grown from collections made by Spongberg and Weaver have been cold hardy in zone 6 at the Arnold Arboretum where foliage color remains attractive throughout the winter in the shade but bronzes heavily in full sun.[24] *C. harringtonia* var. *nana* has a distinctively demure character in the landscape, and it would make a lovely small evergreen for shaded sites.

Cephalotaxus harringtonia 'Duke Gardens' is a broadly rounded, dense shrub reaching about six feet by six feet in about ten years, depending on where it is grown. It was selected at Sarah P. Duke Gardens at Duke University in North Carolina. It makes a beautiful mass in sun or shade in zones 7 to 9 and thrives in soils from sandy loams to clays.

Cephalotaxus harringtonia 'Fastigiata' is a distinctive upright cultivar with dark green needles whorled around the stem in a bottlebrush manner. 'Fastigiata' grows even more slowly than the average *Cephalotaxus*, retaining its broad columnar habit for the first ten to twelve years before beginning to spread into a

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The bold foliage of Cephalotaxus koreana *remains black-green and glossy even in winter.*

multibranched, upright mound. It does best in part shade; full shade causes it to open up and become untidy, while full sun can result in winter burn in severe years. 'Fastigiata' is reliably cold hardy through zone 6 and much of zone 5, especially in walled gardens and other semiprotected areas, but it will suffer from snow and ice damage in severe winters. *C. harringtonia* 'Fastigiata Aurea' is nearly identical to 'Fastigiata' except that its needle margins are gold.

Cephalotaxus harringtonia 'Fritz Huber' is a low-spreading cultivar with stiffer branches and a stiffer habit than other low-mounding types. Its needles are a brighter, more emerald green than other selections. *C. harringtonia* 'Gnome' is a dwarf, rounded mound growing to two feet in height, with light green foliage and shorter, stiffer needles than the species. It is a striking, impish little plant from Hillier Nurseries. *C. harringtonia* 'Korean Gold' ('Ogon', 'Ogon Chosen Maki')[25] is identical to 'Fastigiata' except that new growth emerges bright yellow-gold in spring and fades to green in summer. Also, its growth is slower than that of 'Fastigiata'. 'Korean Gold' is very effective in the spring garden.

The name *Cephalotaxus harringtonia* 'Prostrata' is generally applied in this country to any and all selections with a low-spreading, low-mounding habit—plants often have somewhat pendant branchlets as well. However, it should, at this time, be used only for the Hillier Nurseries selection.[26] (See "A Plethora of 'Prostrata's" on page 35.) The true Hillier Nurseries cultivar 'Prostrata' is especially tolerant of full sun and shows no foliar burn in the northeastern United States, where other forms do burn. With its particularly pleasing, informally irregular, cloudlike silhouette, it is one of the most beautiful and useful selections of plum yew available to gardeners. Its quality was recently recognized by the Pennsylvania Horticultural Society with a Gold Medal Award. There is a reliably named, exceptionally handsome old planting of *C. harringtonia* 'Prostrata' at the Brooklyn Botanic Garden.

Cephalotaxus koreana Nakai (Korean plum yew)

Korean plum yew is found at low to middle elevations in Korea, northern and central Japan, and northeastern China. It is an upright, slow-growing shrub with broad, relatively coarse, black-green needles (about two inches by 1/6th inch). Plants will reach eight to ten feet in as many years, with a narrow spread. Its dense branching and foliage cover make this species one of the most effective for massing. It retains its remarkably beautiful black-green foliage throughout the entire year, even in an exposed winter site at the Arnold Arboretum (zone 6) where other species have bronzed heavily. Cold hardiness will vary with provenance, but *C. koreana* is hardy at least through zone 6 and likely into zone 5. Further collections from the coldest parts of its range would be desirable.

Cephalotaxus lanceolata Feng

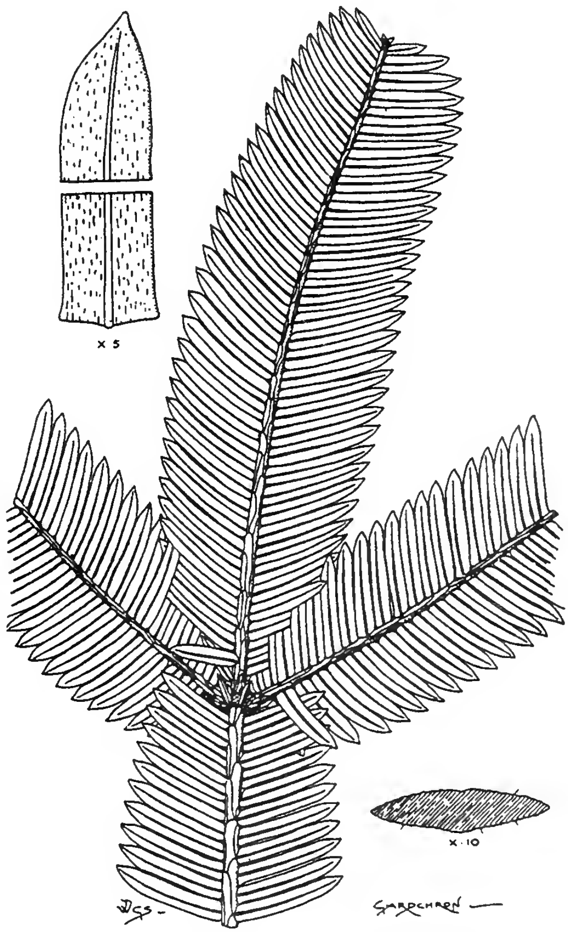
C. lanceolata is known from only a few places in northwestern Yunnan Province. It closely resembles *C. fortunei*; indeed, the majority of herbarium specimens are practically indistinguishable from those of *C. fortunei*. Its needles are long and slender (about three inches by 1/8th inch) and often with needle edges that are distinctly parallel up to a sharply acute apex (as opposed to tapering more gradually to an acuminate apex). Chinese authors distinguished this species from *C. fortunei* on the basis of its wider, thinner needles with sharper apices (hence its name, *lanceolata*).[27]

Cephalotaxus mannii Hooker (Mann plum yew)

This species grows into a tree of about seventy feet in height. It is the southernmost taxon and can be found at low to middle elevations on moist, shaded slopes and gullies in woodlands in southern China, northeastern Burma, India, Laos, and Vietnam (and Hainan if one includes *C. hainanensis* within *C. mannii*). *C. mannii* is sparsely distributed and seriously endangered by harvesting for timber and for medicinal purposes. Its foliage as seen in illustrations and on herbarium specimens is slender, gracefully tapering, and variable in length;[28] even in a dried state it is strikingly beautiful. *C. mannii* is not in cultivation in the United States and is not likely to be cold hardy north of zone 9. It is exciting to learn that the Royal Botanic Garden at Edinburgh has recently acquired cuttings of this species for propagation.

Cephalotaxus oliveri Masters (Oliver plum yew)

The foliage of this species is among the most distinctive of the genus with short, broad needles (one or one-and-a-half inch by 1/6th



The distinctive foliage of Cephalotaxus oliveri *is well illustrated in this figure from* The Gardener's Chronicle *(April 1903), in which "the leaves are disposed, like the teeth of a comb."*

inch) arranged in two militarily precise, nearly overlapping ranks. The needles are pectinate, that is, arranged "like the teeth of a comb";[29] this trait remains distinctive even on diverse herbarium specimens. *C. oliveri* is a large shrub or small tree reaching ten to fifteen feet. It is sometimes found in drier, cooler areas than the other subtropical species of China, but is generally found growing at middle elevations in central, south central, and southwestern China, eastern India, and northern Vietnam. It was once in cultivation at Kew but is no longer listed in their inventory. It is not in cultivation in this country, but it might be a useful horticultural species thanks to its occurrence in somewhat drier and colder areas than other subtropical taxa, as well as because of its distinctive foliage and its moderate size. *C. oliveri* is an endangered species and is rich in anticarcinogenic alkaloids.

***Cephalotaxus sinensis* (Rehder and Wilson) Li (Chinese plum yew)**

Currently also known as *C. harringtonia* var. *sinensis* and historically as *C. drupaceae* var. *sinensis,* this is another very widespread species. It is a medium-sized, somewhat open and rounded shrub with slender, medium-length needles (about two inches by 1/8th inch). It will eventually reach ten to twelve feet in height with half the spread. It occurs naturally in moist woodlands and thickets on limestone slopes throughout eastern, central, and northwestern China, including Sichuan and Yunnan provinces. This species was first collected for the West and brought to the United States by Wilson as *C. drupaceae* var. *sinensis;* Rehder later changed the name to *C. harringtonia* var. *sinensis* and Li ultimately elevated it to *C. sinensis.*[30] Plants are generally cold hardy through zone 6; they may suffer winter burn in exposed sites but have held up well to ice and snow in Boston. *C. sinensis* makes a lovely evergreen shrub in appropriately shaded sites, where it contributes an elegant, yet informal ornamental character.

***Cephalotaxus wilsoniana* Hayata (Wilson plum yew, Taiwan plum yew)**

This species is endemic to Taiwan, being widely but sparsely distributed in diverse woodlands at middle elevations.[31] It is a medium-sized tree, growing to thirty feet with pendant branches. Its needles tend to be slender and of moderate length (about two inches by 1/8th inch). In the United States, it is likely be cold hardy into zone 8. *C. wilsoniana* is in cultivation at Kew and the Royal Botanic Garden at Edinburgh, but it is not in this country.

Propagation

My work with four of the most hardy species and several cultivars indicates that similar propagation techniques are likely to apply to all *Cephalotaxus.*[32] Propagation from seed or cuttings is quite a long process. Seed gives best germination after ten to twelve weeks of cold stratification and after removal of the fleshy seed coat (which, unlike the similarly constructed *Ginkgo,* is usually only very slightly malodorous). Seeds that have overwintered outdoors under the mother plants give reasonable germination results as well. Even in a warm greenhouse, seedlings take a worrisome length of time to completely emerge, and it is particularly important to maintain consistently moderate moisture during this period. One is tempted to conjecture that this slow seedling emergence may contribute to the apparently low regeneration rate of *Cephalotaxus* in the wild.[33]

Propagation from stem cuttings is not difficult, but it too is slow. In the northeastern United States, four- to six-inch stem cuttings can be successfully rooted throughout the year once the spring flush has been completed and foliage has hardened off somewhat (between July and March). In the southeastern United States, cuttings root best when taken during fall or winter (October to February), avoiding the peak heat of the summer. Stem cuttings will root even without rooting hormones, but moderate concentrations result in slightly larger, fuller root systems. With bottom heat, cuttings generally take about four months to develop a viable root system, although they can take as long as six months in low light. Heavily flowering branches from male plants should be avoided since profuse flowering competes with developing roots, and male flowers are a haven for fungal spores. Flowers on female shoots, on the other hand, have little effect on rooting and do not cause fungal problems. Informal observa-

A Plethora of 'Prostrata's

There is great confusion in the trade over plum yew selections with low, creeping, horizontally spreading or prostrate growth habits. A plethora of prostrate forms have been propagated and given names like variety *prostrata,* forma *prostrata,* or cultivar 'Prostrata', 'Prostrate Form', or 'Prostrate Spreader'. Most of these prostrate forms are an artifact of propagation from stem cuttings that used lateral branches instead of terminal shoots. Rooted cuttings of lateral branches retain their lateral orientation, and so young plants grow horizontally for many years. Eventually, such plants will develop at least one upright leader and will begin to grow as an upright shrub or small tree, as most seedlings do in nature. It can take anywhere from three to thirty years for plants grown from lateral branch cuttings to develop a leader, depending on growing conditions and characteristics of the parent plant. Historically, many plants have been used as sources of cuttings for these prostrate forms. Thus, two individual prostrate plants, both, for example, with the botanical name *prostrata* may have been propagated from two very different parent plants. One, both, or neither of the parent plants, however, may have been prostrate in habit, and both parents may exhibit very different landscape characteristics, such as degree of cold hardiness and performance in full sun.

At the turn of the century, to name a plant based on a developmental trait rather than a genetic trait was no problem because it was then correct usage. Confusion entered in the mid-1900s when the botanical designations *forma* and *varietas* were uncritically translated into cultivar names set in single quotes.[1] As a result, a primary source of confusion is that, unlike *varietas* and *forma,* cultivar names with single quotes now imply clonal parentage.[2] This has become a particular problem with prostrate plum yews.[3] For example, Hillier Nurseries now lists their exceptional selection of prostrate Japanese plum yew as cultivar 'Prostrata'.[4] Unfortunately, that cultivar name has been indiscriminately applied in this country to many other plants propagated from the lateral branches of random parent plants, which may or may not have been propagated from clones of the Hillier plant. Horticulturists desiring all of the exceptional qualities associated with the Royal Horticultural Society's Gold Medal Award-winning *C. harringtonia* 'Prostrata' must look for plants produced from clonal propagations of the Hillier Nurseries plant.

Notes

[1] For innumerable examples, see L. H. Bailey et al., *Hortus III* (New York: Macmillan, 1976).

[2] For further discussion of this issue with regard to conifers, see H. J. Welch, *Manual of Dwarf Conifers* (Little Compton, R.I.: Theophrastus, 1979), 40–48, also 151–152, 392.

[3] Propagation of many different plants from lateral cuttings and indiscriminate naming of all of the resulting propagules 'Prostrata', regardless of parentage (or quality of the plant), has led to great confusion among prostrate plum yews in the U.S. nursery trade (see K. E. Tripp, "A Plum Yew Primer," *American Nurseryman* (1994) 180(9): 28–37).

[4] Hillier Nurseries, *The Hillier Manual of Trees and Shrubs,* 6th ed. (Devon, England: David and Charles, 1991), 584–585, 677, 679.

Cephalotaxus fortunei, *thirty feet high and three feet in circumference, photographed by E. H. Wilson at an altitude of 4000 feet near Wa-shan, China, September, 1908.*

tions in the eastern United States indicate that terminal cuttings are slower to root than lateral ones, sometimes needing an additional two to four weeks; these will, however, result in plants with upright growth. Lateral cuttings, while quicker to root, result in plants with prostrate growth, at least for a number of years. For some as yet unexplained reason, 'Duke Gardens' has been more difficult to root than other cultivars.

The only challenge in propagating this genus is the degree of patience required. It would be worth experimenting with fog systems to see if they might hasten the process of rooting. Janick et al. reported success with micropropagation of *C. harringtonia*,[34] but to the best of my knowledge no one has yet applied the technique on a commercial scale.

Cephalotaxus at the Arnold Arboretum

The Arnold Arboretum has had a long and significant relationship with *Cephalotaxus*, having been among the first to collect and cultivate the genus in this country. Several men made important collections of *Cephalotaxus* for the Arboretum, among them Frank Meyer, William Purdom, Joseph Rock, and Charles Sargent; however, the many collections made by E. H. Wilson included some of the most interesting. In Japan, Wilson collected *C. harringtonia*, *C. harringtonia* var. *nana*, and *C. koreana*. In China, he collected *C. fortunei*, *C. harringtonia*, and *C. oliveri*, and was the first Westerner to collect what would eventually be named *C. sinensis*. Throughout his collecting years he consistently expressed an interest in the genus. Both Wilson and Alfred Rehder worked on describing and naming the genus over many years.[35]

While none of the Wilson-era accessions or their progeny survive at the Arnold, the Arboretum remains actively interested in *Cephalotaxus*, and its living collections are home to one of the country's most diverse collections of source-documented, wild-collected germplasm. Among others, Stephen Spongberg has collected material in China, Japan, and Korea. The most recent collections of *Cephalotaxus* for the Arboretum were made by Peter Del Tredici in China last year. We are especially pleased to have new germplasm of *C. sinensis* collected by Peter from the northerly portion of its range, which may offer improved cold hardiness and winter performance in the winter landscape.

Cephalotaxus was once an integral part of the prehistoric, indigenous flora of both North America and Asia. This genus has long since disappeared in North America and is now seriously endangered in Asia, yet plum yews are among the most interesting, beautiful, and useful of evergreen conifers. *Cephalotaxus* warrants increased study and conservation—with respect for its importance as both a wild and cultivated conifer.

Acknowledgments

The author gratefully acknowledges Shiu-ying Hu for translation and interpretation of texts from relevant Chinese systematic references, and sincerely thanks Jack Alexander, Allen J. Coombes, Peter Del Tredici, Michael Dirr, Aljos Farjon, Martin Gardner, Richard Hartlage, Andrew Knoll, Gary Koller, Cynthia Osman, M.D., Stephen Spongberg, Chris Strand, Benito Tan, Tom Ward, and Elizabeth Wheeler for critical discussion, useful information, or helpful suggestions.

Kim E. Tripp is a Putnam Fellow at the Arnold Arboretum, using the living collections for research, teaching, and writing.

Notes

1. E. H. Wilson, *The Conifers and Taxads of Japan* (Cambridge: Publications of the Arnold Arboretum, University Press, 1916), v–viii, 6–9.
2. P. F. von Siebold and J. G. Zuccarini, *Flora Japonica* (1835).
3. L. K. Fu, "A study on the genus *Cephalotaxus* Sieb. et Zucc.," *Acta Phytotaxonomica Sinica* (1984) 22(4): 277–288.
4. J. T. Buchholz, "Generic and subgeneric distribution of the coniferales," *Botanical Gazette* (1948) 110(1): 80–91; W. C. Cheng, *Sylva Sinica* (Beijing: Editorial Commitee of Flora of Woody Plants of China, 1983), 379–385; W. C. Cheng, L. K. Fu, and C. S. Chao, "Cephalotaxaceae, *Cephalotaxus*," *Flora Reipublicae Popularis Sinicae*, tomus 7 (Beijing: Science Press, 1978), 422–436; H. H. Hu, "Distribution of taxads and conifers in China," *Proc. 5 Pacif. Sci. Congr.* (1934) 4: 3273–3288; S. Y. Hu, "Cephalotaxaceae," in "Notes on the Flora of China IV," *Taiwania* (1964) 10: 13–62, 25–31; S. C. Lee, "Distribution of Woody Plants of China," *Taiwania* (1963) 9: 11–21; T. B. Lee (Tchang Bok Yi), *Illustrated Flora of Korea* (Seoul: Hyangmunsa, 1979), 58; H. L. Li., *Woody Flora of Taiwan* (Narbeth, PA: Livingston, 1963), 38–39; H. L. Li, "New species and varieties in *Cephalotaxus*,"

Lloydia (1953) 16(3): 162–164; H. L. Li, "Present distribution and habitats of the conifers and taxads," *Evolution* (1953) 7: 245–261; J. Ohwi, *Flora of Japan* (Washington, D.C.: Smithsonian Institution, 1965), 111; A. Steward, *Manual of Vascular Plants of the Lower Yangtze Valley of China* (Corvallis: Oregon State College, 1958), 61–62.

5 R. Florin, "The distribution of conifer and taxad genera in time and space," *Acta Horti Bergiana* (1963) 20(4): 121–326.

6 See, for example, A. Rehder and E. H. Wilson, "Cephalotaxus," *Plantae Wilsonianae*, vol. II, ed. C. S. Sargent (Cambridge: Harvard University Press, 1916), 3–6. The exact position of *Cephalotaxus* has been argued back and forth since Neger placed it as a single genus in its own family in 1907 (*Die Nadelhölzer (Koniferen) und übrigen Gymnospermen*, Leipzig), which was contrary to A. W. Eichler's original placement within the Taxaceae ("Coniferae" in A. Engler and K. Prantl's *Die Natürlichen Pflanzenfamilien*, Leipzig, 1889).

7 Significant differences in the embryogeny and development of *Cephalotaxus* from the taxads and other conifers were reported by J. T. Buchholz ("The embryogeny of *Cephalotaxus Fortunei*," *Bulletin of the Torrey Botanical Club* [1925] 52[6]: 311–322) but were most definitively elucidated by H. Singh ("The life history and systematic position of *Cephalotaxus drupaceae* Sieb. et Zucc.," *Phytomorphology* [1961] 11: 153–197), whose work in this area has remained a standard reference for modern authors treating the group.

8 As, for example, in C. N. Page's "Cephalotaxaceae," *The Families and Genera of Vascular Plants: I Pteridophytes and Gymnosperms*, ed. K. U. Kramer and P. S. Green (Berlin & NY: Springer-Verlag, 1990), 299–302; and in *The New Royal Horticultural Society Dictionary of Gardening* (New York: Stockton Press, 1992), 569.

9 K. R. Sporne, *The Morphology of Gymnosperms* (U.K.: Hutchinson, 1965).

10 Page, op. cit.

11 H. Singh, op. cit.

12 A. Farjon, C. Page, and N. Schellevis, "A preliminary world list of threatened conifer taxa," *Biodiversity and Conservation* (1993) 2: 304–326.

13 Q. Huang, "*Cephalotaxus mannii* Hook. f.," *China Plant Red Data Book—Rare and Endangered Plants*, vol. I, ed. L. K. Fu and J. M. Jin (Beijing: Science Press, 1992), 24–25.

14 Throughout the *Cephalotaxus* literature, both old and new, there are recurring references to destruction of its habitat due to pressure from humans—both from general activity, like forestry, and from harvesting of the *Cephalotaxus* itself for various purposes. E. H. Wilson noted the use of the seed as an oil source in Japan (op. cit., p. 7). Barry Yinger, after several trips to Korea, reported the general destruction of populations of *C. koreana* by clear-cutting ("Notes on *Cephalotaxus*, the plum yew," *Bull. American Conifer Society* [1989] 6(3): 57–59). In a 1988 publication, Zou Shou-qing reported that the forest cover of Xishuangbanna prefecture was cut from 60% to 33% over the prior twenty years and lists *C. oliveri* as one of the endangered relict species there ("The vulnerable and endangered plants of Xishuangbanna prefecture, Yunnan province, China" *Arnoldia* [1988] 48(2): 3–7). Both *Cephalotaxus* species listed in the *China Plant Red Data Book* are reported to be threatened by lumbering, and *C. mannii* is also reported to be endangered by harvesting for use as a medicinal herb (see Q. Huang, "*Cephalotaxus mannii* Hook. f," and Z. C. Luo et al., "*Cephalotaxus oliveri* Mast." in the *China Plant Red Data Book*, 24–27).

15 The importance of *Cephalotaxus* has expanded beyond horticulture to include potential use as a source of anticancer compounds found in its tissues (C. R. Smith, R. G. Powell and K. L. Mikolajczak, "The genus *Cephalotaxus*, source of homoharringtonine and related anticancer alkaloids," *Cancer Treatment Rpt.* [1976] 60: 1157–1170). The ester alkaloids cephalotaxine, harringtonine, and allied chemicals have shown significant antitumor activity in a number of *in vitro* studies, and there are recent reports of phase I clinical trials (pharmacokinetic) (see D. M. Graifer et al., "Effect of alkaloids of the *Cephalotaxus* group on the elongation of the polypeptide chain on human ribosomes," *Molecular Biology* [1991] 24(6): 1344–1350), and phase II clinical trials (therapeutic) on human subjects as well (see C. T. Tan et al., in *Cancer Treatment Reports* [1987] 71: 1245–48, cited in E. R. Wickremesinhe and R. Arteca, "Establishment of fast-growing callus and root cultures of *Cephalotaxus harringtonia*," *Plant Cell Reports* 12 [1993], 80–83). Other recent publications indicate that progress has been made in development of separation (see D. G. Cai et al., "Semipreparative separation of alkaloids from *Cephalotaxus fortunei* Hook f. by high-speed countercurrent chromatography," *Journal Liquid Chromatography* [1992] 15: 2873–2881) and synthetic production systems for cephalotaxines and harringtonines (see T. P. Burkholder and P. L. Fuchs, "Total synthesis of the *Cephalotaxus* alkaloids *dl*-cephalotaxine, *dl*-11-hydroxycephalotaxine, and *dl*-drupacine," *Journal American Chemical Society* [1990] 112: 9601–9613; and M. Ikeda et al., "Synthetic studies on *Cephalotaxus* alkaloids. A synthesis of (±)-cephalotaxine," *Chemical and Pharmaceutical Bulletin* [1993] 41(2): 276–281), as well as improvements on *Cephalotaxus* tissue proliferation techniques (see P. J. Westgate et al., "Approximation of continuous growth of *Cephalotaxus harringtonia* plant cell cultures using fed-batch operation," *Biotechnology and Bioengineering* [1991] 38: 241–246; and E. R. Wickremesinhe and R. Arteca, op. cit.)

16 T. P. Chu, "A study of the alkaloids in *Cephalotaxus* and their bearing on the chemotaxonomic problems of the genus," *Acta Phytotaxonomica Sinica* (1979) 17(4): 7–20.

[17] The primary conifer references, such as Krüssman's 1976 (1984 translation) *Manual of Cultivated Conifers* (Portland, OR: Timber Press, 66–69), pl. 63, and Humphrey Welch's 1990 *The Conifer Manual*, vol. I (Netherlands: Kluwer Academic) 191–194, rely on these often tenuous, morphological characters to distinguish *Cephalotaxus* taxa.

[18] A specific example of such a tenuous morphological trait used to distinguish a taxon is the "V" outline supposedly created by the foliage of *C. harringtonia* var. *drupaceae*, which has been cited by many prominent references to separate *C. harringtonia* var. *drupaceae* from other *Cephalotaxus*. In reality, this trait can be seen on many plants of *Cephalotaxus* regardless of species—see, for example, W. J. Bean, *Trees and Shrubs Hardy in the British Isles* (England: John Murray, 1950), 405-406; P. Den Ouden and B. K. Boom, *Manual of Cultivated Conifers* (The Hague: Martinus Nijhoff, 1965), 65-69; Hillier Nurseries, *The Hillier Manual of Trees and Shrubs*, 6th ed. (Devon, England: David and Charles, 1991), 584–585, 677, 679; G. Krüssman, op. cit.; J. Lewis, "Cephalotaxaceae," *The European Garden Flora*, vol. I, ed. S. M. Walters et al. (London: Cambridge University Press, 1986), 73–74; and H. J. Welch, op. cit.

[19] S. Y. Hu, "The Metasequoia flora and its phytogeographic significance," *Journal of the Arnold Arboretum* (1980) 61: 41–94.

[20] Interestingly, Fortune collected this species and sent it back to the USDA as part of a shipment of material collected on an expedition in search of the best forms of tea plants *(Camellia sinensis)* (see R. Gardener, "Robert Fortune and the cultivation of tea in the United States," *Arnoldia* (1971) 31(1): 1–18). This was a fortuitous opportunity to include *Cephalotaxus* as part of the collections.

[21] In fact, *C. oliveri* was originally confounded with *C. griffithii*. Oliver's 1890 illustration of *C. griffithii* was *C. oliveri* (see D. Oliver, "*Cephalotaxus griffithii*," pl.1933, *Hooker's Icones Plantarum*, vol. X , pt. 1, 3rd series, J. D. Hooker, 1890). This was later clarified by Masters (see *The Gardener's Chronicle* [1903] 850: 226–228).

[22] J. D. Hooker, *Flora of British India*, vol. V (London, 1890), 647–648.

[23] As reported by J. Ohwi in the 1965 *Flora of Japan* (Washington, D. C.: Smithsonian Institution), p. 111, and as observed by S. Spongberg when traveling in Japan.

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[26] Hillier Nurseries, op. cit.

[27] See, for example, the primary reference, W. C. Cheng et al., op. cit.

[28] Pl. 1523 in J. D. Hooker's "*Cephalotaxus mannii*" (op. cit., 1890) shows the elegant character of this foliage beautifully. Hooker remarks in the accompanying text on *C. mannii*, "A very distinct species . . . but so like *Taxus baccata* as to be easily mistaken for it." Recall the elegant, gracefully tapering outline of English yew, and you will understand the comparison.

[29] M. T. Masters, op. cit.

[30] Alfred Rehder in the 1941 article, "New species, varieties and combinations from the herbarium and the collections of the Arnold Arboretum" (*Journal of the Arnold Arboretum* 22: 569–571) changed the name of what had been called *C. drupaceae* to *C. harringtonia* (he concluded that *harringtonia* was the older of the two specific epithets), and hence, all of the included botanical varieties became *C. harringtonia*. Subsequently, H. L. Li, in his 1953 article, "New species and varieties in *Cephalotaxus*," elevated it to the species *C. sinensis*.

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[33] Huang, op. cit., cites a naturally low pollination rate, and Luo et al., op. cit., report infrequent regeneration, but neither source cites other work in support of these statements. It is possible that a combination of dioecious reproductive biology, relatively slow seed maturation and germination, seed predation by birds and mammals, increasingly sparse distribution of mature plants, and general destruction of habitat favorable for seedling survival and development, leads to the reported infrequent regeneration of *Cephalotaxus*.

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Arnold Arboretum Weather Station Data — 1994

	Avg. Max. Temp. (°F)	Avg. Min. Temp. (°F)	Avg. Temp. (°F)	Max. Temp. (°F)	Min. Temp. (°F)	Precipitation (in.)	Snowfall (in.)
JAN	30	10	20	53	−6	5.46	25.5
FEB	35	16	26	65	3	3.37	26
MAR	45	28	37	66	13	8.34	7.5
APRIL	61	37	49	85	29	2.13	0
MAY	67	47	57	88	36	5.14	0
JUNE	82	60	71	98	50	.95	0
JULY	87	67	77	97	57	1.33	0
AUG	81	60	70	92	50	6.76	0
SEPT	72	53	63	84	42	5.18	0
OCT	65	40	53	74	33	.33	0
NOV	58	37	48	78	19	4.58	0
DEC	45	28	37	66	10	5.75	0

Average Maximum Temperature	61°
Average Minimum Temperature	40°
Average Temperature	51°
Total Precipitation	49.3 inches
Total Snowfall	59 inches
Warmest Temperature	98° on June 19
Coldest Temperature	−6° on January 16
Date of Last Spring Frost	30° on April 19
Date of First Fall Frost	32° on November 11
Growing Season	205 days

Note: According to state climatologist R. Lautzenheiser, 1994 was the 14th warmest year recorded in 124 years. It tied with 1951 and 1976. It was also wetter than average with 6.11 inches above normal. The summer months of June and July brought very high temperatures and minimal rainfall, causing the plants at the Arnold Arboretum to suffer with drought stress. However, the months of August and September were cooler than normal, and we received 11.94 inches of rain that once again invigorated the plants.

As a whole, 1994 was a very good growing year. The year ended with 205 growing days, 20 more than 1993, which in turn had 31 more growing days than 1992 at 154. However, 1991 exceeds all succeeding years with 222 growing days; 1990 had 193.

Summer 1995

arnoldia

The Magazine of the Arnold Arboretum

arnoldia

Volume 55 Number 2 1995

Arnoldia (ISBN 004-2633; USPS 866-100) is published quarterly by the Arnold Arboretum of Harvard University. Second-class postage paid at Boston, Massachusetts.

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 orders, remittances, change-of-address notices, and all other subscription-related communications to: Circulation Manager, *Arnoldia*, The Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130-3519. Telephone 617/524-1718

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

Karen Madsen, *Editor*

Arnoldia is set in Trump Mediaeval typeface.

Page

Front cover: Mixed dipterocarp forest of central Borneo (East Kalimantan, Indonesia). Rich in plant species, the chemical composition of their canopies has been inadequately explored as a source of new medicines. Photograph by J. Andrew McDonald.

Inside front cover: Late summer in the oak collection, photographed near Valley Road by Rácz & Debreczy.

Inside back cover: *Albizia julibrissin*, the silk tree or mimosa, photographed in August by Rácz & Debreczy.

Back cover: *Rosa foetida*, the Austrian copper briar rose. Photograph by Al Bussewitz, 1912–1995. This image first appeared on the cover of *Arnoldia* in summer 1983. It was one of the first of the many photographs by Buzzy that have appeared on our covers.

J. ANDREW MCDONALD

Medicinal Plant Exploration—Past and Present

J. Andrew McDonald

The Arnold Arboretum, in collaboration with the U.S. National Cancer Institute and the Indonesian Herbarium Bogoriense, is exploring the tropical forests of Asia for potential treatments for AIDS and cancer.

Since prehistoric times, the fields of botany and medicine have enjoyed an enduring and fruitful relationship. Whether in the sophisticated setting of a modern pharmaceutical laboratory or an herbalist's hut on the banks of the Amazon River, plants provide a critical source of treatments for the myriad diseases that afflict humans. In either setting, the principal challenge of the medical practitioner is to distinguish plants that possess pharmaceutical properties from those that are toxic or medicinally inert. Although methods used to screen the plant kingdom for bioactive compounds have changed considerably over the course of human history, the invaluable selection of cures and therapeutics available to modern medicine is the product of a long history of pharmaceutical experimentation.

The Past

We can only conjecture as to when and where the search for herbal remedies began. Archeological remains dating back sixty thousand years reveal that Neanderthals laid their dead to rest with plants that later became staples of ancient pharmacopoeias, such as millefoil *(Achillea)*, St. Barnaby's thistle *(Centaurea)*, and joint fir *(Ephedra)*.[1] Whether these plants were actually used as medicines or simply served as a farewell gesture to the deceased may never be established with certainty. We do know, however, that most contemporary preliterate cultures, whose lifestyles closely mirror those of our distant ancestors, maintain oral traditions of medical practice that depend primarily on native vegetation.

By the time literacy developed into a basic means of human communication, the application of botanical lore to the practice of medicine was firmly established and systematized. Sumerian clay tablets and Egyptian papyri (2000 B.C.) describe ancient prescriptions and pharmacopeias in considerable detail.[2] Many of the plants that appear in these early records are now known to possess highly bioactive constituents, evidence for which can be found in our own medicine cabinets. Codeine, derived from the opium poppy and used as a narcotic analgesic in Nyquil®, appears in medical traditions that predate modern pharmacology by thousands of years. Similarly, salicylate (aspirin) was originally extracted from willow bark, and ephedrine, the flu remedy in Vicks®, was derived from *Ephedra*. Approximately twenty-five percent of all modern prescriptions contain natural plant extracts, most of which were used in traditional medicine.[3] Moreover, a significant number of synthetic medicines are derived from plant products whose therapeutic qualities have only recently been improved by chemical tinkering.

The first records of the systematic application of scientific methods to traditional medicine are found in Greece. Hippocrates (fifth to fourth

Large trees can present challenges to collectors of tropical plant materials. When the trunks cannot be shinnied, climbers often use smaller trees as "stepping stones" to reach the summit of a canopy tree. Above, a branch will be pruned to provide samples for the drug screening laboratories of the National Cancer Institute.

century BC), for example, earned his title "father of medicine" by subjecting folk remedies to open and critical discourse. From the *Corpus Hippocraticum*, written twenty-three hundred years ago, we know that practitioners of his school of thought paid limited attention to the spiritual source of disease and focused on the effects of diet and weather on health. Cures were based on the regulation of diet and the use of pills, potions, poultices, gargles, ointments, and inhalations derived from a variety of native and foreign plant products.

Four hundred years later (first century AD), Dioscorides acquired his medical knowledge while travelling throughout Europe and Asia Minor as a surgeon to the Roman army of Nero. *De Materia Medica* describes his medical practice and illustrates the use of over five hundred plant species. Among these, the use of mandrake *(Atropa mandragora)* as a sedative and castor oil *(Ricinus communis)* as a purgative are known to have descended from guilds of priests and seers in Egypt and Mesopotamia.[4] Dioscorides also outlined the natural history of drug plants, specified the parts of plants that contain bioactive properties, and described the methods for preparing medicines. The encyclopedic breadth and utility of *De Materia Medica* ensured its survival for more than a millenium; scholastic monks throughout medieval Europe copied and made use of the work until the Renaissance. By 1655, an English translation of the work provided a model from which emerging European schools of pharmacology developed.

Preceding the Renaissance, however, Christian Europe made notably few advances in medicine. The literate population, usually living as monks in cloisters, were isolated from folk practices and discouraged by church and state from openly questioning established bodies of belief and knowledge. These impediments to progress in medical practice persisted until the end of the fifteenth century, when a new era of exploration revealed rich stores of novel plant lore in foreign lands.

Owing to early contacts with tropical America, Spain took the lead in the new search for medicinal plants. Seventeenth-century friars and scribes were sent to record the medical practices of native American herbalists, resulting in several works of historical significance. A classic example of these, *Rerum Medicarum Novae Hispaniae Thesaurus, seu Plantarum, Animalium, Mineralium Historia*, written in the seventeenth century by a physician to the king of Spain, Francisco Hernandez, summarized the findings of his five-year study of Aztec medicine. The unusual frontispiece of the work depicts the layers of cultural influence that were affecting the practice of European medicine during this period.

While Spain was exploring tropical America, England and France were discovering new and useful drug plants in temperate North America. De Bry (1593) provided early descriptions and illustrations of medical treatments in Florida that paralleled those used at the time of Hippocrates (i.e., herbal potions, vapors, smoke.[5] In Boston, works such as *New-Englands Rarities Discovered* by John Josselyn, published in 1672, described the "*physical* and *chyrurgical* remedies wherewith the *Natives* constantly use to cure their distempers, wounds and sores."[6] Many of these native North American drug plants were assimilated into the comprehensive English *Herbal* of 1633 by John Gerard, including sassafras *(Sassafras albidum)* from Florida, employed "to comfort the weake and feeble stomacke, to cause good appetite . . . stay vomiting, and make sweet a stinking breath," and

Frontispiece from the Spanish treatment on Aztec medicine, Rerum Medicarum Novae Hispaniae Thesaurus, seu Plantarum, Animalium, Mineralium Historia *(1651). The bizarre mixture of Greco-Roman and Latin American images indicate anachronistic and exotic influences on the practice of European medicine during the Renaissance. The upper portion portrays a pillar in the form of a medieval castle turret flanked by two winged serpents, suggesting elements of the caduceus of the Greek god of healing, Asclepius. Just below sit two female figures, one holding in her lap a symbol of the Latin goddess Fortuna, life's horn of plenty, the other with a globe of the world, suggesting the Grecian concept of Mother Earth. The globe does not represent, however, the world of antiquity; rather, it portrays a contemporary view of the world with the American continents in their proper geographic positions. Underneath is a detailed map of central Mexico flanked by two native Americans, one standing by a bundle of medicinal herbs.*


ET PLVS VLTRA
RERVM MEDICARVM
NOVÆ HISPANIÆ
THESAVRVS
SEV
PLANTARVM ANIMALIVM
MINERALIVM MEXICANORVM
HISTORIA
EX FRANCISCI HERNANDEZ
Noui Orbis Medici Primarij relationibus
in ipsa MEXICANA Vrbe conscriptis
A NARDO ANTONIO RECCHO
Monte Coruinate Cath. Maiest. Medico
Et Neap. Regni Archiatro Generali
Iussu PHILIPPI II. HISP. IND. etc. REGIS
Collecta ac in ordinem digesta
A IOANNE TERRENTIO LYNCEO
Constantiense Germ.° Phõ ac Medico
Notis Illustrata
Nunc primũ in Naturaliũ rer. Studiosor. gratiã
lucubrationibus Lynceorũ publici iuris facta.
Quibus Iam excussis accessere demum alia
quor. omnium Synopsis sequenti pagina ponitur
Opus duobus voluminibus diuisum
PHILIPPO IIII. REGI CATHOLICO MAGNO
Hispaniar. vtriusq. Siciliæ et Indiarũ etc. Monarchæ
dicatum.
Queneca
Culias
Meschtan
Panuco
S. Michel
C. Brauo
Mexico
Villa Rucca
SINVS MEXICANVS
MECHOACAN
SCATVLA
MEXICO
Tuchitebeque
TAVSCO
Champaton
IVCATA
TECOANTEPEC
Maxamalca
Leon
Greuter inc.
Cum Priuilegijs. ROMÆ Superior. permissu. Ex Typographeio Vitalis Mascardi. M.DC.XXXXXI.

sarsaparilla (*Smilax* spp.) from Virginia, providing "a remedie against long continuall paine of the joynts and head, and against cold diseases."[7]

To supplement drug materials from temperate regions, the Society of Apothecaries in Chelsea, England, tried to circumvent the Spanish monopoly in tropical America. In 1729 the Society commissioned the British surgeon William Houstoun to procure drugs and dye plants from the New World tropics for introduction into the mild climate of Georgia. Priority was given to such products as the popular jalap root, the cochineal beetle and its host plant, *Opuntia*, and "Jesuit bark" (quinine, *Cinchona officinalis*). Although this particular project was cut short by the premature death of Houstoun, the global search for new medicines was by this time firmly established as a worthy scientific and commercial enterprise.

During the seventeenth and eighteenth centuries, American medicinal plants and their byproducts were exported to Europe by the tons. Major exports from Mexico included the purgative jalap root *(Ipomoea purga)* and tobacco *(Nicotiana tabacum)*, valued for its stimulating, anti-infectant, and anthelmintic properties. Coca leaves *(Erythroxylum coca)* were shipped from South America to be sold as a stimulant and local anesthetic, while ipecac *(Cephaelis ipecacuanha)* was marketed as an emetic and antidysenteric.[8] Apothecaries throughout Europe began dispensing New World medicinal plants and their extracts on a commercial scale. At the same time, society's expectations for improved health care and the desire to increase trade helped justify yet more exploration.

To facilitate the study of pharmaceutical botany, former palace retreats such as the *Jardin*

Theodor De Bry, whose Grands Voyages *was published in 1593, observed native Americans in Florida practicing medicine through the use of herbal potions, smoke, and vapors.*

du Roi in Paris were transformed into educational and scientific establishments.[9] Both living and preserved plant collections were assembled by trained naturalists who were commissioned to accompany trade ships around the world.[10] European physicians and botanists such as Sir Hans Sloane of England, Paul Hermann of the Netherlands, and Carolus Linnaeus of Sweden received large shipments of specimens originating from Asia, Africa, and the Americas. These extensive collections allowed Linnaeus to attempt the first global inventory of the earth's flora. He estimated the total number of species at ten thousand, a number that probably errs by a factor of at least twenty-five. Yet, even with this limited view of the size and complexity of the plant kingdom, eighteenth-century botanists required a lifetime of dedication to cover the full breadth of their subject. As a consequence, the focus of botanical science shifted away from medicine, leaving practitioners of medical botany to establish their own specialized discipline, known today as pharmacology.

The Present

Over the course of the following two centuries, the science of medicine became more sophisticated and specialized than any Renaissance herbalist could have imagined. Indeed, recent developments in the use of laser beams, ultrasonic waves, and genetic engineering continue to challenge the imagination of modern innovators. Surprisingly, this rapid progress in the medical sciences has also reaffirmed the continuing relevance of botany to medicine. Technical innovations have accelerated the search for medicinal substances in natural products by providing increasingly simple and economical methods for screening massive quantities of plant samples.[11] During the last few decades, discoveries of plant products with antitumor, antimalarial, antibiotic, and immunostimulating properties have demonstrated that we are far from exhausting the medicinal potential of botanical resources.[12] With our increased access to the full range of the earth's biological diversity, the possibilities for finding effective treatments for human diseases have never been better.

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Travelling inland from the northern coast of New Guinea, unexplored forests on the banks of the Tor River are surveyed in search of a suitable collection site.

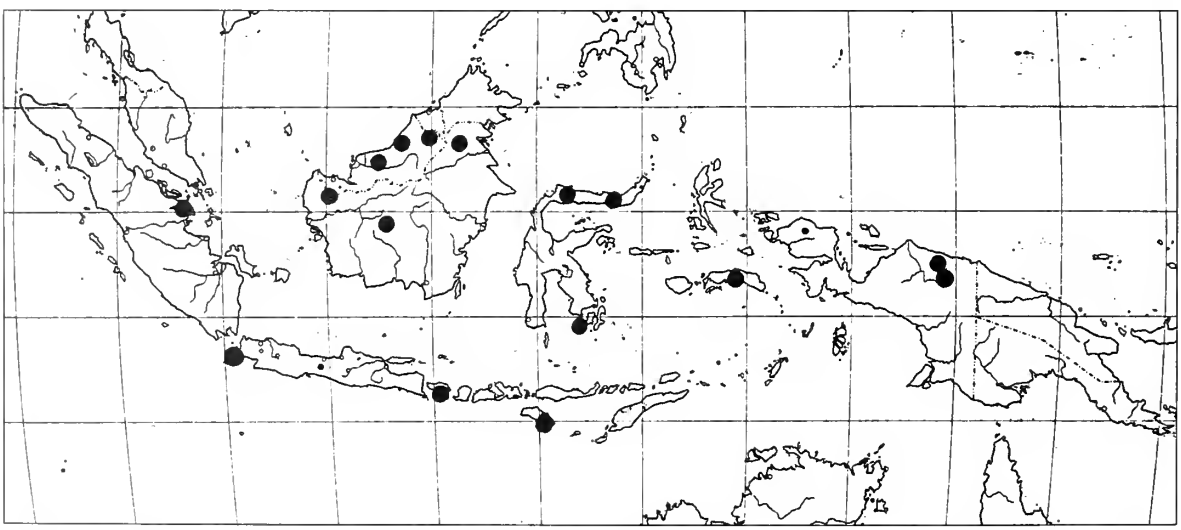
This optimistic view of the future is obscured, however, by the accelerating loss of natural resources that accompanies the exponential growth of human populations. On a global scale, catastrophic rates of deforestation and other kinds of environmental degradation threaten the existence of the rich biological diversity on which the tradition of drug exploration has always depended. This problem is also compounded by the loss of ancient medical practices found in native cultures. In many regions of the world, the traditions of plant use are simply being forgotten. As a consequence, agencies involved in drug research and development are beginning to appreciate the need to preserve these disappearing medical resources. In one exemplary program, the U.S. National Cancer Institute (NCI) is collaborating with tropical countries to inventory plant species and assess their potential for anticancer and anti-AIDS treatments.

Since the establishment of NCI in 1937, modern methods of medical research have isolated a number of plant products that have been successful in treating different types of human cancers. Examples include the antileukemic agent vincristine, derived from a tropical periwinkle *(Catharanthus roseus)*, and the ovarian cancer therapeutic, taxol, derived from the yew plant of the Pacific Northwest *(Taxus brevifolia)*.[13] Pharmacologically active compounds like these are identified by exposing crude extracts of plant tissues to living cultures of cancerous or HIV-infected cells. If an extract exhibits an effect on diseased cells, the active constituent of the sample is isolated, chemically characterized, and subjected to clinical analysis. Up to ten years of study and hundreds of millions of dollars are required to demonstrate that a promising chemical agent is effective, safe to use, and economically producible.[14]

The success of these efforts in drug development depends, however, on a critical first step: a program to collect and screen samples of potentially useful plants. This program requires teams of botanists and the collaboration of a worldwide network of botanical institutions.[15] Medicobotanical explorations focus primarily on the floristically diverse regions of tropical America, Africa, and Asia, and are led by botanical institutions that specialize in these regions: the New York Botanical Garden, the Missouri Botanical Garden, the Arnold Arboretum, and collaborative research institutions of host countries. As one of the leading institutions in the study of Asian floristics, the Arnold Arboretum is responsible for securing plant material from Indonesia, a tropical country with an exceedingly rich flora (about 37,000 species). Over the past seven years, botanists of the Arnold Arboretum have conducted numerous drug plant expeditions in collaboration with the Herbarium Bogoriense, Indonesia's national plant collection facility located in Bogor, on the island of Java. Study sites have included the other major islands of the country—Kalimantan (Borneo), Irian Jaya (New Guinea), Sulawesi (Celebes), Java, and Sumatra—as well as the lesser islands of Bali, Kabaena, Sumba, and the Moluccas.

Just to reach these sites presents the first of many challenges that confront the modern plant explorer. While air transport greatly facilitates travel between the larger islands, moving about the smaller islands can require anything from chartered missionary airplanes to fishing boats. Inland transport depends largely on tropical river systems, with each island presenting a distinctive set of obstacles. In Borneo, for example, only large boats with powerful motors can navigate the island's swift and rocky rivers. The waterways of Irian Jaya, on the other hand, are littered with sunken hardwood trees that permit only small pontooned boats with shallow drafts.

At each site, the plant explorer gathers bulk samples of leaf, stem, bark, and fruit material from about 350 species for analysis at the NCI pharmaceutical laboratories. In addition, up to 1,000 herbarium specimens are collected to identify and document the screening samples and inventory the regional flora. Since 350 bulk collections can weigh more than 1,000 pounds,



Distribution of sites explored for drug plants by the Arnold Arboretum and Herbarium Bogoriense.

J. ANDREW MCDONALD

A small, pontooned craft with provisions for two months departs the northern coast of New Guinea. Three days of ocean and river travel will be required to reach the planned destination.

a team of workers is needed to help collect, transport, and process plant materials. At least four young men with a talent for tree climbing are engaged to sample material suspended up to 150 feet above the forest floor. A knowledgeable resident provides the research team with local names and traditional uses of plants. As samples are brought into camp, other workers process the plant materials as quickly as possible to prevent fungal contaminations. Fresh bulk samples are chopped into small pieces to facilitate drying, while herbarium specimens are pressed and preserved in alcohol in plastic bags. Miscellaneous tasks required to live and work at the camp—gathering fresh vegetables or hunting meat from the forest, sending messages to neighboring villages, or scouting out routes to nearby collection sites—often occupy the entire population of a small village.

After two months in the field, dried bulk collections and preserved herbarium specimens are brought back to the Herbarium Bogoriense. Indonesian staff members carefully press and dry the voucher material in small ovens to finish preparation of herbarium specimens for future study and reference. Screening samples are shipped immediately to NCI laboratories in the United States, where they wait in cold storage for further processing.

During the early phases of testing, up to five percent of the samples exhibit some degree of efficacy against AIDS or cancer. Subsequent investigations by toxicologists will eliminate most of these possibilities, however. Since 1986,

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New Guinean villagers help prepare plant materials for drying in northern Irian Jaya. The dried samples provide a broad range of plant products that will be screened for antitumor and anti-AIDS activity.

over 50,000 plant extractions have been screened at the NCI, of which fewer than ten have been identified as potentially useful drugs.[16] Success rates have been particularly low in the search for antitumor agents. By comparison, the more recently initiated anti-AIDS research has been more promising: after only a decade, a number of potential anti-HIV compounds have been extracted from plants collected in distant continents (*Ancistrocladus* in Africa; *Calophyllum* in Malesia; *Conospermum* in Australia; *Homolanthus* in Samoa).[17] All of these promising discoveries are presently under study by clinical physicians and toxicologists.

Although modern medicine has yet to identify cures for AIDS, many cancers, and a host of other human maladies—arthritis, obesity, schizophrenia, parkinsonism, depression, to name just a few—potential pharmaceutical treatments for many of these conditions undoubtedly reside in the rich chemical diversity of the plant kingdom. Modern tools of pharmacology have greatly improved on the methods of the forest shaman, the Egyptian seer, and the Aztec herbalist, but we have yet to discover or invent a richer selection of chemical possibilities than that which nature has already provided. So long as the natural diversity of the earth's vegetation remains accessible to scientific inquiry, the tradition of medicinal plant exploration is likely to continue for centuries to come.

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RACZ & DEBRECZY

The winter habit of a mature Eucommia ulmoides *growing near the Hunnewell Building in the Arnold Arboretum. The plant was received from the Veitch Nursery of England in 1907 and was probably grown from seed collected by E. H. Wilson on an early expedition to China.*

Two Thousand Years of Eating Bark: *Magnolia officinalis* var. *biloba* and *Eucommia ulmoides* in Traditional Chinese Medicine

Todd Forrest

With a sense of urgency inspired by the rapid disappearance of plant habitats, most researchers are focusing on tropical flora as the source of plant-based medicines. However, new medicines may also be developed from plants of the world's temperate regions.

While working in his garden in the spring of 1763, English clergyman Edward Stone was positive he had found a cure for malaria. Tasting the bark of a willow *(Salix alba),* Stone noticed a bitter flavor similar to that of fever tree (*Cinchona* spp.), the Peruvian plant used to make quinine. He reported his discovery to the Royal Society in London, recommending that willow be tested as an inexpensive alternative to fever tree. Although experiments revealed that willow bark could not cure malaria, it did reduce some of the feverish symptoms of the disease. Based on these findings, Stone's simple taste test led to the development of a drug used every day around the world: willow bark was the first source of salicylic acid, from which Bayer chemist Felix Hoffman synthesized aspirin (acetylsalicylic acid) in 1899.

The recent search for new plant-based medicines has focused on tropical species, but aspirin is not the only drug derived from garden plants of the temperate zones: the antitumor agent taxol and the heart stimulant digitoxin come from plants found in front yards across North America. During random screening of plant material in 1980, the U.S. National Cancer Institute discovered taxol in the bark of the endangered Pacific yew *(Taxus brevifolia).* Since then, chemists have developed a method for extracting the active compound from the needles of the English yew *(Taxus baccata),* a species common in cultivation. Foxglove *(Digitalis purpurea),* the source of digitoxin, had a long history as a folk medicine in England before 1775, when William Withering found it to be an effective cure for dropsy. Doctors now prescribe digitoxin as a treatment for congestive heart failure.

EGb 761, a compound extracted from the maidenhair tree *(Gingko biloba),* is another example of a drug developed from a plant native to the North Temperate Zone. Used as an herbal remedy in China for centuries, ginkgo extract is now packaged and marketed in the West as a treatment for ailments ranging from short-term memory loss to impotence. Although the claims made for the extract might seem too miraculous to be true, research has shown that ginkogolides (the active ingredients in EGb 761) do have a beneficial effect on symptoms associated with aging.[1] Inspired by these results, pharmaceutical companies have established ginkgo plantations in Europe, China, and the United States.

Gingko is only one of many Chinese plants used as medicine. With an estimated 3,118 indigenous genera and more than 25,000 native species of seed plants, the flora of China is the largest and most diverse in the North Temperate Zone.[2] For thousands of years, practitioners of traditional Chinese medicine have developed treatments from plants, changed these treatments in response to empirical research and availability of raw materials, and documented their findings in herbals. Trade within China has enabled herbalists in Kunming to use the same plant materials as herbalists in Beijing, over a thousand miles away. Always searching for better cures, the Chinese have also looked to the rest of the world for useful plants: as early as the eighteenth century, the Chinese were importing American ginseng *(Panax quinquefolius)* from eastern North America to complement their own medicinal plants.

The documentation of traditional Chinese medicine goes back to the Han Dynasty (206 BC–220 AD). Written in approximately 100 BC, *Sheng Nong Ben Cao Chien* (The Herbal Classic of the Divine Plowman) is China's earliest known pharmacopoeia. This materia medica lists 365 traditional remedies, including 252 derived from plants, categorized into three classes based on toxicity: first-class remedies with no adverse side effects, used regularly to promote overall health; middle-class remedies, applied carefully to treat a smaller range of ailments; and lower-class remedies with potentially dangerous side effects, used to treat specific illnesses. *Sheng Nong Ben Cao Chien* gives general advice on the application of these remedies and specific instructions for their identification, preparation, and use.

Among the plants mentioned in this two-thousand-year-old work are joint fir *(Ephedra sinica)* and ginseng *(Panax ginseng)*, both of which have been appropriated by Western medicine. Joint fir is the source of ephedrine, an active ingredient in asthma and hay fever medicines. Ginseng, an important herbal medicine in China, is gaining popularity in the West as an adaptogen—a drug used to treat a variety of symptoms, to increase resistance to pathogens, and to promote general health. Research has shown that the active substances in ginseng

PETER DEL TREDICI

Eucommia ulmoides *in the Hangzhou Botanic Garden is elaborately sheathed to protect it from local bark harvesters. Even though most herbalists remove only part of the bark from a given tree, the popularity of the drug that is derived from* Eucommia ulmoides *makes every tree vulnerable to damage or even death from harvesting.*

E. H. WILSON

The bark of Eucommia ulmoides *was photographed by E. H. Wilson in China in 1907. The white band of fibers in the middle of the slab is the latex that gives the tree its common name, the hardy rubber tree.*

stimulate nerve centers, improve the metabolism and vascular system, and lower cholesterol levels.[3]

While ginseng and ephedrine are familiar to many Westerners, some Chinese medicinal plants are essentially unknown outside China. Two of these plants, *Eucommia ulmoides* and *Magnolia officinalis* var. *biloba*, grow in the Arnold Arboretum. Many Chinese use soups, pills, teas, and tinctures made from dried eucommia leaves and bark to lower blood pressure and increase strength. Herbal practitioners prescribe magnolia bark to treat coughs and colds and use magnolia flower buds to improve digestion and ease menstrual cramps. Both species are uncommon in cultivation outside China but will grow in Boston gardens.

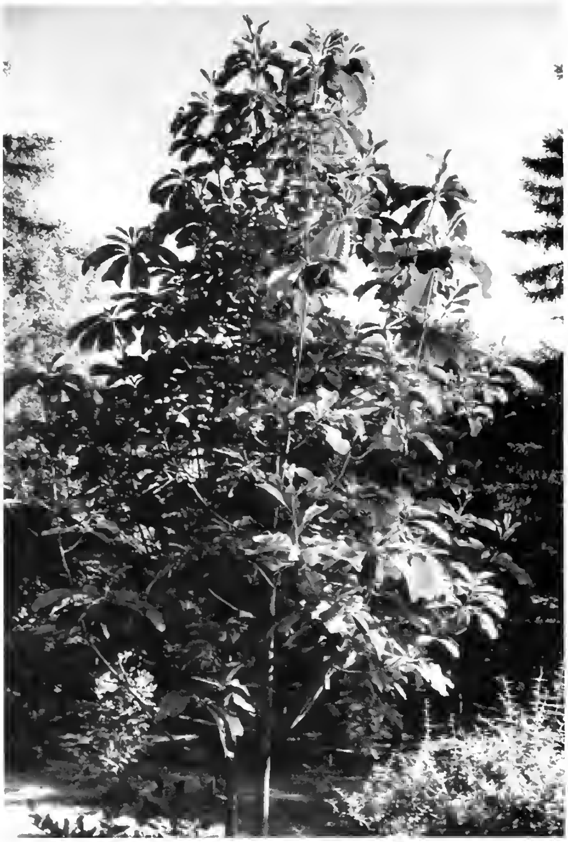
Eucommia ulmoides

A medium-sized, deciduous tree with lustrous, serrate leaves and inconspicuous, unisexual flowers, *Eucommia ulmoides* is the sole species in the Eucommiaceae. Native to the Tsinling Mountains in central China, eucommia was not seen by Western botanists until 1886, when specimens collected by Augustine Henry, a British customs official, trained medic, and amateur botanist, arrived at Kew Gardens. It was first grown in Europe in 1892, from seeds sent by French missionary Paul Farges to Maurice de Vilmorin, a Parisian plantsman. Its common name, the hardy rubber tree, refers to the white strands of latex found in its inner bark, leaves, and fruit. This latex attracted the attention of Europeans as early as 1903 when *The Gardener's Chronicle* claimed "there is good reason for believing that it would be worth while to plant [eucommia] in the warmer parts of the British Isles as a probable source of rubber."[4] Though the Chinese do produce some rubber from eucommia, it is not of high enough quality to be a replacement for the traditional, tropical source of rubber, *Hevea brasiliensis*.

The Chinese value eucommia more for its therapeutic properties than its latex. *Sheng Nong Ben Cao Chien* lists duzhong, the medicine derived from eucommia bark, in the first class of remedies, claiming it "revitalizes the internal organs, increases prowess, strengthens the bones, muscles, and tendons . . . and delays aging when taken continuously."[5] Augustine Henry found duzhong to be potent, telling William Watson of Kew Gardens that it is "tonic, invigorating, and . . . a most valuable drug with the Chinese, selling at 4s to 8s a pound."[6]

Farmers harvest eucommia in April, when the bark can be easily removed from the trunk of the tree. The process involves a number of steps. First, harvesters peel bark from trees with a diameter of greater than six inches, being careful not to girdle and kill the plants. They then tie the strips of bark together in bundles and sweat them under straw for a week or until the white inner bark turns black. Next, they lay the strips in the sun, drying the bundles so they can remove the outer bark, leaving only the stringy inner bark. They then chop the strips of inner

KAREN MADSEN



Magnolia officinalis *var.* biloba, *approximately twenty feet tall, in the Arnold Arboretum. This plant was grown from seed sent by the Hangzhou Botanic Gardens in 1981.*

bark into blocks and send them to market. Herbalists prepare these blocks according to a number of different recipes, depending on the needs of the patient.[7]

There are twelve accessions of eucommia represented in the collections of the Arnold Arboretum, including AA #14538-A, received as a plant from the Veitch Nursery Company of England in 1907. It is likely that this plant was grown from seed collected by E. H. Wilson in 1900 on his first trip to China for the Veitch firm. Almost ninety years old, this tree is now thirty feet tall with a spread of about twenty feet. Although no direct provenance information is available for this accession, Wilson's description of eucommia in *Plantae Wilsonianae* indicates that it is probably of garden origin. Wilson reported that he found no eucommia of indisputably wild provenance, apparently the result of overharvesting.[8] However, due to wide cultivation, the species is not in danger of extinction: farmers grow the tree in plantations in Sichuan, Hubei, Shaanxi, and Guizhou provinces, exporting the bark throughout the rest of China.

Magnolia officinalis

The Chinese also cultivate *Magnolia officinalis* for its medicinal properties. *The China Plant Red Data Book* lists this unusual magnolia, native to central China (Hubei, Sichuan, Guizhow, and Guangxi Provinces), as vulnerable, with most of its wild population destroyed by the over-harvesting of its valuable bark.[9] *Magnolia officinalis* is a fast-growing deciduous tree with large, obovate leaves and fragrant white flowers as large as twelve inches in diameter. In its native range, it occurs at elevations of nine hundred to six thousand feet, generally reaching a height of forty-five feet in full sun and well-drained soil.

This species has been plagued by taxonomic confusion since 1885, when it was first collected in Hubei Province by Augustine Henry. Nearly identical in appearance to *Magnolia hypoleuca*, a closely related Japanese species, it was identified as such until 1913, when E. H. Wilson and Alfred Rehder examined specimens Wilson had collected for the Arnold Arboretum in Hubei six years earlier. Rehder and Wilson gave the Chinese plant the species epithet *officinalis*, Latin for "of the shops," to signify its medicinal importance. They also named a variety, *Magnolia officinalis* var. *biloba*, distinguished from the type variety by the deep notches at the leaf apices and a slight variation in its native range (native to southeastern China—Hubei, Jiangxi, Zhejiang, Fujian, and Hunan Provinces). The bark of both is used as an herbal remedy.

In their description of *Magnolia officinalis* in *Plantae Wilsonianae*, Alfred Rehder and E. H. Wilson wrote, "the Chinese designate this species 'Houpo' tree, and its bark and flower buds constitute a valued drug which is exported in quantity from central and western China to all parts of the empire." *Sheng Nong Ben Cao Chien* lists houpo in the third class of remedies

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SUMMER • NEWS • 1995

Albert W. Bussewitz, 1912–1995

Jim Gorman

How rarely a man's love for nature becomes a ruling principle with him, like a youth's affection for a maiden, but more enduring! All nature is my bride. — Henry David Thoreau, April 23, 1857

Educator, naturalist, photographer, Albert W. Bussewitz, or "Buzzy," as he preferred, died this past August 8 of heart failure. The Arboretum's staff, volunteers, friends, and visitors will sorely miss his special warmth and quality of character as well as the encyclopedic knowledge of the natural world that he so readily shared with all. For the past seventeen years, Buzzy made the Arboretum his primary outdoor studio and classroom, developing many deep friendships. He had been a sanctuary director and educator for the Massachusetts Audubon Society for twenty-seven years before, as he used to say, he was "granted an honorable dismissal, having qualified chronologically."

In 1978 he and his wife, Flora Quirin, moved to Jamaica Plain—during the infamous February blizzard—and he "was recycled instead of retired." As the Arboretum's preeminent docent, Buzzy enthralled thousands of visitors as well as staff on his walks, which encompassed not just botany but the total natural environment. "Being a teacher," he said, "you share with others the opportunity to see what you're looking at—the petals of a plant, the plume of a bird—how one form relates to another. As a naturalist, I try to keep the doors open to show how one form of life connects to all others, as in a spider's web, where in touching one strand you touch the whole."

Buzzy loved words nearly as much as nature; he was our resident lexicologist. How he delighted in creating phrases with unexpected words. Richard Warren, longtime friend of both the Arboretum and Buzzy, observed, "He had a store of words and phrases that, while grammatical, were not usual. They could worry the listener in that an involved sentence might seem to have no ending, but he always crashed through with the most dramatic and grammatic word to save the day."

Born on a 160-acre farm in Juneau, Wisconsin, Buzzy's formative years exposed him to agriculture and the out-of-doors. He later would recall that he learned the songs of bobolinks, redwing blackbirds, and meadowlarks while walking the purebred Holsteins back home down a long country lane. "These walks also exposed me to the landscape," he said in a 1985 *Harvard Gazette* interview. "I remember a limestone quarry where salamanders lived under the rocks and where in spring I first got acquainted with the frogs and their sounds. I was, I suppose, the only one in Juneau with the audacity or maybe the courage to forage through the landscape with a butterfly net."

Susan Hardy Brown

A gathering in remembrance of Buzzy will be held Sunday, October 8, at 1 pm at the Hunnewell Building.

He graduated from Northwestern College in nearby Watertown, then entered Lutheran theological training, where he learned Greek and Latin. Later he would attend the University of Wisconsin, studying biology, entomology, and other natural history. His professor of wildlife management was Aldo Leopold, author of *A Sand County Almanac* and a founder of the Wilderness Society.

Soon after school, he came east, settling in Rochester, New York. A first job in the florist business was followed by work in the testing lab of Bausch and Lomb's precision optics department. It was in Rochester that his avocational affiliation with several natural history organizations began; he was a founder of the Genesee Ornithological Society and served as editor of their journal, *Goshawk*. He and

Flora would stay nine years in Rochester, and it was there that their three children, Robert, Betty Ann, and Barry, were born.

In 1949 he took the position of director of the Massachusetts Audubon Society's Moose Hill Sanctuary in Sharon, the oldest sanctuary within the oldest Audubon Society in the United States. Responsible for outdoor and classroom education and, in summer, for nature camps, he influenced scores of individuals in their decisions to pursue careers with an environmental focus. Later, when Stony Brook Sanctuary opened in Norfolk, he was asked to assume responsibility there. In 1966 he moved to Audubon's Rocky Knoll Nature Center in Milton and worked as natural history lecturer for sixth graders in many communities south of Boston. At his retirement Massachusetts Audubon Society's Allen Morgan praised him as "one of the true pioneers in environmental education."

Always photographing, Buzzy's vision was panoptic, taking in all parts of plants. Many of us were particularly struck by his skillful use of light, which revealed the translucency of fruits or the softness of tomentose leaves. His exquisite photography was often seen on the covers and pages of this and other publications. He was a longtime member, officer, and judge of the Boston Camera Club and its Nature Group. In 1980 he was named a Master Member of the New England Camera Club Council.

A member and past president of the Thoreau Society, Buzzy had carefully studied all of Thoreau's writings, especially the fourteen volumes of the *Journals,* and would often easily recite a passage to accentuate a moment with an audience. Of all the myriad programs, walks, and lectures Buzzy developed throughout his life, perhaps the most notable was "Through the Seasons with Thoreau." Combining excerpts from the *Journals* with his own interpretive images, this remarkable performance was Buzzy's magnum opus. First presented at Concord's Thoreau Lyceum in 1971, his "synergistic message," as he called it, was continually revised. "Doesn't have to be finished," he would say. "I keep it as an ongoing effort."

At the time of his death, he was returning from Carleton-Willard Village in Bedford, where he had presented "Through the Seasons with Thoreau." Flora, his beloved wife of fifty-five years, was at his side. One of the excerpts from Thoreau's journal for September 7, 1851, that he recited to that audience pertained to Buzzy as well:

> *How to extract its honey from the flower of the world. that is my everyday business. I am as busy as a bee about it: I ramble over all the fields on that errand and am never so happy as when I feel myself heavy with honey and wax. I am like a bee searching the lifelong day for the sweets of nature.*

To recall his tours and walks at the Arboretum is to remember fine performance art. We can think of no one who presented botanical information so colorfully and eloquently, interwoven with poetry, prose, and art as well as science. He was inspired and he inspired those with whom he came in contact, casual visitor or expert plantsperson. Often at the end of his tours he would remind you that it would take another lifetime or two to see the Arnold Arboretum, and even then you might miss something. Many of us know that because we knew Buzzy, we have seen much that we would otherwise have missed. We join the multitudes who are indebted to this noble, yet humble, poetic man, a special teacher who inspired us all.

Pamela Thompson Appointed Adult Education Coordinator

On August 1, Pam Thompson, former course registrar, took over as the new coordinator of Arboretum adult education. Over the past four years Pam has spoken with many of you over the phone as she has been responsible for

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overseeing course registrations and many other aspects of the program. Prior to her work for the Arboretum, she served as Director of Administration for the Center for Plant Conservation.

Pam has a particular interest in creating programs that further utilize the living collections and that provide learning activities for families. She invites your suggestions and comments as she plans courses for 1996 (617/524–1718 x 162). When not aranging classes at the Arboretum, Pam enjoys caring for her own garden as well as spending time with her six-month-old daughter, Ailsa Jeffries.

We also wish to send our congratulations to former program manager Marcia Mitchell, who has just entered a degree program at Harvard's Kennedy School of Government. Marcia's dedication and good humor will be sorely missed.

AA/NPS Forum

Karen Madsen

The Arboretum as a partner in the Olmsted Center for Landscape Preservation held a Forum on Vegetation Management for Historic Sites on August 3. An audience of over eighty maintenance managers, field personnel, and landscape preservation professionals attended. Topics included the application of principles of preservation to vegetation management, the management of mature specimen plants, and woody plant succession on historic sites.

Speakers included, in the back row, left to right, Bob Cook of the Arboretum, Charles Birnbaum of the National Park Service, David Barnett of Mt. Auburn Cemetery, Richard Harris of the University of California at Davis, Edward Toth of Prospect Park in Brooklyn, Phyllis Andersen of the Arboretum; center row, left to right, Lauren Meier and Nora Mitchell of the National Park Service, Lucy Tolmach of Filoli in Woodside, California; and front row, left to right, John Fitzpatrick of the Garden Conservancy, Peter Del Tredici of the Arboretum, Elizabeth Vizza of the Halvorson Company, Charlie Pepper of the National Park Service. Missing from the photograph are Glenn Dreyer of the Connecticut College Arboretum and Stephen McMahon of The Trustees of Reservations.

Summer Interns of 1995

Karen Madsen

1995's fifteen interns come from thirteen different institutions across the U.S. and from Ireland. From left to right in the outermost circle are Heather Storlazzi, Emma Ross, Niamh Page, Landry Lockett, John Creasey, Benjamin Zaitchik, and Scott Ritchie; inner circle, Brian Grubb, Crystal Lee, Angela Ingerle, Tanya Sandberg-Diment, Laura Brogna, Kristen Kleiman; front center left, Sonya Del Tredici, right, Jeremy Fink.

Each summer, the Horticultural Training Program brings students interested in horticulture, botany, or landscape design to the Arboretum for work and study. Work ranges from sharpening lawnmower blades and running chippers to pruning woody plants, transplanting trees, and computer-mapping the living collections. Study revolves around twice-weekly classes in plant identification, pests and diseases, weeds, pruning, planting and transplanting, taught by Arboretum staff. Assistant Superintendent of Grounds Julie Coop, who supervises the program, leavens the mix with field trips. This year these included Mt. Auburn Cemetery in Cambridge, Ponkapoag Pond in Canton, Blithewold Arboretum and Newport estates in Rhode Island, as well as the rest of the Emerald Necklace, the Boston park system of which the Arboretum is a part.

Arboretum Hosts Wood Collectors Meeting

Chris Strand, Outreach Horticulturist

J. A. Kruza

Chris Strand, second from right, exchanges tree lore with members of the New England Chapter of the International Wood Collectors Society.

On June 24 the Arnold Arboretum hosted a meeting of the New England Chapter of the International Wood Collectors Society (IWCS). As the staff member responsible for coordinating this meeting I confess I was wary of their intent. The term "wood collectors," so prominent in the name of their organization, made me suspect that they would be asking questions like "How many board feet of lumber do you have at the Arboretum?" I was in for a pleasant surprise.

IWCS president Alan Curtis gave a slide presentation of his experiences at the Fairchild Tropical Garden, where he and other volunteers helped clean up in the aftermath of Hurricane Andrew, which literally destroyed the garden. As the garden's crews removed logs, Curtis and volunteers from the Wood-Mizer Company sawed them into boards. At a public sale later in the year they auctioned off 8,000 board feet of exotic lumber and raised $32,000 for the Garden.

After Curtis' lecture, Jim Gorman, Tour Coordinator at the Arboretum, and I led the group on a walking tour. We were able to share with them the botanical and horticultural qualities of the plants, and they shared with us the characteristics of the respective woods. For example, an IWCS member was able to explain why the wood of the princess tree *(Paulownia tomentosa)* is so highly valued in Japan, namely, for its use in special obi boxes. If the box is made correctly it will swell shut from the humidity in the season when the obi is not worn and will open in the season when it is worn. It is this property that makes the *Paulownia* wood so dear.

As the meeting continued into the afternoon with a lecture on the restoration of a savanna forest in South Africa, it had become clear that the wood collectors were, like all true aficionados, interested in many aspects of trees including their growth, unique qualities, and conservation.

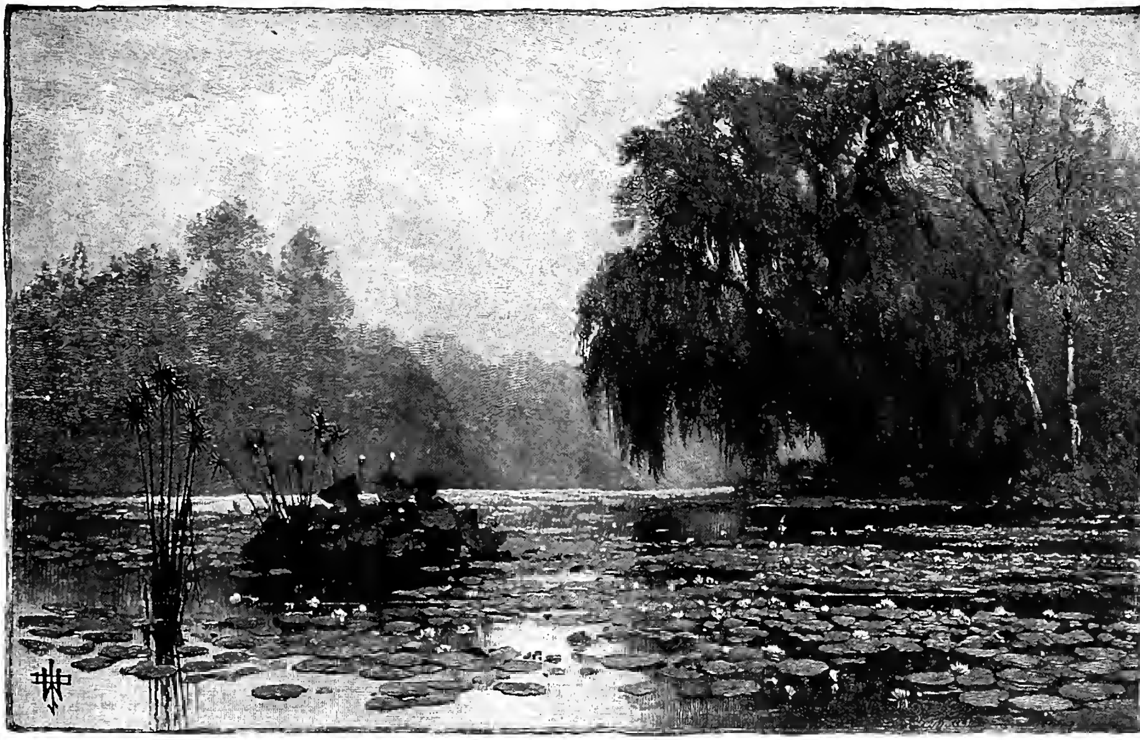
Cynthia Buff

GCA Visits Boston

The national meeting of the Garden Club of America, held in Boston this past spring, provided several opportunities for Arboretum staff and GCA members to share knowledge about plants, horticulture, and preservation. Director Bob Cook spoke on the Arboretum's collaboration with the Olmsted Center for Historic Landscape Preservation, discussing the work of the Center and recent developments in the rapidly evolving preservation field. On Mother's Day, Arboretum staff hosted a GCA tour group, providing attendees with an excursion into the living collections and a plant recently introduced by the Arboretum, *Weigela subsessilis.*

Arboretum Open House, Saturday, October 14

Join Arboretum staff for a special open house welcoming the Friends of the Arnold Arboretum and the larger Boston community. Scheduled to run from 2:00 to 4:00 pm, the event will feature tours of the landscape, greenhouse, and Hunnewell Building and offer opportunities to chat with Director Bob Cook and other staff about Arboretum plans and programs. Please mark your calendars. We look forward to seeing you this October!



From *Landscape Gardening*, Samuel Parsons, Jr., 1900

Samuels Parsons, Jr: The Art of Landscape Architecture

Presented by the Frederick Law Olmsted National Historic Site and the Arnold Arboretum and sponsored by Wave Hill, The Bronx, the exhibition *Samuel Parsons, Jr: The Art of Landscape Architecture* will be on view in the Arboretum's Hunnewell Building, 125 Arborway, Jamaica Plain, from 1 October through 15 December 1995.

Charles A. Birnbaum, curator of the exhibit and coordinator of the National Park Service's Historic Landscape Initiative, will present a lecture on the work of Parsons on Thursday, 26 October, 7:30–8:30. It is free and open to the public. For reservations, please call 524–1718 x162. Samuel Parsons, Jr. (1844–1923), worked extensively in the design of parks for American cities, helping to define landscape architecture for the generation that followed Frederick Law Olmsted. The son of an accomplished horticulturist, Parsons received his initial training at Parsons & Sons Company Nursery. Later, Parsons served as Landscape Architect for New York City, where his innovative inner-city parks marked a new direction in American park design. The exhibit and lecture will trace the development of Parsons' career through his work for New York City as well as projects for San Diego, Washington, DC, and other cities across the country.

New Staff at the Arboretum

Kirsten Ganshaw, a 1994 summer intern, has returned to the Arboretum as a member of the grounds staff. She is responsible for the seven-acre Bradley Garden

Karen Madsen

of Rosaceous Plants where her work includes pruning, transplanting, weeding, mulching, updating the plant records in the computer database, and overseeing interns as they rotate through the garden as part of their summer experience. She is presently working to contain the erosion and weeds that plague Dawson Pond.

Kit brings to her job fifteen years' experience in landscape gardening. She's been senior gardener at a public botanic garden; landscape supervisor on an estate garden; a contractor specializing in water gardens; and crew supervisor in many situations. She holds a BS in natural resource management and applied ecology from Cook College, Rutgers State University, where she worked as greenhouse technician in the Department of Entomology.

Andrew Hubble has joined the Arboretum to serve as curator of computers. His official title is Network Systems Manager; as such he will ensure that our PC and Macintosh computers are able to talk to our UNIX and Novell

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servers. He also provides technical support to Arboretum and Herbarium staff in Jamaica Plain and in Cambridge, especially in connection with the Asian biodiversity project, community science education programs, and the living collections database. Moreover, he is responsible for planning and developing initiatives in Internet access, a World Wide Web home page, and visitor center computer kiosks.

Andrew has worked in information technology for the last fifteen years in the fields of biotechnology, library automation, and academic research. He is a graduate of the University of California at Davis with a BS in plant science.

Karen Madsen

Deby Pasternak is the newest addition to the Arboretum's Development Office. She has worked in development at the Berklee College of Music and at the Harvard Business School. She also has experience in environmental education in the photovoltaics industry and as a volunteer science teacher on the Hudson River Sloop Clearwater.

Deby helps to organize events, researches funding sources for the Arboretum's many environmental and educational programs, and provides invaluable support to the development staff as the Arboretum embarks on its first campaign since the Charles Sprague Memorial Campaign of 1927. A graduate of Amherst College, Deby is also a performing and recording musician.

Have You Finished Reading 54:1?

The Spring 1994 issue of *Arnoldia*—volume 54, number 1: the one with the statuesque Lombardy poplars on the cover—has been in especially heavy demand. We ran out of copies many months ago, and still the requests come in. We're especially concerned about the missing-issue claims from horticultural and botanical libraries, where the lack of 54:1 will interrupt complete collections.

If you've finished reading 54:1 and have no further need of it, would you consider returning it to the Arboretum for redistribution? We'd be very grateful.

The Arboretum's Education Department offers a wide variety of courses, programs, and lectures in horticulture, botany, and landscape design. A selection of fall courses is shown here. For a complete catalog of programs and events at the Arboretum, please call 617/524-1718 x 162. Note that fees shown in **boldface** are for members of the Arboretum. For information about becoming a member, call 617/524-1718 x 165.

SEPTEMBER/OCTOBER

BOT 224 The Mosses of New England

Benito Tan, Bryologist, Harvard University Herbaria

Join Dr. Benito Tan to learn about New England mosses in the field and in the laboratory. This course will focus on moss species that are common and biologically unique to New England. The class will visit a site rich in mosses where the instructor will supervise the limited collection of moss samples for study in the laboratory. Most class time will be spent in learning to recognize moss species with a hand lens and under the microscope. Discussion will touch only briefly on the horticultural use of mosses. Equipment needed: 7x or 10x field lens and a small pocket knife for collecting.

Fee: **$85**, $100

5 Wednesdays, September 27, October 4, 11, 18, 25/ 6:00–8:00 pm (HUH) and 1 Sunday field trip, October 1 (TBA)

HOR 419 The Year-End Garden: Plants for the Fall and Winter

Gary Koller, Senior Horticulturist, Arnold Arboretum

Learn the palette of plant material, both herbaceous and woody, that provides interest in the garden as the year wanes and the weather turns cold. At the first class meeting, we will discuss the fall possibilities for flowers and foliage color, especially the plants for late fall. Weather permitting, we will visit the Case Estates teaching garden, which peaks in fall.

Fee: **$30**, $35

2 Wednesdays, October 18, 25/ 5:00–7:00 pm (CE)

HOR 450 Looking at Plants with Michael Dirr

Michael Dirr, Professor of Horticulture, University of Georgia

Dr. Michael Dirr, world authority on woody plants and author of the standard reference work *Manual of Woody Landscape Plants,* will make one of his rare speaking trips to Boston this fall. Dr. Dirr's many friends and students know that early registration is needed to ensure that they will hear his latest information about newly introduced plants and new cultivar availability.

Fee: **$15**, $18

Friday, October 20/ 7:00–8:30 pm (HB)

NOVEMBER

HOR 246 The Plant Connoisseur: Annuals and Half-Hardy Perennials

Brian McGowan, Owner, Blue Meadow Nursery, Montague Center, MA

Many desirable garden plants that are perennial in warmer climates are not used in New England gardens because they cannot survive our winters. Brian McGowan specializes in growing these plants, and his talk provides the information necessary to overwinter tender perennials and even some annuals. His slide presentation introduces some of the hundreds of new annuals and tender perennials now being grown for the home gardener.

Fee: **$12**, $15

Wednesday, November 8/ 7:00–8:30 pm (CE)

WAL 339 Plant Interactions: Vegetation Dynamics of Southern New England

William A. Niering, Professor of Botany, Connecticut College, and Editor, Restoration Ecology

Well-known plant ecologist William A. Niering, author of *The Audubon Society Field Guide to North American Wildflowers,* will speak on plant interactions in upland and wetland regions of southern New England. Competition among these plants largely determines their success in different habitats. Knowledge of changing conditions, and how plants affect each other under these changing conditions, is important to understanding future patterns of plant growth.

Fee: **$8**, $10

Thursday, November 2/ 7:00–8:30 pm (HB)

BUSINESS REPLY MAIL

KAREN MADSEN

The spectacular foliage of Magnolia officinalis *var.* biloba.

because its active ingredient, the alkaloid magnocurarine, is toxic in high concentrations. The Chinese, Wilson observed, use it as "a cure for coughs and colds, and as a tonic and stimulant during convalescence."[10] More recently, the Harvard botanist Lily Perry described the drug extracted from the bark as "bitter, pungent, and warming" and said it is prescribed for "flatulence, nausea, lack of appetite, shortness of breath, and dysentery."[11] The dried flower buds, called Yu-po, are used to treat intestinal problems, and are "esteemed as a medicine for women."[12]

Harvesters do not show the same concern for magnolia when removing its bark as they do when harvesting eucommia. In May they cut down twenty-year-old trees and strip the bark from the roots, trunks, and branches. After drying the bark, first in shade and then in sun, the harvesters steam it, roll it into tubes, and sort it according to the part of the tree from which it comes: tube houpo, from the trunk; boot houpo, the irregular remnants of tube houpo; root houpo, also known as "chicken intestine po"; and branch houpo. Since houpo is toxic in large doses, it is never given to pregnant women and always prescribed with other herbs. Herbalists decoct the bark and use the extract in mixtures with rhubarb, licorice, ginger, or other herbs to make teas, powders, and tinctures.

Magnolia officinalis has not performed well in the Arnold Arboretum, but its variety *biloba* has thrived. Not available outside China until 1936, this interesting plant, like eucommia, grows mostly in botanic gardens and arboreta. Seeds obtained by the Arnold Arboretum from the Hangzhou Botanic Garden in 1981 (AA #398–81) have already grown into plants twenty feet tall. Like *M. fraseri* and *M. macrophylla*, both native to North America, its leaves are arranged in false whorls at the ends of its branches, giving the plant an open, tropical appearance. The combination of these eighteen-inch-long, notched leaves, light gray bark, and large, fragrant flowers make this a striking ornamental tree. Although *M. officinalis* var. *biloba* is not yet used medicinally in North America, its exotic habit and foliage have made it a popular plant for zoo horticulture—curators use it to create tropical exhibits for zoos in temperate climates.

Western chemists have examined both *Eucommia ulmoides* and *Magnolia officinalis* and isolated active compounds from their bark. Tests done at the University of Wisconsin support the claim that duzhong has potential as an antihypertensive drug.[13] Magnocurarine, the alkaloid in houpo has "a neuromuscular blocking effect and cause[s] relaxation of the skeletal muscles."[14] Pharmaceutical companies have not developed these compounds for use in North America because there are already similar drugs on the market.

With a sense of urgency inspired by the rapid disappearance of plant habitats, most researchers are focusing on the diverse flora of the tropics as the source of plant-based medicines. However, as drugs such as taxol and EGb 761 demonstrate, new medicines may also be developed from plants of the temperate regions of the world. Of these regions, China offers the highest floristic diversity and a more than two-thousand-year-old tradition of using plants as medicines. This long history of herbal medicine has already proven valuable to Western medicine and may do so again in the future.

Todd Forrest came to the Arnold Arboretum as an intern in 1994 and now maintains the plant records system for the institution.

Endnotes

1 F. V. DeFeudis, Ginkgo Biloba *Extract (EGb 761): Pharmacological Activities and Clinical Applications* (Paris: Elsevier Press, 1991).

2 T. S. Ying, Y. L. Zhang, and D. E. Boufford, *The Endemic Genera of Seed Plants of China* (Beijing: Science Press, 1993), i.

3 K. C. Huang, *The Pharmacology of Chinese Herbs* (Boca Raton, FL: CRC Press, Inc., 1993), 21–45.

4 William Watson, "A Hardy Rubber-Yielding Tree," *The Gardener's Chronicle* (1903) 842: 104.

5 Quoted from *Sheng Nong Ben Cao Chien* by Shiu-ying Hu in "A Contribution to Our Knowledge of Tu-chung—*Eucommia ulmoides*," *American Journal of Chinese Medicine* (1979) 1: 6.

6 Augustine Henry quoted in William Watson, op. cit. An excellent reference for Henry's travels in China is his own *Notes on Economic Botany of China* (1893; reprint, Kilkenny, Ireland: Boethius Press, 1986).

7 Dr. Shiu-ying Hu is an invaluable source of information on all Chinese medicinal plants. She translated the sections of the *Sheng Nong Ben Cao Chien* dealing with *Eucommia ulmoides* and *Magnolia officinalis* for me and kindly pointed me towards many other sources.

8 A. Rehder and E. H. Wilson, *Plantae Wilsonianae*, vol. I, ed. C. S. Sargent (Cambridge: Harvard University Press, 1913), 433.

9 *China Plant Red Data Book—Rare and Endangered Plants*, vol. I, ed. L. K. Fu and J. M. Jin (Beijing: Science Press, 1992), 416–417.

10 Rehder and Wilson, op. cit., 392.

11 L. M. Perry, *Medicinal Plants of East and Southeast Asia* (Cambridge: MIT Press, 1980), 250.

12 Rehder and Wilson, op. cit., 392.

13 Hu, op. cit., 27–28.

14 Huang, op. cit., 174.

Jane Colden: Colonial American Botanist

Mary Harrison

"She deserves to be celebrated," wrote Peter Collinson to Linnaeus of Jane Colden, whom he described as "perhaps the first lady that has perfectly studied Linnaeus' system."[1]

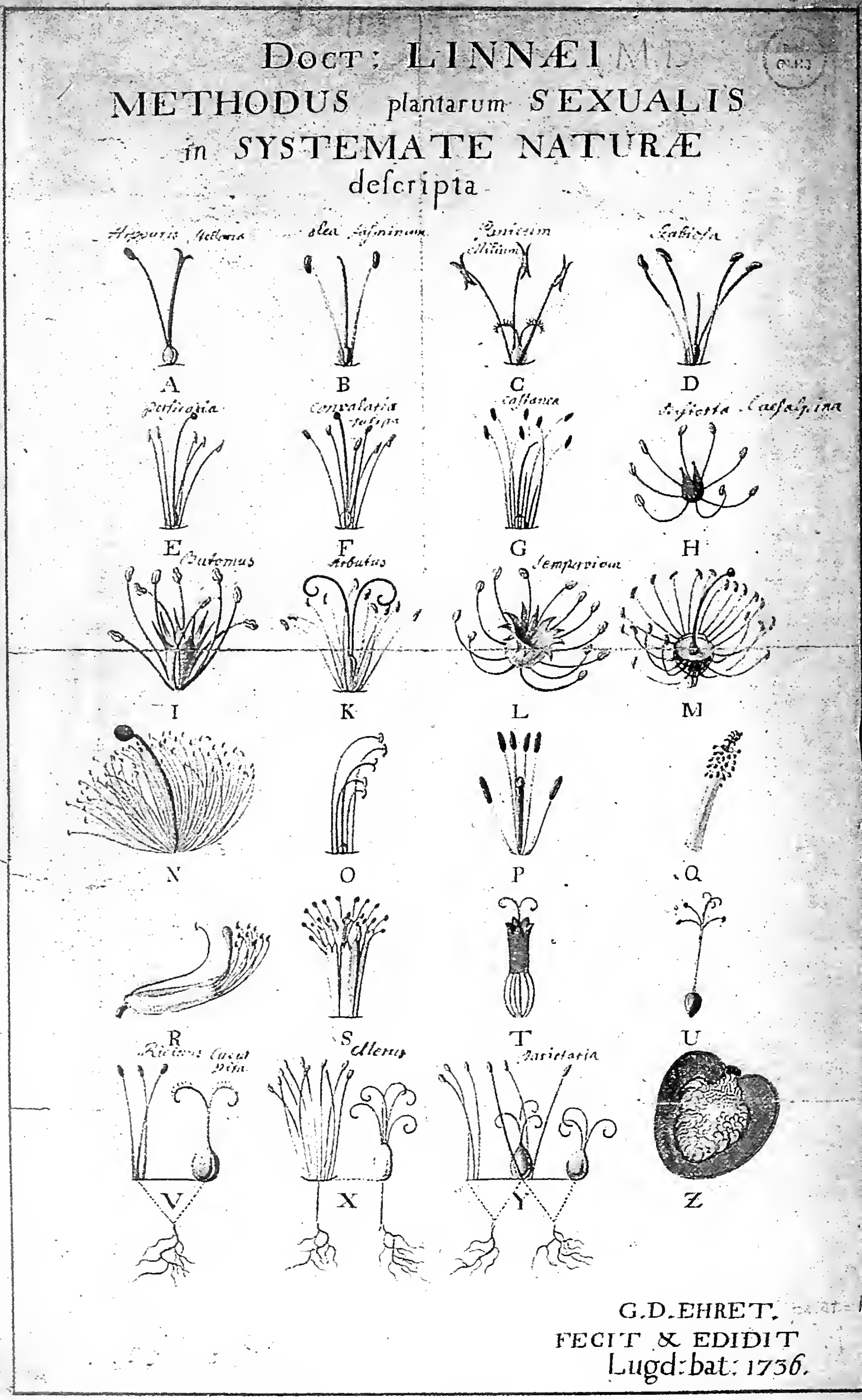
In the early eighteenth century only a few women in Europe or the American colonies were involved in botany or any other science. Those few were usually related to a man working in the subject: Sophia Sarah Banks assisted her brother, explorer and naturalist Joseph Banks; Caroline Herschel became an astronomer through her association with her brother William. And Jane Colden (1724–1766), the subject of Peter Collinson's praise to Linnaeus in his 1756 letter, was initiated into botany by her father Cadwallader Colden.[2]

We know directly of Jane Colden's botanical work through a single manuscript of hers that now resides in the British Museum. Nonetheless, there is little doubt that she was a respected member of an international community that was deeply involved in the exchange of plants and botanical information that followed the discoveries of new plant material in North America. Contemporary botanists in England and the colonies discussed her in their correspondence, describing her with such accolades as "assiduous," "accomplished," "scientifically skilful," "ingenious." Collinson wrote enthusiastically about her not only to Linnaeus but to John Bartram: "our Friend Coldens Daughter Has in a Scientificall Manner Sent over Several sheets of plants very Curiously Anatomised after [Linnaeus'] Method I believe she is the first Lady that has Attempted any thing of this Nature."[3]

Only a few letters written by Jane Colden survive, none of them dealing with her botanical work, but we know she corresponded with botanists in Europe and America, among them John Bartram whom she had met when he visited her father's estate at Coldengham, New York. In a letter written in January 1757, he thanks her for her letter and reports that he has read it "several times with agreeable satisfaction." He adds, "Indeed I am very careful of it and it keeps company with the choicest correspondents, ye european letters"—a high honor, for his European correspondents included the predominant naturalists of the day: Peter Collinson, a wealthy London draper and plant collector; Philip Miller of the Chelsea Physic Garden; Carolus Linnaeus; and John Fothergill, patron of scientists and plant collectors.[4] Another friend and correspondent, Dr. Alexander Garden of Charleston, South Carolina, in a letter to John Ellis in 1755, passes on the information that Dr. Colden's "lovely daughter is greatly master of the Linnean method."[5] And John Ellis, in a letter to Linnaeus written in 1758, reports on Jane's botanical activities and her knowledge of Linnaeus' system.

In view of the limited educational opportunities available to women in the eighteenth century, Jane Colden's acceptance by this august group of naturalists and botanists is all the more remarkable. Like most women of her station and period, she had no formal education, but she was blessed with parents who recognized her talents and encouraged and equipped her to pursue her interests. Cadwallader Colden, the son of a Scottish minister, studied at Edinburgh University. He abandoned his original intention of entering the Church of Scotland and turned instead to medicine. Since his father was financially unable to help him establish a career in

FROM GERTA CALMANN'S EHRET FLOWER PAINTER EXTRAORDINARY (BOSTON: NEW YORK GRAPHIC SOCIETY, 1977)



Scotland, Colden left for the American colonies in 1710. Aided by family connections, he settled in Philadelphia. In 1715 he returned to Scotland and married Alice Christy. They left Scotland for Philadelphia in 1716 and moved to New York a few years later. Through his acquaintanceship with the governor of New York, Dr. Colden was named to the position of Surveyor General of the colony, the first of many important offices he held. The governor also offered him a stipend to compile a list of the plants and animals of New York; however, funds were not forthcoming and the project did not materialize. Later Colden was to assemble an inventory of plants growing on his own estates.

In 1719 Colden received a grant of two thousand acres of land situated in what is now the town of Montgomery in Orange County, New York, followed shortly by another grant of one thousand acres. It was here, behind the highlands of the Hudson, about ten miles west of Newburgh, that Colden built "Coldengham," his country house, and settled with his family. Even before the family moved into their new home, Colden had begun to cultivate the land and in 1727 was recording in his journal the details of crops sown and harvests gathered. Jane was four years old when the Colden family, now with six children, moved to this wilderness estate, in the words of her father, "the habitation of wolves, bears and other wild animals."[6]

There was no school available in the area so the charge of educating their children fell entirely to Alice and Cadwallader Colden. Mrs. Colden was the daughter of a clergyman and had been brought up in Scotland in an intellectual atmosphere. Dr. Colden was a man of infinite interests and talents: he wrote on anthropology and philosophy as well as medical subjects, but he claimed little knowledge of botany except for the rudiments acquired during his medical training. In letters to Collinson and Gronovius he refers to his "ignorance in botany as a science" and his awareness that he could "understand so very little botany."[7] Some years after moving to Coldengham, however, he records that he "accidentally met Dr. Linnaeus' *Genera Plantarum*. I was so taken with the accuracy of his characters, that I resolved to examine them with the plants that grow near my house. And this is the sole occasion of what you have seen from me in Botany and which is so inconsiderable that I can have no pretensions of merit in the Science."[8] Nevertheless, his collection and documentation of plants around his home resulted in the first local flora of New York, "Plantae Coldenhamiae," which Linnaeus published in 1749.[9]

Linnaeus' ideas had infiltrated the American colonies some years earlier. In 1737 Collinson wrote to John Bartram, "The *Systema Naturae* is a curious performance for a young man; but [Linnaeus'] conning a set of new names for plants, tends but to embarrass and perplex the study of Botany. As to his system on which they are founded, botanists are not yet agreed about it." But by 1743 Collinson was able to report to Linnaeus, "Your system, I can tell you obtains much in America. Mr. Clayton and Dr. Colden at Albany of Hudson's River in New York are complete Professors. . . . Even Dr. Colden's daughter was an enthusiast."[10] (Linnaeus' binomial system reduced plant names to two words, the first the generic name, the second the specific name. As an example, before Linnaeus, the common flax that we know botanically as *Linum usitatissimum*—where *Linum* is the genus and *usitatissimum* is the specific name—was listed as *Linum raris foliisque alternis linearilanceolatis radice annua*.)

Testimony to Jane's interest in botany is also offered in a letter of 1755 from Colden to Gronovius.

> I have a daughter who has an inclination to reading and a curiosity for natural phylosophy or natural History and a sufficient capacity for at-

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Opposite: George Dionysius Ehret drew and engraved this "tabella" of Linnaeus' so-called sexual system of plant classification in 1736. In this system, plants were grouped according to the number of reproductive parts in the flower. By counting the number of stamens and pistils in its flower, a plant could be put into any one of Linnaeus' twenty-four classes. Ehret labelled the twenty-four classes with the letters of the alphabet and selected representative plants to illustrate the first eleven and the last four classes. Linnaeus used Ehret's engraving in his Genera Plantarum *of 1737. The original watercolored drawing is in the Natural History Museum, London.*

taining a competent knowledge I took the pains to explain to her Linnaeus's system and to put it in English for her to use by freing it from the Technical Terms which was easily don by useing two or three words in place of one. She is now grown very fond of the study and has made such progress in it as I believe would please you if you saw her performance Tho' perhaps she could not have been persuaded to learn the terms at first she now understands to some degree Linnaeus' characters notwithstanding that she does not understand Latin.[11]

Jane's lack of knowledge of Latin was characteristic of women of her time both in England and in the American colonies. Seventeenth-century writers commenting upon the lack of Latin instruction recognized it as a miserable handicap. "Not to read Latin was to go in blinkers," and the few females who overcame this difficulty had to put up with "those wise Jests and Scoffs that are put upon a Woman of Sense and Learning, a Philosophical Lady as she is call'd by way of Ridicule."[12] Jane's mother, and Jane herself, were not far removed from such attitudes and were certainly not yet liberated from the traditions that produced them. Nevertheless, Jane's father was able to report that her enthusiasm for botany did result in the acquisition of "some knowledge of Botanical Latin." Women were not alone in suffering from lack of knowledge of Latin. "Learned languages," according to Colden, were little understood in the colonies, and the need for English botanical works was crucial. He begged Collinson, who had cultivated North American plants in his garden for many years, to publish descriptions of them, for "We have nothing in botany tolerably well done in English."[13]

Though he was pleased that living in the country protected his children from "the temptations to vice which youth is exposed to in the city,"[14] Dr. Colden was aware that the isolation and lack of cultural opportunities in a young colony were very restricting for a young woman with a serious interest in botany. He wrote to Collinson,

As [Jane] cannot have the opportunity of seeing plants in a Botanical Garden I think the next best is to see the best cuts or pictures of them for which purpose I would buy for her Tourneforts Institutes and Morison's Historia plantarum, or if you know any better books for this purpose as you are a better judge than I am I will be obliged to you in making the choice.[15]

Collinson was able to acquire "Tournefort's Herbal . . . in excellent preservation." He also provided two volumes of Edinburgh Essays and "2 or 3 of Ehrett's Plants for your ingenious Daughter." More prints were promised but they had to be sent "by another ship" as they were "liable to be taken"—a reference to the piracy prevalent at the time.[16]

In addition to providing her with a good library and sharing his correspondence with her, Colden was able to offer Jane the company of other botanists. One of many visitors to Coldengham was Peter Kalm, a student of Linnaeus who had been sent by the Royal Academy of Sweden to study the natural history of the northern parts of North America. A notable gathering in 1754 included Alexander Garden of Charleston, South Carolina, then a young man of twenty-four, and William Bartram, fourteen. Garden, an active collector of his local flora, later corresponded with Jane, exchanged seeds and plants with her, and instructed her in the preservation of butterflies. The young Bartram was already recognized as a skilled illustrator of plants, birds, and animals, though he had had no formal instruction in this art. In Peter Collinson's words, "He paints them in their natural colors so elegantly so masterly that the best judges here think they come nearest to Mr. Ehrett's, of any they have seen." Collinson had, in fact, written to Colden that "I wish your fair Duagt. was Near Wm. Bartram he would much assist her at first Setting out."[17] John Bartram, too, recorded visits to Coldengham where he and William "looked over some of the Doctor's daughter's botanical curious observations."[18]

Another young visitor who shared Jane's interests was Samuel Bard, who later became physician to George Washington. The son of John Bard, a friend of Colden, he was fourteen when he spent the summer of 1756 with the Colden family. His memory was filled "with pleasing recollections both of the society and studies to which it introduced him . . . In the family resided Miss Colden . . . With this lady, differing in years but united in tastes, Mr. Bard formed an intimate friendship; under her instruction he became skilful in botanizing . . . to the end of his life he never mentioned the name of his instructress without some admiration or attachment."[19]

Colden seems to have closely supervised his daughter's botanical activities and acted as her negotiator and in some cases her amanuensis. In 1755 he wrote to Gronovius, collaborator with Linnaeus in the cataloging of the *Flora of Virginia,* introducing his daughter who "has a curiousity for natural history" and offering her services if "she can be of any use to you. She will be extremely pleased in being employed by you either in sending Descriptions for any seed you shall desire or dried specimens of any particular plant. . . . She has time to apply herself to gratify your curiosity more than I ever had."[20] Alexander Garden apparently asked Colden's permission to use Jane's work. In a 1755 letter he wrote, "It gives me great pleasure that you give me leave to send Miss Colden's Description of the new plant to any of my correspondents."[21] And it was Colden who sent one of Jane's plant descriptions to John Fothergill. One wonders whether her father's supervision was a form of protection for a young woman operating in an unfamiliar sphere. Or perhaps Jane was too busy performing her domestic responsibilities and keeping her botanical records to conduct her affairs independently. We know she corresponded with John Bartram, with Alexander Garden, and with two Edinburgh doctors, Whyte and Alston, but her letters do not survive.[22]

Since her father's interests were not confined to botany, Jane became increasingly responsible for collecting and recording the plants discovered on their vast acres. There is no record that she ventured beyond Coldengham boundaries, and indeed the times did not favor the most intrepid collectors venturing into the wilderness. The French and Indian wars were spreading, making travel very threatening. Bartram complains in a letter to Alexander Garden, "I want much to come to Carolina to observe ye curiosities toward ye mountains but ye mischievous Indians is so treacherous that it is not safe trusting them. No traveling now."[23] Indeed, in December 1757 Colden was "forced out of my own house and farm" and removed his family to Flushing, Long Island. Villages in the vicinity of Coldengham were being burnt and destroyed and "cunning French spies are everywhere."[24]

On March 12, 1759, Jane married Dr. William Farquhar, a Scottish widower and a medical practitioner, "distinguished for his knowledge and abilities in New York City and vicinity."[25] There is no evidence to suggest that she continued botanizing during her brief marriage. Nor do we know the cause of her death in 1766 at the age of forty-two; her only child also died in that year.

In spite of the great impression she obviously made on her contemporaries during her brief botanical career, Jane received no formal recognition during her lifetime. One of her plant descriptions was published in full in *Essays and Observations,* Volume II (Edinburgh, 1770), four years after her death. Jane had received a specimen of the plant in question, *Hypericum virginicum* (marsh St. Johnswort) from Garden in 1754. She herself had already discovered it the previous summer, and as first discoverer, had named it *Gardenia,* intending to honor her friend. It must have been a great disappointment to discover that John Ellis, the English botanist, had given the name *Gardenia jasminoides* to the Cape jasmine and under the conventions of botanical nomenclature was entitled to its use.

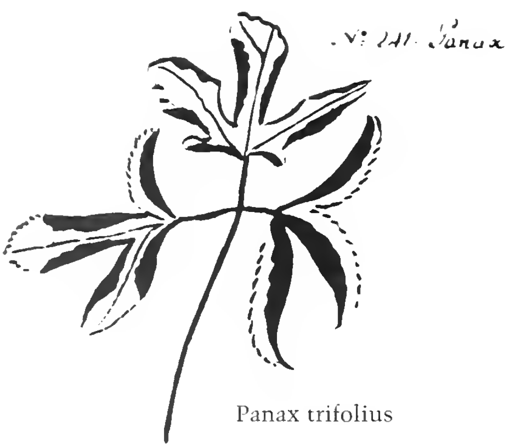
In 1758 John Ellis, a fellow of the Royal Society, informed Linnaeus that Dr. Colden had sent

Hypericum virginicum. *This and the following drawings by Jane Colden are from* Botanic Manuscript of Jane Colden, *edited by H. W. Rickett and E. Hall (New York: Chanticleer Press, 1963).*

to Dr. Fothergill a new plant described by Jane Colden and called by her *Fibraurea,* a translation of its common name, goldthread. Ellis pointed out to Linnaeus that "this young lady merits your esteem and does honour to your System," and suggested that Linnaeus name for her the plant she had described: "Suppose you should call this Coldenella, or any other name that might distinguish her among your Genera," adding that Jane had described four hundred plants "in your method only."[26] Linnaeus did not recognize the genus as distinct, however, and placed the plant in the already known genus *Helleborus.* His decision was subsequently countermanded by Richard Anthony Salisbury, who gave it the name *Coptis.*

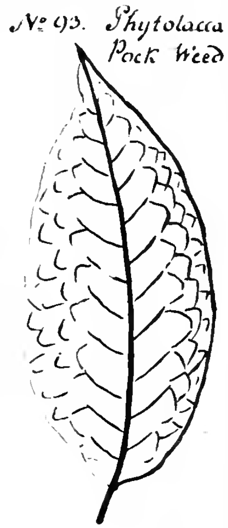
Jane's father was among those who admired her prowess, of course, and in spite of his understated manner one senses his pride when he writes to Gronovius in 1755, reporting of Jane,

> She has allready a pretty large volume in writing of the Description of plants . . . That you may have some conception of her performance and her manner of describing I propose to inclose some samples in her own writting some of which I think are new Genus's. One is of Panax folys ternis ternatis . . . I never had seen the fruit of it till she discover'd it . . . Two more I have not found described any where and in the others you will find some things particular which I think are not taken notice of by any author I have seen.[27]



Panax trifolius

The manuscript that comprises Jane's "pretty large volume" is now part of the Botany Library of the British Museum (Natural History) in Kensington, London. Its journey to England was a circuitous one. After the author's death it became the property of Captain Frederick von Wangenheim, a Prussian who served in a Hessian regiment during the American Revolution. We don't know how he acquired it, though his interest in forestry might have steered him in the direction of other areas of botany and its practitioners. An introductory letter by him, included with the manuscript, is marked New York, 1782, but gives no information on how he acquired it. Later it passed through the hands of Godfrey Baldinger, Professor of Botany at the University of Göttingen, who added a title page. Ultimately it was acquired by Sir Joseph Banks (1743–1820). It was at his death that the manuscript went to the British Museum.



Jane Colden's manuscript consists of 341 descriptions and 340 illustrations. Records are written in a legible, consistent hand with neatly underlined headings and subheadings. Latin and common names for the plants are given. Some of the vocabulary used is unfamiliar to modern readers: *cup* for calyx, *chives* for stamens, *tips* for stigmas, *fibers* for veins. Observations on each part, including root and seed, are noted in great detail. The month of flowering is recorded and the habitat described. Often the medicinal use of the plant is given, information gleaned through her familiarity with the remedies used by Indians and country people, and no doubt through consultation with her father. Suggestions are given to aid in propagation, as in her entry on pokeweed, *Phytolacca decandra* (now *P. americana*).

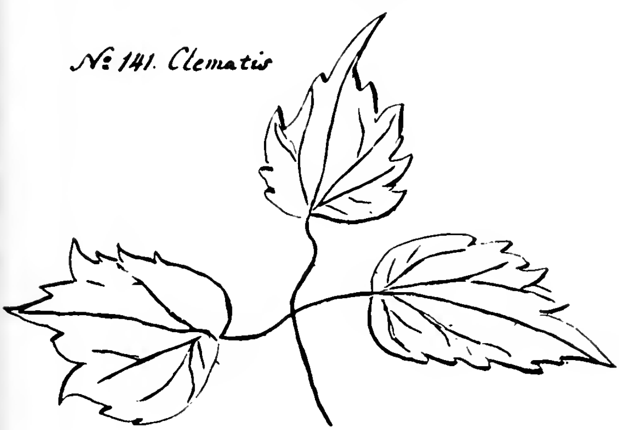
> . . . some curious persons in England have endeavoured to propagate this plant by the seed braigth from America, but could not produce any plant from the Seed. The propagation from this plant is maket in America in the Dung of birds. For this reason it may be necessary to give in Europe the berries to birds, and to plant the seeds with the Dung of the fowls through which they pass intire.[28]

In her description of snakeroot, *Polygala senega*, an additional section is headed "Observat," in which she takes Linnaeus to task, for he

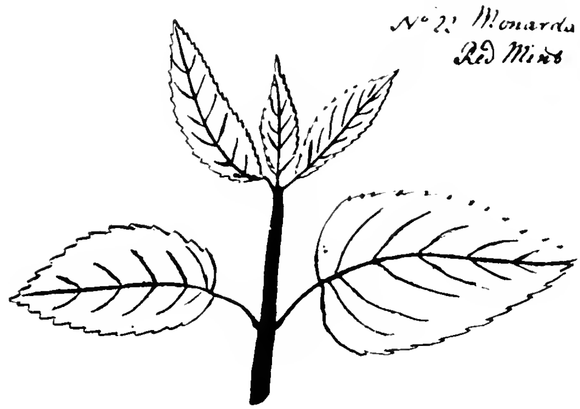
> describes this as being a Papilionatious Flower, and calls the two largest Leaves of the Cup Alae, but as they continue, till the Seed is ripe and the two flower Leaves, and its appendage fol together I must beg Leave to differ from him. Added to this, the seed Vessell differs from all that I have observed of the Papilionatious Kind.[29]

She continues in this stern vein in her description of *Clematis virginiana*, pointing out to Linnaeus that "there are some plants of Clematis that bear only male flowers, this I have observed with such care that there can be no doubt about it."[30]

The descriptions include observations of plants as they develop and indicate the long



hours she must have spent visiting and revisiting the plants under study. Of red mint, *Monarda didyma*, she writes, "There are but few of the flowers blown at the same time, those in the middle or top blow first, and those towards the edges gradually afterwards, as they do not continue long the first are fallen before the last come out." When technical terms elude her she resorts to her own vocabulary and describes one leaf rising through the "hollow neck" of the first leaf in the dogtooth violet, *Erythronium*



americanum. The female flowers of the common ragweed *(Ambrosia artemisifolia)*, she writes, grow at the "Arm Pits" of the leaves.[31]

These descriptions portray plant characteristics that are familiar to most modern gardeners, and much of their appeal is evoked by the charm of the language and an awareness of the period in which they were written. Jane Colden was documenting for her countrymen, and for eager Europeans, an entirely new flora, and it is with this in mind that we can fully understand her delight in botany and appreciate her contribution.

There seems to have been agreement concerning the high quality of Jane's descriptions, and the manuscript confirms that judgment. In the case of her illustrations, however, a disparity exists between the surviving comments about her work and the illustrations themselves. Walter Rutherfurd, a contemporary admirer though not a botanist, wrote to a friend, "[Jane] draws and colors [her illustrations] with great beauty."[32] However, the manuscript illustrations are very simple sketches, and while venation, shapes, and arrangement of leaves are clearly portrayed, there is little evidence of artistic merit. Certainly those of "great beauty" were not used in her manuscript and, like her letters, are not available to us.

Unfortunately, Jane's manuscript was out of the reach of succeeding generations who might have been inspired by her enterprise; and more than two hundred years after her death the major part of her work remains unpublished.[33] Nevertheless, by its compilation, though she might not have shattered the contemporary view that natural history was only "an amusement for ladies," she has provided us with an intimate glimpse of the initiation of a woman into colonial botany.

Mary Harrison is a volunteer at the Arnold Arboretum.

Endnotes

1 James Britten, "Jane Colden and the Flora of New York," *Journal of Botany, British and Foreign* (1895) 33: 15.

2 For the history of women in science, two recent works are *Women in Science: Antiquity Through the Nineteenth Century: A Biological Dictionary* by M. B. Ogilvie (Cambridge: The MIT Press, 1986); and *Hypatia's Heritage: A History of Women in Science from Antiquity Through the Nineteenth Century* by M. Alic (Boston: Beacon Press, 1986).

3 E. Berkeley and D. S. Berkeley, eds., *The Correspondence of John Bartram, 1734–1777* (Gainesville: University of Florida Press, 1992), 393.

4 Ibid., 414.

5 A. M. Vail, "Jane Colden, An Early New York Botanist," *Torreya* (1907) 7(2): 30.

6 *Letters and Papers of Cadwallader Colden*, 9 vols. (New York: New York Historical Society, 1918–1937) 2: 263.

7 Ibid., 3: 88.

8 Ibid., 4: 260.

9 Vail, "Jane Colden," 22.

10 E. Berkeley and D. S. Berkeley, *John Clayton: Pioneer of American Botany* (Chapel Hill: University of North Carolina Press, 1963), 84.

11 *Papers of C. Colden* 5: 30.

12 A. Fraser, *The Weaker Vessel* (New York: Alfred A. Knopf, 1984), 465, 85.

13 *Papers of C. Colden* 5: 203; 2: 282.

14 Ibid., 2: 262.

15 Ibid., 5: 37.

16 Ibid., 5: 37, 139, 149, 190.

17 Ibid, 5: 190.

18 *Correspondence of J. Bartram*, 360.

19 H. W. Rickett and E. Hall, eds., *Botanic Manuscript of Jane Colden* (New York: Chanticleer Press, 1963), 19.

20 *Papers of C. Colden* 5: 30.

21 Ibid., 5: 10.

22 Ibid., 5: 263; Vail, "Jane Colden," 32.

23 *Correspondence of J. Bartram*, 404.

24 *Papers of C. Colden* 5: 212, 213.

25 Rickett and Hall, *Manuscript of J. Colden*, 18.

26 Britten, "Jane Colden," 14.

27 *Papers of C. Colden* 5: 30.

28 Rickett and Hall, *Manuscript of J. Colden*, 82.

29 Ibid., 51.

30 Britten, "Jane Colden," 15.

31 Rickett and Hall, *Manuscript of J. Colden*, 29, 143, 114.

32 Vail, "Jane Colden," 32.

33 In 1963 the Garden Club of Orange and Dutchess Counties, New York, commemorated their fiftieth anniversary by publishing fifty-seven of Jane Colden's descriptions with illustrations in a limited edition of fifteen hundred copies.

In 1989 the manuscript was bound in red leather by the Botany Library at the Natural History Museum, London, in a volume measuring approximately 12.5 x 8.75 X 2.25 inches. On the spine, printed below the Botany Department symbol, we read: "J.Colden, Flora Nov. Eboraensis."

Arnold's Promise Fulfilled

James L. Jones

One of the roles of the Arnold Arboretum is to make worthy plants available to the gardening public, whether through cuttings workshops, the annual plant sale, direct requests to the propagators, or simply casual seed collection. An avid gardener reports on how these plants fare once they've left the grounds.

On a warm December day some twenty-five years ago I was strolling through the Arboretum when suddenly I found myself pelted by seeds. I traced the source to the bare branches of a twiggy, twelve-foot shrub and took some of the seeds home with me. This incident was brought back to me recently when, browsing through my garden records, I was struck by the number of plants I've acquired from the Arnold Arboretum. I've taken advantage of its plant offerings for nearly thirty years, long enough to get to know a number of trees, shrubs, and herbaceous perennials quite thoroughly. The following notes relate my experience with several of them, focussing chiefly on the success stories, but also including one or two interesting failures.

My garden is to the west of Boston and enjoys a zone 5B climate, with -10 degrees Fahrenheit a very rare occurrence and the all-time low over these thirty years of -13 degrees. The soil is a reasonably good, well-drained acidic loam. The sharp western wind has been tamed to some extent by a row of spruces. Fertilization and other soil amendments have been on the low end of standard. Except where noted, no special conditions have been provided.

ARCHIVES OF THE ARNOLD ARBORETUM

The big, bold, and blocky Orixa japonica *on the grounds of the Arnold Arboretum.*

Orixa japonica

It was this species that set my review in motion. The plant that resulted from those importunate seeds has proven valuable as either a hedge plant or a distinguished specimen, big, bold, and blocky. Its attractive properties include shapeliness, even after years of absent-minded hacking; glossy foliage that produces a pleasant scent when rubbed; and a useful habit of slow but steady suckering, offering a good number of offsets ready for instant use. My single specimen doesn't pester me with seeds, however, since male and female flowers are borne on separate plants.

Albizia julibrissin 'Rosea'

Starting trees from seed is usually a long-term venture—for instance, two of my other acquisitions, *Cornus florida* and *Cornus kousa*, both grown from seeds collected at the Arboretum, took a little over twenty years to flower after a 1970 sowing. An outstanding exception to this rule is *Albizia julibrissin* 'Rosea': mine went from seedling to flowering size in a mere seven years (1967–1974), reaching thirty feet in height before poor siting (too close to the house) forced me to cut it down. The next batch of self-sown seedlings, more appropriately placed, was already well underway and is now pushing the thirty-foot mark as well.

This tree has many things going for it besides quick growth: a graceful, spreading form; fragrant, fuzzy, pink flowers late in the summer; ferny foliage that admits dappled sunlight when mature but appears so late in the season that several cycles of early bloomers can run their course beneath the tree's bare branches. Those quickly spreading branches can be a liability—for instance, if the tree is placed right next to the house—and the blossoms are messy if they drop onto low-growing plants. I now have my albizias in a separate grove, with *Clerodendrum trichotomum* and chocolate mint (*Mentha* sp.) romping at their feet. Year by year I trim off the lower branches to get more of the airy effect I have in mind. I have had no problems with hardiness ('Rosea' is considered the most cold tolerant), although a plant protected by the house grew more swiftly than did one in the open; nor has the wilt disease seen in southern states been a problem in the Northeast.

Poncirus trifoliata

This small tree, the hardy orange, produces a crop of perfect little oranges chock full of seeds. Plants from seeds I acquired at the Arboretum grew the first few inches very quickly; then they remained almost static for several years. Eventually—1970 to 1987 in one case, 1982 to 1993 in another—they reached a height of some eight feet and began to put forth fragrant, citrus-like blossoms in May, with the fruits ripening in October if the summer has been warm. This last year a particularly heavy crop of fruit raised a pressing question: What to do with all those fruits? They *are* edible, though pithy and seedy and even more sour than lemon, with a bitter aftertaste. I once tried them in a chiffon pie, and though it wasn't bad I felt no real need for another. Instead I use the juice (in moderation) in a fruit salad, where it provides an excellent zing.

ARCHIVES OF THE ARNOLD ARBORETUM

The wickedly sharp thorns of Poncirus trifoliata *as seen in April.*

Placement of *Poncirus* (which can reach twelve feet) may be a problem, since the branches are heavily armed with long, stout, wickedly sharp thorns, and pruning is a hazardous undertaking. However, it is visually one of the better small trees around, never more so than when bedecked with its improbable orange globes. Like *Orixa*, another member of the rue family (Rutaceae), its leaves are glossy and aromatic.

Aesculus parviflora

The seeds of the buckeyes, including *Aesculus parviflora*, are immensely appealing. Back in 1980 I planted one from a large, spreading, suckering plant twenty feet high and forty feet across. I had those dimensions in mind when I

RÁCZ & DEBRECZY

Aesculus parviflora *with its spires of flowers photographed in August.*

chose a spot for the resulting seedling, but since I was dealing in years compared to the Arboretum's decades, it soon became clear that a more prominent location could be risked. The plant was already three feet high with a root almost as long, but against the apparent odds it survived and flourished. Perhaps somewhat delayed by the setback of moving, it began flowering in May 1992 and is now a delightful twelve-foot tree, single-stemmed and showing no tendency to spread by suckers, though the occasional seedling will pop up. It deserves a prominent position, giving value in all seasons with spires of white flowers in summer, large pleated leaves that briefly turn a pleasant yellow in fall, and a spreading tree-like form that can be enhanced by removing lower limbs.

Acer palmatum

Fifteen years ago I gathered seeds from one of the smaller, redder cultivars of Japanese maple, motivated by the unquestionable charm of these trees as well as the high cost of plants. I have especially enjoyed the wide range of characteristics among the resulting specimens, from slow to vigorous and from red-leafed to green, with a one-hundred percent correlation between redness of leaf and slowness of growth. The tallest is now some twelve feet high, the shortest less than three feet. I early on placed the redder ones as accents in small garden areas (even then they were clearly slower growing) and positioned the taller, greener ones as individual specimens.

Magnolia virginiana 'Milton'

I purchased *Magnolia virginiana* 'Milton' at the Arboretum's fall plant sale in September 1991, too recently to do more than report on its good health and pass on the advice someone else gave me: keep the plant in its pot (in a greenhouse or plunged in a coldframe) for at least a year before planting it out. Following that advice I succeeded with this plant where I had failed several times in the past. It will in time be a fifteen-foot tree with fragrant, relatively small white flowers. The 'Milton' cultivar is evergreen; at this stage, however, my plant hangs onto only a single leaf over the winter, with spring bringing a new covering of leaves. The leaves are smaller in all dimensions than those of *M. grandiflora*, better suited to dealing with the snow loads that can be the death of the larger species, even for those cultivars that are otherwise quite hardy.

Clerodendrum trichotomum

At the extreme of its range, the hardy glorybower is somewhere between a shrub and an herbaceous perennial, dying to the ground over winter but still sprouting and blooming the next summer. In fact, it is one of the most precise indicators of local climate I know: a fifteen-foot mini-tree in coastal Rhode Island; from zero to eight feet here west of Boston, depending on the severity of the winter; and a surefire winter casualty only a little to the north and west. Where growable, it is a wonderful plant, bearing fragrant, pale pink flowers in late summer followed by eyecatching turquoise fruits surrounded by deep pink bracts. Have some care with the leaves, however; they stink when bruised.

I started my plants as cuttings in 1972. In general, I treat cuttings with a certain benign neglect, simply sticking a two-to-six-inch length in a sand and peat moss mix kept moist in a north-facing coldframe, without benefit of rooting hormone. Rooted cuttings are then kept in a coldframe or greenhouse, depending on species and degree of root development, until the following season. My *C. trichotomum* plants first bloomed in 1982 and grew to eight feet after several relatively mild winters. The harsh winter of 1993–1994 cut all but one plant to the ground,

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The fragrant late-summer flower clusters of Clerodendrum trichotomum.

but all survived to flower again. For nice late-summer effects I grow the glorybower with the albizias in one area and with *Heptacodium miconioides* in another.

Cotoneaster divaricatus

A cutting nurtured as another species eventually proved to be *Cotoneaster divaricatus,* a big, unkempt plant I would never have consciously invited into the garden. But by then I had moved it here and there, pruned it as necessary, and discovered that it made an excellent two-dimensional hedge, six feet high and little more than a branch thick, yet rigidly upright. The initial cutting was taken in 1980; within eight years suckers and self-sown seedlings had yielded enough material for a space-saving screen around a nursery area, spangled in late summer and fall with a generous helping of red berries.

Euonymus hamiltonianus ssp. *sieboldianus (E. yedoensis)*

This was another mistake, irremediable this time. It seemed to be just what I had in mind when I saw it in the Arboretum, a small tree of interesting shape that would provide light shade and a properly sized vertical accent for a garden I was developing. Seeds sown in 1977 came along nicely, the resulting seedlings becoming large enough to be put in place about seven years later. After another seven years they were unceremoniously ripped out as their multitude of faults became apparent: susceptibility to insect attack (especially tent caterpillars) and aggressive seeding and suckering, not to mention a contorted, lopsided shape.

Lonicera fragrantissima

This is a plant I requested from the Arboretum, having a need for something that bloomed early and sweetly. The cuttings I received rooted easily, but the plant turned out to be much too large and vigorous for the intended space, which was a sunhouse (a greenhouse heated by sun alone). I moved it to the front entrance of the house where, seven years later at a height of five feet, it began perfuming the April air with its heady fragrance. Its growth should be controlled by sharp pruning, since the basic form is awkward, somewhere between a shrub and a vine, with branches jutting out in all directions. It increases by suckers at a reasonable rate. It is almost evergreen, the foliage remaining in good condition through most of January. The thoughtful gardener will position it near a sidewalk as a kindness to passersby at a time of year when a bit of fragrance is sorely needed.

Mahonia japonica

I acquired *Mahonia japonica* as a cutting in 1980, and its long sprays of coarsely toothed evergreen leaves make it one of the most attractive plants in my garden. It is hardy where the western native, *M. aquifolium*, is not, and if it is protected from the winter wind, the cold will not scar its foliage. It grows quite rapidly to about six feet, with a narrower spread. In April of a very good year it bears fragrant yellow flowers, although they are usually destroyed by the cold. With just the least protection—as in a sunhouse—it may begin blooming in December and carry on right through the winter. However, the foliage is quite exceptional enough without flowers. Cuttings root with the greatest ease; I simply stick them in the ground in the spring on the north side of my house.

Paeonia suffruticosa

Tree peonies are very slow to grow from seed, requiring two years just to germinate, but the results can be spectacular. My original seed was sown in 1982; the resulting plant flowered in May 1989—a huge, sumptuous white flower held proudly erect, reminiscent of photos of *P. suffruticosa* 'Joseph Rock' but with a center that's yellow rather than purple. Tree peonies require care in placement because of their overwhelming (if brief) springtime presence and the dowdiness of their bare stems in winter. I addressed both concerns by draping one with *Rhododendron* 'Blue Peter', low growing enough that the peony flowers poke through, large-flowered enough to hold its own and, of course, flowering at the same time. When the embrace of the rhododendron became too smothering, simple pruning set things right again. High shade is another matter, the peonies being quite tolerant of it.

ARCHIVES OF THE ARNOLD ARBORETUM

The extravagant flower of Paeonia suffruticosa, *photographed at the Arnold Arboretum in mid-May.*

Telekia speciosa

Even herbaceous perennials require a year or two of care before being put into the open garden. Mine go into a nursery bed where they can be carefully watered and monitored. The soil there is somewhat improved by the addition of leafmold.

Though *Telekia* is indeed a herbaceous perennial, I found that it developed with almost tree-like slowness, not flowering until July 1990 though I acquired it in 1985. It was worth the wait, with golden yellow flowers four inches in diameter. Like the better known *Ligularia*, *Telekia* is a shade-requiring member of the composite family. It stands equally as tall, two-and-a-half to three feet, but has majestically large leaves that form a massive clump and flowers of a gentler shade of yellow. Like *Ligularia* it will droop under direct sun and yet needs good light to flourish. And flourish it will under the right conditions—one gardener reports that it becomes rampant when grown in high shade and with even moisture. It flowers at the same time as *Rhododendron maximum*, and the pair add a surprising flash of color to the shady summer garden. *Telekia* can readily be grown from seed, but as with many composites the seed must not be sown right away. I suggest storing it until fall in a place protected from sun and rain.

Indigofera pseudotinctoria

Indigofera is a good example of the plants sent by the Arboretum to its members—little known but with great garden potential. It is an eight-inch-high subshrub that bears a scattering of pink pea flowers from July to September. Mine arrived in 1986 and began flowering a year later. It makes an excellent groundcover in a sunny spot, shapely and not overly aggressive, having spread to only a square yard in seven years. I use it at the base of box (*Buxus sempervirens* 'Vardar Valley') for a well controlled, slightly formal effect. Offsets can be detached for transplantation.

Cassia marilandica

Our native senna is an excellent garden plant, shrublike in appearance, arching to four-and-a-half feet over the summer but dying to the ground each winter, with attractive pinnate foliage and pleasant pea flowers of a subdued yellow in July. It would fit in very well with clumping grasses in a mannered meadow garden. It sets plentiful seed, and I have had germination with sowing; I have seen no self-sowing although others have found it almost too prolific. I purchased my plant in 1988 and had my first flowers two years later. Senna can be divided before growth starts in spring, which gives a lot of leeway, since it is one of the latest plants to begin seasonal growth. For maximum drama I combine it with *Macleaya cordata*, the two of them giving massive cover where only bare ground had been brief months before.

Clematis recta

I had been unsuccessful in my attempts to raise nonvining clematis from seed, so I was entirely receptive when my *C. recta* cutting (a plant dividend) arrived in the mail. The resulting plant has not been disappointing, though not wildly exciting either. It shares the shrublike though herbaceous quality of the *Cassia marilandica*, but instead of having a dignified upright stance, it sprawls, making placement a good deal more difficult. However, its abundant white flowers in June are showy, and the foliage is distinctive and attractive. I grow one in a sunken area where a two-and-a-half foot high retaining wall forces it into a semblance of tidiness and another behind a sturdy *Buxus sempervirens* 'Vardar Valley'. It is three feet high and equally broad. It would probably do better in a larger garden where it could billow to its heart's content.

As my plant records make clear, serendipitous gardening of the sort I practice can succeed if the gardener is willing to experiment, to learn from failures, to continue working with plants until a satisfactory effect is achieved. Experience with my Arnold Arboretum acquisitions has demonstrated that many happy surprises are in store for the gardener who goes beyond the tried-and-true and gives garden space to some of the lesser known species and varieties.

Jim Jones is a gardener of wide-ranging interests with a special fascination for the obscure. At present he is president of the North American Rock Garden Society.

Fall 1995

arnoldia

The Magazine of the Arnold Arboretum

arnoldia

Volume 55 Number 3 1995

Arnoldia (ISBN 004-2633; USPS 866-100) is published quarterly by the Arnold Arboretum of Harvard University. Second-class postage paid at Boston, Massachusetts.

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 orders, remittances, change-of-address notices, and all other subscription-related communications to: Circulation Manager, *Arnoldia*, The Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130-3519. Telephone 617/524-1718

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

Karen Madsen, *Editor*

Arnoldia is set in Trump Mediaeval typeface.

Page

Front cover: The buttery yellow of the autumn leaves and flowers of *Hamamelis virginiana.* One of its great admirers was Henry David Thoreau. In his journal of October 9, 1851, he recorded that "The witch-hazel tree is in full blossom on this magical hillside, while its broad yellow leaves are falling. . . . It is an extremely interesting plant, October and November's child, and yet reminds me of the very earliest spring. . . . I lie on my back with joy under its bounds. While its leaves fall its blossoms spring."

Inside front cover: A stone wall surrounded by forest bears witness to abandoned farmland. Photograph by Peter Del Tredici.

Inside back cover: The cork-like bark of *Phellodendron amurense,* AA #143–A, photographed in 1988 by Rácz & Debreczy.

Back cover: The tree-of-heaven, *Ailanthus altissima,* demonstrates its propensity for root suckering at the interface of a concrete block wall and an asphalt surface in Brighton, Massachusetts. Photograph by Peter Del Tredici.

Reading the Landscape: Primary vs. Secondary Forests

P. L. Marks

In much of the eastern United States, the forests within a region vary enormously. Some forests are young thickets while others consist of old, majestic trees. There are oak forests and there are maple forests; some are wet, others dry. Distinguishing between primary and secondary forests can help to explain some of the variation.

"Secondary forests" are those growing on land that was once cleared for farming, and "primary forests" are on land that has never been cleared for agriculture. Both primary and secondary forests are common in the eastern United States, and their distribution is largely a function of land history. How land has been used, in turn, has been strongly influenced by intrinsic features such as soils and topography. In prime agricultural regions secondary forest is generally uncommon because little farmland has been abandoned. In mountainous regions secondary forest is also uncommon, in this case because very little land is suitable for farming. In other areas where agriculture was widely practiced and then substantially abandoned, secondary forests are common today. This essay focuses on why and how these two kinds of forest differ and, using the example of beech trees, discusses the process of succession that occurs when land is reverting from agricultural use to forest.

The term "primary" forest should not be confused with "old-growth" forest—forest free from significant human disturbance or influence. The few old-growth stands that exist today in the eastern United States are all primary forests, but the reverse is not true. The vast majority of primary forests are not old growth because they have been substantially disturbed by the activities of people, most commonly by logging and grazing. Despite having been disturbed in various ways, often repeatedly, primary forests have had continuity of forest habitat for thousands of years.

Looking for Clues

Trying to decipher the history of forests when walking in the woods is fun and informative. Sometimes it is easy. Younger secondary forests (say twenty to forty years since farming) are readily recognizable from their scrubby or thicket-like structure, the absence of large trees or stumps, and the presence of some trees with open, spreading growth forms resembling specimen trees in lawns. As secondary forests age, however, they gradually take on some of the appearance of primary forests. After sixty or ninety years or more, they can be more difficult to distinguish and closer scrutiny is required.

One useful clue is the degree of undulation in the ground surface. Conspicuous irregularities are normally present in the ground surface of primary forests, the result of centuries of tree-uprooting by wind. The mounds and pits, as these small-scale topographical features are called, tend to be on the order of one to two yards across. In contrast, the ground under secondary forests is relatively level because over the years agricultural plowing smoothed the surface of the ground.

Other features useful in distinguishing primary from secondary forests can be seen at the

P. L. MARKS

The initial stage of pit-and-mound formation. In this photo of red pine trees (Pinus resinosa) *uprooted by wind, the mounds are the root balls and the pits are the original locations of the root balls.*

PETER DEL TREDICI

When soil is displaced by an uprooted tree, a mound and a closely associated pit are formed. The pits and mounds in this photo, of Hemlock Hill in the Arnold Arboretum, were created nearly sixty years ago, in the hurricane of 1938.

P L MARKS

A well-defined edge (above the arrow) between an older primary forest to the right and a younger secondary forest to the left. Note the profusion of spreading branches on the left side of the edge.

P L MARKS

Secondary forest grows on both sides of this older hedgerow of trees, which runs from the left foreground of the picture to the center rear. Note the spreading branches growing out on both sides of the hedgerow.

edges of stands. One hundred (or more) years ago, when the sites that today support older secondary forests were still being farmed, the edges of farm fields were commonly either hedgerows or primary forest. Many of the trees that once grew on the edge of these fields retain evidence of their former edge environment. Specifically, trees on the edge of a primary forest adjacent to secondary forest will show a pronounced asymmetry in their branching, with more large, nearly horizontal, low-to-the-ground branches on the formerly sunny side. Older hedgerows with older secondary forest on both sides will likewise show evidence of a remnant branching pattern, but in this case large, spreading branches grow out on both sides of the trees. Sometimes, the large, spreading branches have died but their former existence can be deciphered from the large, bulging branch bases along the trunk.

Rocks can also tell a story. Rock piles or walls are common occurrences along the edges of secondary forest, generally indicating that the rocks were moved to the edge of the field to facilitate plowing. Sometimes it is unclear at first from which side of an edge the rocks came, but a bit of sleuthing usually reveals the answer. For example, two common situations are (1) an edge between primary and older secondary forest and (2) two older secondary forests separated by a hedgerow that was present when the forests were fields. Suppose that the edges in both situations contain rock piles. Which site did the rocks come from, and how can you be sure?

In the first situation, the secondary forest would have relatively smooth ground, the result of previous plowing, and thus the rocks must have been removed from that site; the adjacent primary site, in contrast, would show mounds and pits. Confirmation should come from the branching pattern of the edge trees: many more large, spreading branches should be growing out into what is now the secondary forest. In the second situation, mounds and pits would most likely be absent from both sites, suggesting that the rocks came from fields that were on both sides of the hedgerow. If the branches of the larger hedgerow trees are growing outward on both sides, this would confirm secondary forest on both sides of the hedgerow.

How Do They Differ In Species?

Secondary forests contain more sun-loving, open habitat plants than do primary forests. Examples are *Cornus racemosa* (gray dogwood), *Lonicera* spp. (honeysuckle), *Rhamnus cathartica* (buckthorn), and *Solidago rugosa* (goldenrod). These open habitat species typically invade early in old field succession; they are present in secondary forests because they can persist, at least for a while, in a shady forest understory. A number of the open habitat shrub and herbaceous plants are exotic species, and thus another difference between primary and secondary forests is that the latter have more exotic (nonnative) plant species.

There are other noteworthy differences in species, if we consider just the common plants of primary forests. Secondary forests contain a subset of the forest plants and animals found in primary forests; a few examples of plants that are common in each kind of forest in the northeastern United States are listed in Table 1. Even within a group of closely related species, we sometimes find that one species is common only in primary forests, while another is common in both secondary and primary forests, as shown in Table 2. For example, in central New York (and elsewhere) *Acer rubrum* (red maple) is common both in primary and secondary forests whereas *A. saccharum* (sugar maple) is abundant in primary forests but is seldom abundant in secondary forests. Where forest plants are present in secondary as well as primary forests, we can assume that they colonized the secondary forest sites from the primary forests and hedgerows that surround most fields. Why have some forest plants been so successful in colonizing secondary forests from source populations in primary forests and hedgerows?

To answer this question, consider the different land-use histories of primary and secondary forests. Clearing of the original forests, combined with the sustained use of a site for agriculture for the better part of a century, would eliminate the forest plants and animals present at the time of clearing. Thus, when a farm field is abandoned, primary forest plants and animals can colonize it only if they can get there from nearby forests and hedgerows. The distances over which forest species must travel in order to

Table 1. A list of selected plants that are characteristic of primary or secondary forests in the northeastern United States

Primary	Secondary
Fagus grandifolia (American beech)	*Acer rubrum* (red maple)
Acer saccharum (sugar maple)	*Fraxinus americana* (white ash)
Tilia americana (basswood)	*Pinus strobus* (white pine)
Tsuga canadensis (hemlock)	*Cornus racemosa* (gray dogwood)
Polystichum acrostichoides (Christmas fern)	*Viburnum dentatum* (arrowwood viburnum)
Trillium grandiflorum	*Botrychium virginianum* (grape fern)
Dentaria diphyllum (toothwort)	*Lycopodium flabelliforme* (ground pine)
Caulophyllum thalictroides (blue cohosh)	

Table 2. Examples of plant differences between primary and secondary forests in the northeastern United States

	Primary	Secondary
Trees	*Acer rubrum* (red maple)	*Acer rubrum*
	Acer saccharum (sugar maple)	
Shrubs	*Viburnum dentatum* (arrowwood viburnum)	*Viburnum dentatum*
	Viburnum acerifolium (mapleleaf viburnum)	
Herbs	*Dryopteris austriaca* var. *spinulosa* (spinulose wood fern)	*Dryopteris austriaca* var. *spinulosa*
	Polystichum acrostichoides (Christmas fern)	

colonize abandoned farmlands are often not great—perhaps fifty to several hundred yards—but they are nonetheless significant because plant species differ so much in seed dispersal ability. Some forest species are much better than others at dispersing seeds to abandoned fields. Thus one reason secondary forests differ in species from primary forests is that they contain species with better dispersal capabilities. I suspect this explains why secondary forests contain herbaceous plants with tiny spores that drift long distances on the wind, such as spinulose wood fern.

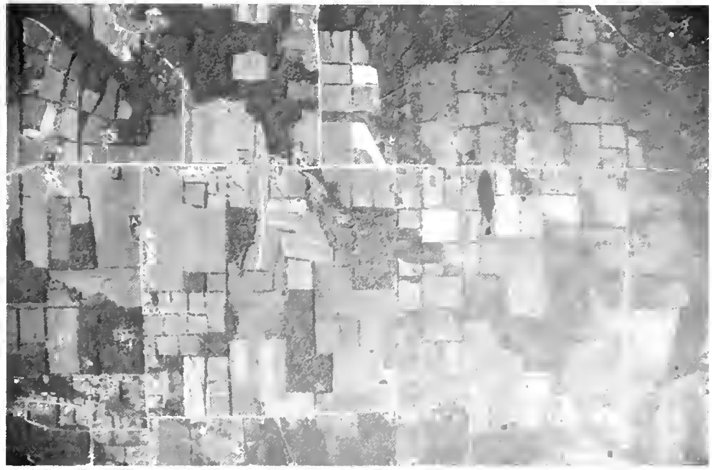
But not all forest species capable of dispersing to abandoned farmlands are well represented in secondary forests. Some shade-tolerant forest species are uncommon in secondary forests, perhaps because they cannot tolerate the sunny, open conditions of rundown, abandoned fields. And finally, plants may be uncommon in secondary forests because of seed size. Small seeds give rise to small seedlings, which compete poorly with the dense meadow vegetation of abandoned farm fields. The scarcity in secondary forests of the primary forest species listed in Table 1 can presumably be explained by one or more of the three factors just described.

The Case of Beech Tree Colonization

Beech *(Fagus grandifolia)* behaves quite differently in secondary forests than it does in primary forests, and the pattern of its invasion

Investigating Two Centuries of Change

In the eastern United States, the mixture of forest and open nonforest land has changed dramatically over the last two hundred to three hundred years. A recent study estimated how much forest was present in rural Tompkins County, central New York, in 1790, 1900, 1938, and 1980. Our estimates were drawn from a variety of sources. We used contemporary information for 1790, 1938, and 1980. Records from the original land surveyors indicated that in 1790, 99.7% of the county was covered in forest. By carefully examining aerial photographs taken in 1938 and 1980 we determined the amount of forest present at those times: 28.5% in 1938; 50.7% in 1980. Old agricultural census records revealed that the maximum acreage in farmlands occurred between 1890 and 1900. This was a key date because the amount of forest in Tompkins County would have been at its lowest when the amount of agricultural land was at its maximum. Before 1890, forest was still being converted to agricultural land; after 1900, agricultural lands were being abandoned. Fortunately, the short time interval between 1900 and 1938, when the earliest aerial photographs were taken, meant that we could distinguish on the 1938 photos young forest growing on abandoned agricultural fields from older forest that had been present in 1900. By this means we estimated that only 19.4% of the county was forested in 1900. Thus, in only two hundred years, the landscape of Tompkins County changed from being all forested, to mostly agricultural, to an equal mixture of agricultural and forest lands today.



In studying how much of Tompkins County's forest was once cleared for agriculture, we made extensive use of aerial photographs. This one shows primary forest as well as abandoned agricultural fields in the process of becoming secondary forest.

The major kinds of vegetation present in 1790 are here today: oak forests, swamp forests, and various forests with sugar maple, basswood, beech, hemlock, and other trees. Cattail marshes, other marshes, beaver meadows, and alder thickets are some other landscape components present today and in 1790. There are also present today landscape components that were rare or absent in 1790. Examples are active and abandoned cow pastures and abandoned crop fields (old field succession). Thus, we see that landscape components have changed both quantitatively and qualitatively over the last two hundred years. Many of the original components are still with us, but we have less of each one. At the same time we have some distinctly new components.

How general are the results from Tompkins County? The results probably apply to many parts of the eastern United States, provided that allowance is made for differences in both the dates and the amount of forest cleared. For example, the chronology would be shifted earlier in southern New England.

This information is based on two collaborative studies, which are cited at the end of the article: B. E. Smith, P. L. Marks, and S. Gardescu, 1993; and P. L. Marks and S. Gardescu, 1992.

illustrates one of the general principles underlying plant succession. I first noticed that beech was showing an interesting pattern about ten years ago when I was studying forests around Ithaca, New York, to determine whether each stand was primary or secondary. After a while I realized that if I saw a stand with large beech trees—trunks greater than about fifteen inches in diameter—invariably the forest had not been cleared for agriculture. (Incidentally, the reverse was not true. Not all forests that lacked large beech trees had been farmed. Some were primary forests, but the soil was too wet or too dry for beech.)

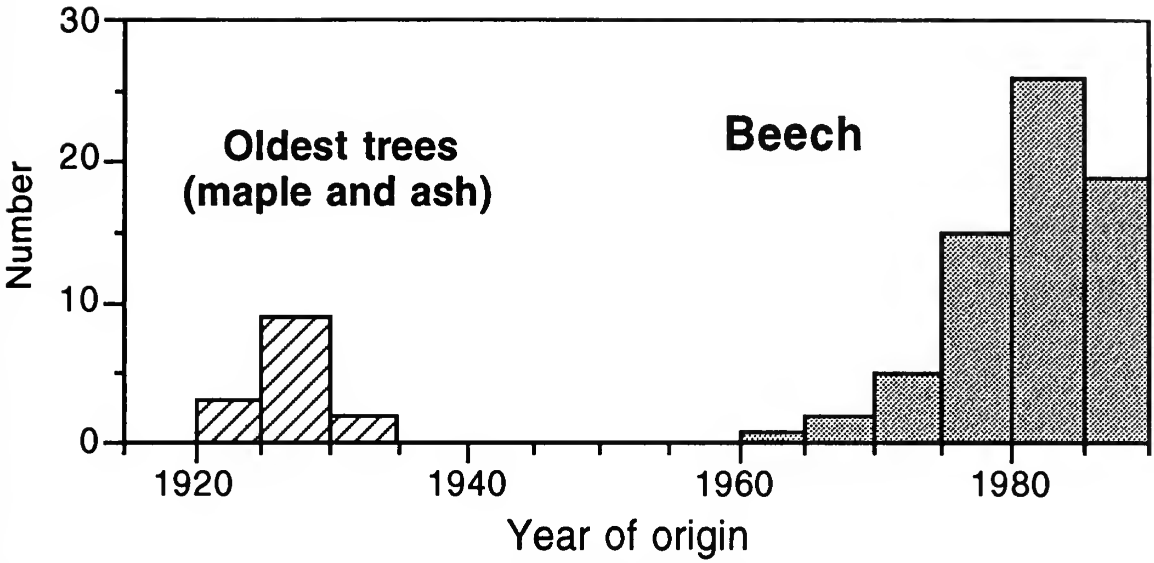
Subsequently I began to notice the widespread occurrence of beech seedlings and saplings in secondary forests, the same forests that lacked large beech trees. Apparently, secondary forests were being invaded by beech, since there were small, vigorously growing beech in the understory but no large beech trees in the overstory. On my own land, there is a well-defined edge between secondary and primary forest. The primary forest contains lots of beech, ranging from large trees to small stems. The adjacent secondary forest grew up in a field where agriculture had been abandoned around 1920, an estimate derived from examining old aerial photographs and deed records. Maples, pines, and ashes, but not beech, are among the dominant, tall tree species in the secondary forest today. These trees are sixty or seventy years old, having invaded the field within a decade or two after the last time crops were grown. In the understory, seedlings and saplings of beech are common. Many of the large beech in the adjacent primary forest are close to the edge of the secondary stand, and there is every reason to think that these trees have produced large numbers of beech seeds for a hundred years or more. Nevertheless, beech has been able to invade the former agricultural site only in the last couple of decades. Why? Why has it apparently taken so long for beech seedlings to get started after the field was abandoned?

Students in the plant ecology course at Cornell University have studied beech invasion in secondary forests, and it is instructive to examine some of their results. In several older secondary forests—on land that was last farmed

Beech leaves remain on saplings and lower tree branches throughout winter, making it easy to spot beech in a forest when other deciduous trees are leafless.

about seventy years ago—the density of beech seedlings and saplings is about one stem per hundred square feet, dense enough to produce a beech forest in the future if most of these stems survive. The ages of the beech invaders are revealing, as can be seen in the graph on the next page. In the secondary stand on my own land, beech began to invade about forty years after abandonment—thirty to forty years after the other tree species got started. The beech invasion continues, and most of the beech seedlings and saplings became established in the last twenty years. However, we can't tell whether the low density of beech dating from the 1960s and early 1970s is due to mortality or to a gradual beginning of the invasion.

More specifically, how might we explain the failure of beech seedling establishment in the first forty years following agricultural abandonment and the clearly successful establishment over the ensuing twenty-five years? As with vir-



Abundances of different ages of beech seedlings and saplings (in gray), and of the oldest trees of other species (diagonal lines), showing the years in which they originated, in a secondary forest that developed on farmland abandoned about 1920. (Younger maple and ash are not shown.)

tually all such questions in the science of ecology, there is more than one plausible answer. First, although as I have suggested above beech seeds have no doubt been available throughout the past seventy-five years, perhaps seeds began dispersing into the site only after it had become a forest, rather than in its earlier stages of meadow or thicket. In this part of the world, around forty years are necessary for an abandoned agricultural field to develop into young forest through natural succession. A second possible answer is that beech seeds have been dispersing into the site for the entire seventy-five years but were unable to become established as seedlings until something changed about thirty years ago.

How do beech seeds disperse from one place to another? What sorts of changes might have occurred thirty years ago that could have favored the establishment of beech seedlings? The answer to the first question hinges on the behavior of the animals that disperse beech seeds. Beechnuts are contained in prickly burs, which hold two shiny brown triangular nuts, each the size of a small acorn or a large lima bean. The burs open in early fall, at which time the seeds are eaten by birds such as blue jays, grouse, and turkeys, and by mammals ranging from chipmunks and squirrels to fox and deer. Of these animals, blue jays, squirrels, and chipmunks do carry beechnuts away from the trees, burying them to eat later. Blue jays, for example, can carry up to fourteen nuts at a time and may fly several miles from the beech trees back to their feeding territories, where they bury the nuts individually beneath the leaf litter covering the soil. When food is abundant in the fall of the year, these animals store beechnuts, acorns, and other tree seeds in their feeding territories, returning over the winter to eat the nuts. Even though the number of nuts left behind may be a small fraction of the number stored in the feeding territory, these seeds have been "planted" by the animal and thus stand a good chance of germinating and becoming established as seedlings.

The explanation for the delay in beech invasion could involve the behavior of the dispersal agent. It may be that blue jays, squirrels, and chipmunks bury beechnuts mainly in forests. In other words, forty years or so are required to produce the kind of habitat where these animals bury nuts. There is an alternative explanation, however. Blue jays, and for shorter distances, chipmunks and squirrels, could be burying beechnuts during most or all of the forty years from farm abandonment to young forest, but the uneaten nuts may seldom become vigorous seedlings during this early period because beech seedlings require shade to keep their roots from drying out. Several decades would therefore be needed to produce the forest conditions that permit beech seedlings to thrive.

Whatever the reasons for the delay in beech invasion into post agricultural forest, the phenomenon illustrates one of the earliest theories about how succession works—namely, that the first invading plants alter the characteristics of a site in ways that favor invasion by other plants. These first invaders might cast shade that favors plants that do better away from direct sunlight. Or they might be legumes that fix nitrogen and thus favor plants that do better in richer soil.

But this process of "facilitation"—of early invaders facilitating later invaders—is not the only determinant of succession. When—or even whether—a species invades involves an element of chance. For example, a tree species might invade an abandoned field if it happens to be common around the edges of the field, or if it has a good seed year during a critical decade of succession, or if the weather is favorable during a critical stage in the life cycle (for example, during seed germination). In the case of delayed invasion of beech in secondary forests, both of the likely explanations appear to involve facilitation: Before beech trees can become established, an abandoned farm field apparently must become young forest either to encourage burial of beechnuts by animals, or to provide the environmental conditions that allow beech seedling establishment, or both.

The history of the landscape cannot be read with certainty, but that hasn't stopped historically minded ecologists from thinking about it. There is much to learn about today's landscapes by developing a picture of how they were in the past. Because landscapes are constantly changing, especially under the influence of humans, there are striking contrasts between contemporary and historical landscapes. Such contrasts help our present understanding by revealing how recently certain kinds of habitats, which we may take for granted, have become part of the landscape. At the same time, other elements of the landscape are relatively old; they are present today and were also present hundreds of years ago. Deciphering the landscape's history enriches our understanding by allowing us to see it as dynamic, as something that has changed from an earlier condition, and that is still changing today.

Acknowledgments

This article is an adaptation from the author's series, "Reading the Landscape," published in *Cornell Plantations*, Winter 1993, Summer 1994, and Summer 1995. The author is indebted to S. Gardescu for help in preparing the paper and for commenting on a draft manuscript, and to Cornell University students Celia Harvey, David Jadidian, Chris Jonas, and Marcia Kirinus for the use of their results.

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P. L. Marks is a professor and the chair of Cornell University's Section of Ecology and Systematics.

Shoots From Roots: A Horticultural Review

Peter Del Tredici

Many successful plant propagation techniques were inspired by observations of plants in nature. What plant propagator has not seen suckers arising at some distance from the main stem of a tree or shrub and concluded that this is a plant that could be propagated from root cuttings.

Such observations can be traced back at least to the days of the ancient Greek philosopher Theophrastus (371–287 BC). As he was in most botanical matters, Theophrastus was the first to describe the process of root-sucker formation and to attempt to elucidate the causes:

> Now most trees produce these suckers next to the trunk, the roots being here most shallow; and the olive produces them from the base of the trunk as well. But the pear, pomegranate and all trees that produce suckers not only close to the trunk but at a distance from it, have long roots, and send up the shoot wherever the long root comes near the surface, for it is here that the conflux is formed with the resulting concoction as it is warmed. This is why there is nothing fixed about the place of the sucker, for there is nothing fixed about the approach of the root to the surface and the site of the conflux (Book 1: 3.5).

The earliest description that I could find of actual propagation of trees from roots is by John Evelyn, who in 1706 (and perhaps as early as 1664) noted that species of *Ulmus*, *Prunus*, and *Populus* produced root suckers that could be

A stand of root sprouts from a single forty-year-old sweetgum tree, Liquidambar styraciflua. *The sprouts range in age from one to fifteen years, and some are over five inches in diameter at breast height. The grids are one meter on each side. Photograph by P. P. Kormanik, U.S. Forest Service, Athens, Georgia, from Kormanik and Brown, 1967.*

dug up and planted. Evelyn went so far as to include detailed instructions for how to propagate trees from roots: "To produce succers, lay the roots bare and slit some of them here and there discretely, and then cover them."

The most famous case of plant propagation from root cuttings is, of course, that of the breadfruit, *Artocarpus altilis*. This was the plant that the notorious Captain Bligh of the HMS *Bounty* was charged with transporting from the South Pacific to the West Indies. It was during the breadfruit's five-month propagation period in Tahiti that the Bounty's crew developed the taste for liberty that ultimately led to their infamous mutiny in 1789.

The Ecology of Root Suckering

In addition to its importance to propagation, root suckering in trees and shrubs also has significant ecological implications, as documented in the new edition of *Silvics of North America*, edited by Russell Burns and Barbara Honkala and published in 1990. Of the 108 nontropical, native trees listed in *Silvics*, 22 of them (21%) are reported to reproduce from root sprouts. Whether this ratio of root-sprouting to nonroot-sprouting species would hold true for a wider sample of trees remains to be determined.

PETER DEL TREDICI

An old specimen of the American beech growing at the Arnold Arboretum. It has produced abundant root suckers.

The most well-known root-suckering tree is the quaking aspen, *Populus tremuloides*. This species plays a particularly important ecological role in the Rocky Mountain region, where "clones" of a single tree have been found covering more than 107 acres and totalling an estimated 47,000 distinct stems. In the East, *Sassafras albidum* spreads primarily from root suckers, as does the ubiquitous black locust, *Robinia pseudoacacia*, and the understory-dwelling pawpaw, *Asimina triloba*. Another root-suckering species that has been extensively studied is the American beech, *Fagus grandifolia*, which grows over much of eastern North America. In the northern and eastern parts of its range, the species grows at moderate elevations on cool, rocky slopes and root suckers profusely following logging or disease-induced injury. In the southern and western parts of its range, however, beech is a bottomland species and shows little or no tendency to root sucker. Because this trait is difficult to put onto a herbarium sheet, however, few taxonomists have recognized it as a legitimate character for distinguishing the southern and northern ecotypes as distinct subspecies.

Propagation From Root Cuttings

Since the mid-1800's, an extensive literature on the propagation of plants from root cuttings has appeared. Especially noteworthy is an article by the German author, Wobst (1868), that provides an extensive list of species—including many not referred to by other authors—that can be propagated from root cuttings. Other early articles on root-cutting propagation are by an American (Saul 1847), a German (Katzer 1868), and an Englishman (Lindsay 1877, 1882). Interestingly, references to root-cutting propagation are more numerous in the older literature than in the modern. This is probably because modern advances in softwood stem-cutting technology—

The Arnold Arboretum

F A L L • N E W S • 1 9 9 5

Cathaya Comes to the Arnold Arboretum

Stephen A. Spongberg, Horticultural Taxonomist

S A Spongberg

Likuo Fu (left) and Nan Li (center) from the Institute of Botany, Academia Sinica, Beijing, with Peter Del Tredici and Kim Tripp of the Arnold Arboretum and conifer specialist John Silba. It was wonderfully serendipitous that Professor Fu was visiting the Arboretum when the *Cathaya* seeds arrived in Jamaica Plain from Edinburgh.

The Arnold Arboretum of Harvard University has recently received fifty seeds of *Cathaya argyrophylla* Chun & Kuang, a rare and endangered conifer endemic to China, which has not been grown or cultivated previously outside of the People's Republic. Like the dawn redwood, *Metasequoia glyptostroboides*, which was known as a fossil before living trees were discovered in China in the early 1940s and subsequently introduced into cultivation by the Arnold Arboretum in 1948, *Cathaya* is known as a fossil from Tertiary sediments in Eurasia and was only discovered as a living plant by Chinese botanists in the early 1950s.

Small native populations of this unusual cone-bearing tree are now known to exist in six counties in Guangxi, Hunan, Sichuan, and Guizhou provinces in China, yet the tree ranks as a rare and endangered species and is listed in the *China Plant Red Data Book*.

Peter Del Tredici

Cathaya is intriguing from an evolutionary perspective inasmuch as its embryo and pollen are similar to those of the true pines (species of *Pinus*), while its wood resembles that of the Douglas firs (species of *Pseudotsuga*), and its overall habit and seed-producing cones are much like those of the spruces (species of *Picea*).

The consignment of seeds received at the Arnold Arboretum was forwarded from the offices of the Conifer Conservation Programme at the Royal Botanic Garden, Edinburgh, where a quantity of seed collected from one of the native populations was provided by Professor Likuo Fu, Director of the Herbarium and Laboratory of Taxonomy and Plant Geography, Institute of Botany, Academia Sinica, in Beijing. Professor Fu had requested that the seeds be shared with other botanical institutions in Europe and North America.

While these seeds provide the first opportunity to attempt germination of *Cathaya* at the Arboretum, the propagation staff is optimistic that plants will result. Diverse treatments will be applied to induce germination, but it may be six to eight months before it is known if plants will result. If plants are successfully grown, asexual propagation will be under-taken to increase their numbers. The young trees will ultimately be included in the living collections of the Arboretum to evaluate cold hardiness and performance under New England climatic conditions. Material of *Cathaya* will also be available for further botanical and horticultural investigations by scientists utilizing the Arboretum's collections. It is hoped that the success rate with the Cathaya seeds will be similar to the high germination levels obtained with the *Metasequoia* seeds received in 1948 and that this unique conifer will be preserved in cultivation as well as in nature in China.

Plant Sale Ends Drought

This summer's forty-day drought came to a spectacular end on the day of the 1995 Fall Plant Sale. Despite the downpour, the event was a great success. Over six hundred members and friends participated in the sale, Rare Plant Auction, and Plant Society Row.

John Furlong

A Visit From Mike Dirr

Dorothy Littel Greco

This fall Mike Dirr (center), author of *Manual of Woody Landscape Plants* and former Arboretum Fellow, gave a lecture and led two walks through the living collections for over two hundred students. Here, Gary Koller (left) enters into an animated exchange on the virtues of various cultivars.

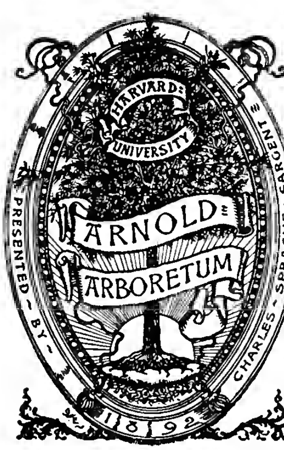
How to Create a Logo

Bob Cook, Director

There comes a time in the life of every institution when it confronts the logo issue, that desire to project a modern, with-it image. Such times typically follow the arrival of a new administration. The usual procedure is to put a blank check in the hands of highly paid consultants who will bring a progressive understanding of marketing to the design of an emblem that—once created—will be ridiculed by your entire staff and vilified by at least half your constituency.

Instead, about a year ago we decided to tackle this issue ourselves with the help of *Arnoldia* designer, Andy Winther. Our first decision was recognition of reality: If one's institution is an arboretum, one can hardly avoid a tree in the logo. Next we asked whether there was something lying around that we already liked. Our attention immediately turned to an old, much-loved bookplate used by our first director, Charles Sprague Sargent. Could it be modified to enhance its symbolic content and simplify its design while retaining the quality of antiquity appropriate for the oldest public arboretum in the country?

With a reduction in ornamentation, we decided to keep the Victorian frame and banners but to seek a different, more emblematic tree. We quickly chose *Metasequoia glyptostroboides*, more popularly known as the dawn redwood, to replace the nondescript pine in the bookplate.



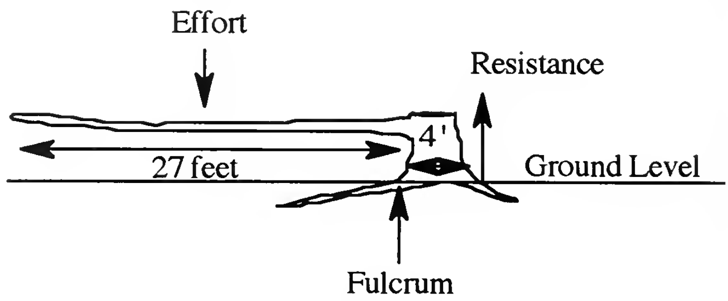
This species was once abundant in the forests of North America millions of year ago, known to Western science only as an extinct species preserved in fossilized stone. During World War II the dawn redwood was discovered growing in a remote river valley of central China, and an Arboretum-sponsored expedition was sent late in 1947 to retrieve seed. Following the arrival of the first shipment in early 1948, the Arboretum distributed the newly discovered species to over six hundred botanical institutions around the world. The first dawn redwood repatriated to North America after an absence of several million years is growing in the Arnold Arboretum today.

By choosing this species for our new logo, we hope to symbolize our traditional mission to support research and education through the collection of trees from distant lands. At the same time, by setting the dawn redwood against a rising sun, we hope to signal a new dawn for the future programs of the institution.

Cork Tree's Last Hurrah Provides a Science Lesson on Leverage

Christopher Randall

Can there be a silver lining to the passing of an old friend? As someone who has spent more than ten years teaching in the science classroom, my first reaction after an initial sadness was to consider the toppling of the cork tree in terms of a science lesson. Soon after hearing the news, I was bursting with questions: How many girls were on the branch? How much does a sixth grader weigh? How long was the branch they were sitting on? This tragedy was shaping up into a great lesson on levers and leverage.



Cork tree and branch depicted as a lever.

The cork tree was a classic example of a lever. The tree was similar to a seesaw, albeit a very unequally proportioned one. This seesaw had one incredibly long side, the branch, and a phenomenally short side, roughly the diameter of the tree. The roots at the base of the trunk directly under the branch were the fulcrum at the "center" of this lopsided seesaw.

Intuitively, we know that on a seesaw, the farther out we sit or the more weight we add to our side, the easier it is to lift our partner. Furthermore, if we place a great deal of weight at the extreme position of our seesaw, we can lift even an enormous partner. To determine the effect of a particular force (the weight of the girls in this case) at a certain position, one can use the following equation, known in physical-science parlance as the Law of the Lever:

Effort Force	×	Effort Distance	=	Resistance Force	×	Resistance Distance
(Girl's Weight)		*(Girl's Position)*		*(Force on Roots)*		*(Root's Distance from Fulcrum)*

That fateful day, 22 sixth-grade girls seated themselves along the branch, as had been the custom each year at the end of their class visit to the Arboretum. Let's assume that the average sixth grader weighs 100 pounds and that the branch is 27 feet long—quite close to the actual situation. To calculate the cumulative force the group developed, the force each girl contributed must be calculated. Since each girl sat at a different distance from the fulcrum, the force each girl contributed must be calculated individually, and then each of these forces must be added together to find the total force on the effort side of the above equation. Assuming the girls were equally spaced along the branch, this force amounts to 31,050 foot-pounds!

Let's now assume that the tree was four feet in diameter, again not far off the actual dimension. According to the Law of the Lever, the relationship between the two sides of the fulcrum can be stated as:

31,050 foot-pounds = 4 feet × ? Resistance Force

Dividing this through yields:

Resistance Force = 15,600 pounds (or 7.8 tons)

By using leverage, 2,200 pounds worth of sixth graders translated themselves into 7,763 pounds of force. Add to this the considerable weight of the branch itself, and it is no wonder the tree roots gave way. Interestingly, the fact that the tree's central leader and a large lateral branch had been removed a few years ago meant that the appreciable counterbalancing effect of the original trunk was absent. Additionally, the rot affecting the roots on the opposite side of the limb may have weakened the roots' ability to support the girls that day. I am not sure anyone approves of extending this lesson to other trees in the Arboretum, but I am sure that our beloved friend would appreciate knowing that we could leverage this calamity into a corker of a science lesson.

Chris Randall taught science for more than ten years in Baltimore, MD. and Cambridge, MA. Currently at the Center for the Enhancement for Science and Mathematics Education (CESAME) at Northeastern University, he works with math and science teachers on program implementation.

Amy L. C. Wilson

The cork tree's very long, horizontal branch has been left in place on the ground, one end still attached to its foreshortened trunk, the other propped up by a log. The Arboretum staff sought to make the death of "Corky" an educational experience by describing the negative effects of soil compaction on tree health. When heavy loads—or lots of small loads—are applied over the tree roots, the pores between soil particles are compressed and the amount of oxygen available to the roots is diminished. Over time, the effect on a tree can be lethal.

The Arboretum was among a select group of American museums to receive a grant for general operating support from the federal government's Institute of Museum Services. The grant of $112,500 is awarded through a peer review process that evaluates general standards in collections management, education, and other areas of museum operation.

The New England Chapter of the Victorian Society in America recognized one of the Arboretum's most outstanding landscape features, **the Eleanor Cabot Bradley Garden of Rosaceous Plants,** with their 1995 Preservation Award. Funded by the late Eleanor Cabot Bradley, it was designed by Gary Koller and Stephen Spongberg in the spirit of the larger Olmsted/Sargent landscape.

Jack Alexander, Chief Plant Propagator, has been elected a Fellow of the Eastern Region of the International Plant Propagators' Society. He is one of twenty-six to receive the honor since it was instituted in 1990 to recognize outstanding contributions to plant propagation through research, teaching, or leadership.

Peter Del Tredici, Assistant Director for Living Collections, was awarded a Presidential Citation at the annual Presidents' Conference of the Garden Club Federation of Massachusetts, Inc., by President Arabella Dane, for his significant work in documenting, managing, propagating, and reintroducing the endangered *Magnolia virginiana* at its only verified Massachusetts location. Peter reported on the initial stages of this work in *Arnoldia*, March/April 1981.

Kim Tripp, Putnam Fellow, has won the 1996 Research Grant of the International Plant Propagators' Society–Eastern Region for a collaborative project with Dr. Anne Stomp of the Department of Forestry, North Carolina State University. The grant will be used to test the influence of *Agrobacterium rhizogenes* on the rooting of stem cuttings in woody ornamentals that do not respond to standard propagation techniques (for instance, *Cercis* and some *Prunus*).

Autumn Beginnings for Visitor Learning

Richard Schulhof, Assistant Director for Education and Public Affairs

As we began testing two new programs this fall, ideas about education at the Arnold Arboretum grew by leaps and bounds. Over the past ten years, the Arboretum has reached thousands of adult and elementary school students with classroom courses, lectures, and field studies in horticulture and life science. On a drizzly Saturday afternoon in October, we broke new ground by testing programs designed to provide visitors to the grounds with equally rich opportunities for discovery and learning.

Amy L. C. Wilson

As part of our Fall Open House event, Candace Julyan and Diane Syverson of the Community Science Connection (CSC) project set out to enable parents and their children to explore the diversity of maples and the wonder of fall color change in leaves. The hands-on activity, called Reading

Amy L. C. Wilson

Maples, included a tabletop exhibit of maple specimens, products, books, and a treasure hunt map that guided families in the search for leaves and data from a number of maple species. Created for Arboretum visitors as well as CSC participants, the program tested strategies that utilize the living collections to foster exploration and the exchange of observations and ideas about the natural world.

On the same afternoon, outreach horticulturist Chris Strand asked visitors to help test new orientation signage for the grounds. Consisting of "you are here" maps and roadside location markers, the system is designed to encourage visitors—particularly those visiting for the first time—to more confidently explore the Arboretum's full 265 acres. With installation scheduled for 1996, we envision the new signs and maps greatly improving access to the diverse collections and natural sites of the Arboretum landscape.

Amy L C Wilson

In the jargon of the museum world, these efforts seek to support "informal learning," the kind of exploration that occurs around exhibits and in discovery rooms, in which learners investigate at their own pace, responding to their own curiosities and interests. In keeping with Charles Sargent's vision for the Arboretum as a "great museum of public instruction," such are the kinds of experiences we wish to make available for our visitors and the surrounding community.

Remembering Buzzy

On a beautiful Sunday in October, well over a hundred friends of Albert W. Bussewitz gathered in remembrance at the Arboretum. Many spoke eloquently of Buzzy, who died of heart failure this past August. Included in this group were associates from his years with the Massachusetts Audubon Society in Sharon and Norfolk and his earlier years spent in Rochester, New York, as well as Arboretum staff, volunteers, and friends.

Albert W. Bussewitz

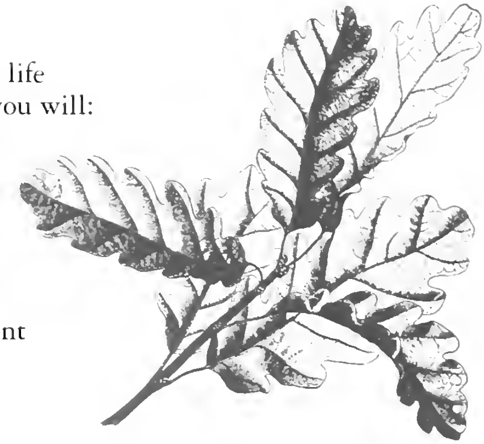
Director Bob Cook, who hosted the occasion, announced that the Bussewitz family will give Buzzy's many superb photographs of woody plants to the Arboretum. The collection will eventually be housed here and made available for educational use. The family asks that donations in remembrance of Buzzy be sent to the Arboretum, where they will be designated for the curation of his photographic legacy.

Arboretum Cleanup

As it has for more than a dozen years, the Arnold Arboretum Committee, a community support organization, recently coordinated a fall cleanup of perimeter areas of the Arboretum. Working with City Year, an organization for volunteer youth, over 125 volunteers removed woody weeds and general debris from the abutting state-owned parcel as well as the Arboretum's South Street tract.

We are indebted to volunteers from Keyport Life Insurance Company of Boston and to Mercer Management of Lexington, which contributed a second year of service. Compliments and thanks are also due to the staff of the State Laboratory Institute and to Arboretum staffers Julie Coop, Kit Ganshaw, Jim Papageris, and Patrick Willoughby.

Grow with us . . .



When you give cash, stock, or other property to a life income plan supporting the Arnold Arboretum, you will:

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Lisa M. Hastings, Development Officer
Arnold Arboretum
617/524-1718 ext. 145

or

Anne D. McClintock, Director
Planned Giving Office, Harvard University
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Flora of the Lesser Antilles

Copies of the six-volume *Flora of the Lesser Antilles,* a long-term project of Dr. Richard A. Howard, former director of the Arnold Arboretum, is still available in limited quantities.

These six volumes constitute the first comprehensive flora of the area, and the treatments present keys to the genera as well as the species for easy identification. For each genus and species a complete modern description is provided; it includes coloration as well as measurements of floral parts. The descriptions are followed by geographic distribution both within and without the Lesser Antilles. All volumes are abundantly illustrated with line drawings that are both botanically correct and highly artistic. All species known in the Lesser Antilles, both native and introduced, are included.

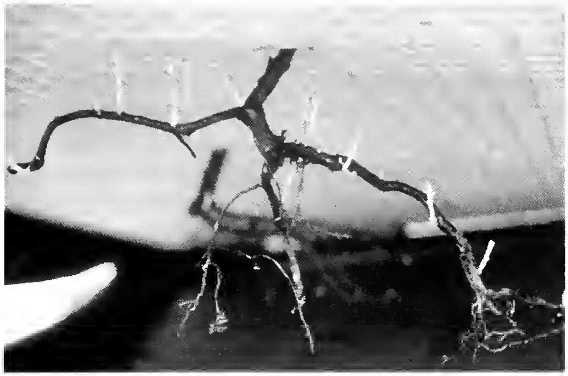
The six volumes are available either individually or as a complete set. For the complete set a special price of $260 is offered that includes shipping and handling within the USA. (Add $5 for shipping outside the USA.) For volumes 4, 5, and 6 only, the special price is $205.

Individual volumes may be purchased at the prices given below, plus $2 per volume for shipping and handling:

Volume 1: Orchidaceae	$20
Volume 2: Pteridophyta	$25
Volume 3: Monocotyledoneae (other than Orchidaceae)	$35
Volume 4: Dicotyledoneae 1	$75
Volume 5: Dicotyledoneae 2	$85
Volume 6: Dicotyledoneae 3	$85

Checks should be made payable to the Arnold Arboretum, and all orders should be addressed to the attention of Frances Maguire, Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130, USA.

PETER DEL TREDICI



This specimen of sweet fern (Comptonia peregrina) *was dug up from the wild and placed in a closed "mist box." Buds developed along the roots within a month.*

including the use of polyethylene film, rooting hormones, and intermittent mist—have rendered the slower and more cumbersome process of propagating by root cutting obsolete. Nevertheless, a number of difficult-to-root woody plants—primarily in the families Anacardiaceae, Araliaceae, Leguminoseae, Myricaceae, and Rosaceae—are still most effectively propagated from root cuttings. In particular, there are many native shrubs that, because of their root-suckering habit, are ideal candidates for stabilizing roadside banks and other difficult habitats. Species in the genera *Rhus*, *Comptonia*, *Myrica*, *Robinia*, *Aralia*, and *Clethra* do well under such conditions and can all be propagated from root cuttings.

Unfortunately, much of the literature on root-cutting propagation is difficult to interpret because of imprecise use of terminology. In particular, many horticulturists consider any woody structure that occurs underground to be a root, regardless of its anatomical origin. This means that plants that produce shoots from underground stems—including rhizomes, stolons, or lignotubers—are often incorrectly classified as "root sprouters." Another problem is that many horticulturists have uncritically copied plant lists from earlier writers without either evaluating the validity of the prior observation or citing a proper source (*e.g.*, Donovan 1976).

The primary purpose of this article is to cut through the confusion that has plagued the literature on root cuttings by identifying those species that have been reported by more than one author to reproduce from root cuttings (see Tables 1 and 2). I have made an exception to this requirement of independent confirmation if an author provides documentary evidence of successful root-cutting propagation with a given species. Of necessity, this article is limited to hardy woody plants. To critically evaluate the extensive literature on tropical plants or herbaceous perennials propagated from root cuttings would be a massive task that is well beyond this author's experience or expertise.

It is worth noting that all of the species listed in this article as being propagated from root cuttings are angiosperms. The only two gymnosperms ever documented as producing root suckers in nature are tropical conifers, *Araucaria cunninghamii* (Burrows 1990) and *Dacrydium xanthandrum* (Wong 1994). Interestingly, *A. cunninghamii* was also listed by Wobst in 1868 as propagated from root cuttings. Despite reports that *Ginkgo biloba* and *Sequoia*

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Root suckers produced by Crataegus punctata *(AA#5608) growing at the Arnold Arboretum.*

sempervirens produce root sprouts (Donovan 1976), recent research (Del Tredici 1992) has shown that these gymnosperms produce shoots from underground stems (lignotubers) not from roots.

The anatomy and physiology of root sprouts is a very complex subject, and well beyond the scope of this paper. For information on this topic, one should consult the excellent review by Peterson (1975). For a detailed ecological study of root sprouting by a tree in its native habitat, consult Kormanik and Brown (1967) on *Liquidambar styraciflua.*

What follows is a summary of the information available on the techniques for propagating woody plants from root cuttings, as described in the English-language horticultural literature. After the section on techniques are lists of species that have been successfully propagated from root cuttings.

Types of Root Cuttings

When discussing the propagation of plants from root cuttings, precise terminology is needed to describe the so-called polarity of the root. *Proximal* describes the end of the root nearest to the stem from which the root grew; *distal* describes the end furthest from the parent stem. This is important to remember because when a root cutting develops a bud, it typically forms at the proximal end. Following the classification system established by Hudson (1956), five distinct types of root propagation can be distinguished among woody plants, based on the relationship between parent plant and root sprouts, or suckers, as they are also known:

1) *Natural suckering without division.* This category includes species that produce root suckers naturally near the parent trunk, forming a densely packed cluster of stems.

2) *Natural suckering with division.* This category includes plants—mainly shrubs—that sucker from uninjured roots at some distance from the base of the parent plant. Under undisturbed conditions these plants form large, spreading colonies. The connecting roots have a tendency to wither away, thereby creating natural fragments of the parent plant that can be readily transplanted.

3) *Induced suckering.* This category includes plants that form root suckers in response to superficial injury to the root, such as that caused by lawn mowers. Induced suckering also occurs following traumatic injury to the trunk of a tree or shrub, provided its root system is left intact. Many of the tree species listed in *Silvics of North America* (Burns and Honkala 1990) fall into this category insofar as they only produce root sprouts following logging.

4) In situ *whole root cuttings.* This category includes plants that form suckers from a root that has been completely severed from the par-

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Successfully propagated root cuttings of the English hawthorn, Crataegus laevigata.

ent plant but left *in situ* until a sucker has grown from the proximal end. This phenomenon is often observed in nurseries after a tree or shrub has been dug, leaving numerous severed roots behind. Provided they are not disturbed, these roots will give rise to new shoots.

5) Ex situ *detached root cuttings.* This category includes plants that form suckers from root cuttings dug up in the fall or winter, cut into short segments, and planted in the field or in containers. From the propagator's point of view, this is the most important category of root-cutting propagation because it allows for rapid increase in the number of plants produced.

Source of Root Cuttings

When propagating plants from root cuttings, the source of the propagules is critical. The following generalizations apply:

1) There is a clear distinction between roots spouting in nature and induced sprouting from root cuttings. Some species that do not appear to sucker in nature can be induced to produce sprouts from root cuttings propagated under nursery conditions.

2) Unfortunately, many horticultural selections in which the desired mutation consists of a periclinal chimera, including many desirable variegated plants, will not come true from root cuttings. This is because root buds typically arise endogenously from the interior of the root, while buds that are produced on shoots arise exogenously from more superficial tissue layers. This difference in the point of origin produces different types of meristems in root versus shoot buds, a difference that is most strikingly seen in blackberries (*Rubus* spp.), in which plants propagated from stem cuttings are covered with thorns while those from root cuttings are thornless (Creech 1954; Peterson 1975).

3) While it may seem obvious, it is important to remember that horticultural selections grafted onto seedling understock cannot be propagated from root cuttings.

4) Younger plants reproduce more reliably from root cuttings than older plants.

5) Thick pieces of the root proximal to the parent trunk seem to produce shoots more readily than thin root pieces distal to the parent trunk (Creech 1954).

6) Some species can readily be propagated from *ex situ* detached root cuttings, while others will only produce shoots from *in situ* whole root cuttings. Experience is the only way to determine the most effective type of propagation method for any given species.

Timing for Root-Cutting Collection

Most authors agree that late fall or early winter—from October through December, when roots possess their maximum carbohy-

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A grove of Sassafras albidum *at the Scott Arboretum of Swarthmore College in Pennsylvania. All the stems are derived from root suckers.*

drate concentrations—is the best time to collect root cuttings (Browse 1980b; Macdonald 1987; Hartman et al. 1990). In areas with cold climates, root cuttings are also collected in late winter to early spring (Saul 1847; Flemmer 1961). Because root buds must develop *de novo* from the inner tissues of the root, they can sometimes be quite slow to develop. In contrast, dormant buds on the trunk are preformed and sprout out rapidly following injury. In general, the later in the season the root cuttings are collected, the warmer the environment they require for successful propagation (Hudson 1956; Browse 1980b).

Size of Root Cuttings

The optimal size of the cuttings is determined by the environment in which the cuttings will be placed. In general, cuttings stuck in a greenhouse can be three to six centimeters long, while those planted directly out-of-doors should be ten to fifteen centimeters long (Flemmer 1961; Dirr and Heuser 1983). As Browse (1980b) points out, however, such generalizations can sometimes oversimplify the situation: "Only experience can dictate the length of the root cutting of any particular plant and only then in relation to the environment to which it will be subjected—usually a prepared outdoor bed, a cold frame, or a glasshouse bench—the size of the cutting needed decreasing with the warmth of the environment. Size is, of course, a function of two parameters, length and thickness, and although it has been shown that thicker cuttings produce shoots more effectively, those produced from thinner roots establish better."

Polarity of Root Cuttings

All authors agree that the so-called polarity of the cuttings must always be respected. Buds tend to form most readily at the proximal end of the cutting (that closest to the trunk). Most authors recommend that this end of the cutting be given a straight horizontal cut, while the distal end of the cuttings receives a sloping, diagonal cut (Flemmer 1961; Macdonald 1987). This makes it easier to establish proper orientation when sticking the cuttings into the propagation bed. Cuttings can be stuck either vertically or diagonally, with the proximal end of the cuttings just at or slightly above the soil surface. Cuttings can also be placed horizontally in flats and covered with a centimeter or two of soil (Creech 1954; Macdonald 1987).

Treatment of Root Cuttings

The use of fungicide greatly improves the success rates of root cuttings (Browse 1980b; Macdonald 1987). Once cuttings have been made, they can either be put in a plastic bag with a powdered fungicide and shaken so that the entire root piece is covered or dipped briefly in a liquid formulation. Treating root cuttings with superficially applied cytokinin does not appear to significantly enhance shoot production above that of untreated controls (Brown and McAlpine 1964; Macdonald 1987).

Winter Storage of Root Cuttings

Root cuttings collected in the fall can be stored in boxes or flats, covered with a moist, well-aerated medium, and put in a minimally heated storage structure until early spring. During this storage period, the cuttings will callus over and begin the bud formation process. (Browse 1980b; Macdonald 1987).

Propagation Environment

1) *Out-of-doors.* In areas with mild winters, root cuttings can be planted directly in the field in late fall or early winter. In areas with severe winters, root cuttings can be collected in the fall and put in cold storage until spring, when they can be planted directly in the nursery. Direct field planting works best with shrubs that naturally form root buds (Flemmer 1961).

2) *Cold frames.* These have reportedly been used successfully in areas with relatively mild winters, such as Great Britain or the Pacific Northwest. They afford more protection to the cuttings than does field planting and therefore offer a greater chance of success.

3) *Cool greenhouse.* Fall-collected root cuttings that have been kept in cold storage can be propagated very well in a cool greenhouse when "direct stuck" in individual containers in late winter. Root cuttings collected in late winter or early spring should be immediately planted in a cool greenhouse with bottom heat (Dirr and Heuser 1987).

Additional information on the relationship between the propagation environment and root cutting performance, as well as the optimum environment for propagating selected species, can be found in Browse (1980b) and Macdonald (1987).

Propagation Medium

The rooting medium should be very well drained to provide maximum aeration. Good drainage inhibits the growth of pathogenic fungi and enhances root development (Flemmer 1961; Browse 1980b; Macdonald 1987). Successful mixes consist of various percentages of peat, bark, sharp sand or grit, and perlite.

Root Cuttings as a Source of Shoots for Stem-Cutting Propagation

Interestingly, many root cuttings will produce shoots relatively quickly, but soon collapse after failing to generate new roots (Creech 1954; Macdonald 1987). Typically, new roots do not form on a cutting until after the shoot is formed, and often they develop from the base of the new shoot rather than from the original root piece. Because of this phenomenon, a modified technique has been developed that involves removing shoots propagated from root cuttings in the greenhouse and using them as softwood cuttings. Because these shoots are physiologically juvenile, they tend to root more readily than cuttings taken from other parts of the tree (Creech 1954; Flemmer 1961; Fordham 1969).

***In Situ* Root Cutting Techniques**

It is important to keep in mind that there are many species that sucker naturally in nature, such as the pawpaw, *Asimina triloba*, that have not been successfully propagated from *ex situ* root cuttings. These species must be pro-

Table 1. Hardy trees that have been successfully propagated from root cuttings, followed by their appropriate literature citations

Ailanthus altissima: 2, 4, 6, 14, 17, 23, 26, 28	*Laurus nobilis:* 2, 12
Albizia julibrissin: 2, 4, 8, 10, 14, 15, 17, 23, 26	*Liquidambar styraciflua:* 3
Amelanchier spp.: 4, 10, 14, 23, 28	*Maackia amurensis:* 4, 8, 10
Asimina triloba: 1, 2	*Maclura pomifera:* 4, 5, 22, 26
Broussonettia papyrifera: 2, 10, 17, 23, 26	*Malus* spp.: 4, 10, 14, 17, 24
Carya spp.: 2	*Morus* spp.: 2, 14, 28
Catalpa spp.: 2, 4, 23, 26, 28	*Paulownia tomentosa:* 6, 23, 26, 28
Cedrela sinensis: 1, 2, 4, 23	*Phellodendron amurense:* 2, 4,10, 23
Cladrastis spp.: 2, 4, 10, 23	*Picrasma quassioides:* 15, 23
Crataegus spp.: 1, 28	*Populus* spp.: 1, 10, 14, 17, 23, 25, 26
Cydonia oblonga: 2, 12, 26, 28	*Prunus* spp.: 1, 2, 4, 8, 14, 17, 24, 28
Elliottia racemosa: 15	*Pterocarya* spp.: 1, 10
Euonymus spp.: 1, 12, 24	*Pyrus calleryana:* 10, 17, 24
Evodia spp.: 2, 4	*Robinia pseudoacacia:* 2, 14, 17, 23, 25, 28
Ficus carica: 17, 28	*Sassafras albidum:* 2, 4, 14, 17, 23, 26
Gleditsia triacanthos: 10, 24	*Sophora japonica:* 17, 28
Gymnocladus dioicus: 4, 10, 22, 23, 26	*Staphylea* spp.: 2, 10, 28
Halesia spp.: 2, 26	*Ulmus* spp.: 10, 14, 17, 28
Kalopanax pictus: 10, 23	*Xanthoceras sorbifolium:* 1, 2, 4, 8, 10, 21, 23
Koelreuteria paniculata: 1, 2, 4, 8, 10, 17, 23, 26	*Zizyphus jujuba:* 2, 17, 28

pagated using *in situ* techniques applied to plants in the late fall. The method involves cutting around the stem(s) of a plant with a sharp spade, then moving out fifteen to twenty-five centimeters and cutting a second, concentric, circle around the first. All roots are left in the ground, and shoot buds will form at their distal ends come spring. Such "pre-cut" plants can easily be dug and potted up in the fall or the following spring. This technique is particularly effective for propagating shrubs that sucker naturally.

Table 2. Hardy shrubs and vines that have been successfully propagated from root cuttings, followed by their appropriate literature citations

Acanthopanax spp.: 2, 17
Actinidia deliciosa: 10, 17
Aesculus parviflora: 4, 10, 14, 17, 23
Amorpha spp.: 4, 28
Aralia spp.: 1, 2, 4, 10, 14, 17, 23, 28
Aristolochia spp.: 1, 22
Aronia spp.: 4, 24, 28
Berberis spp.: 12, 28
Bignonia capreolata: 4, 23, 26, 28
Camellia spp.: 8, 19
Campsis radicans: 4, 14, 17, 23
Caragana spp.: 2, 28
Celastrus spp.: 1, 2, 4, 14, 17, 28
Chaenomeles spp.: 2, 4, 8, 10, 14, 17, 23, 24, 26, 28
Clematis: 21, 28
Clerodendrum spp.: 1, 4, 10, 14, 17, 23, 22
Clethra alnifolia: 1, 8, 10
Comptonia peregrina: 1, 4, 10, 14, 17, 23, 28
Corylus maxima: 12, 17
Cotinus spp.: 11, 24
Cyrilla racemiflora: 8, 10, 17
Daphne spp.: 4, 8, 10, 17, 23, 28
Decaisnea fargesii: 23
Elaeagnus spp.: 2, 26
Fatsia spp.: 2, 4
Forsythia spp.: 12, 17, 24, 28
Fothergilla spp.: 10, 28
Gardenia spp.: 19, 28
Hippophae rhamnoides: 2, 26, 28
Hydrangea quercifolia: 10, 14
Hypericum calycinum: 17, 12
Ilex spp.: 8, 11, 24
Illicium floridanum: 10, 11
Indigofera spp.: 4, 10, 23
Lagerstroemia indica: 4, 8, 10, 23
Leitneria floridana: 1, 4
Lonicera spp.: 12, 28
Meliosma spp.: 4, 23
Myrica spp.:10, 14, 17
Nandina: 26, 28
Orixa japonica: 4, 23
Paliurus spp.: 2, 26
Pyracantha coccinea: 10, 24
Rhododendron spp. (azaleas): 8, 16, 28
Rhodotypos scandens: 10, 24
Rhus spp.: 4, 10, 14, 17, 23, 26, 28
Ribes spp.: 10, 28
Robinia hispida: 4,10, 14, 17, 23
Rosa spp.: 2, 10, 14, 17, 21, 23, 28
Rubus spp.: 1, 2, 4, 10, 14, 17, 18, 23, 28
Sambucus spp.: 2, 23
Sorbaria sorbifolia: 2, 10
Spirea spp.: 11, 24
Symphoricarpos spp.: 17, 24
Syringa vulgaris: 2, 8, 10, 14, 17, 23, 24, 28
Vaccinium spp.: 1, 2
Viburnum spp.: 24, 28
Wisteria spp.: 4, 8, 14, 28
Xanthorhiza simplicissima: 14, 28
Zanthoxylum spp.: 2, 4, 10, 23, 28

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Acknowledgments

This article originated in a paper presented at the annual meeting of the Eastern Region of the International Plant Propagators' Society in Hartford, Connecticut, on 3 November 1995, which will be published in full in the *Combined Proceedings* of that organization. The author would especially like to acknowledge the inspiration of Mr. John Wilde of St. Charles, Illinois, and thank him for the encouragement he has provided since 1982.

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Mystical, Medicinal Witch Hazel

Sheila Connor

Fall is our native witch hazel's best time. In this season it will reward the passerby with a faint, clean scent reminiscent of spring and the sight of ribbons of gold among equally golden leaves. But because it has long been used as a natural astringent, *Hamamelis virginiana* may be more familiar to most people as a bottle of liquid on a shelf in the medicine cabinet than as an understory species of the New England woodland.

As an all-purpose home remedy, witch hazel extract has outlived many of the patent medicines of our great-grandparents' day. Commercial manufacture of witch hazel extract began in 1866, when Thomas Newton Dickinson, a minister and entrepreneur, built a witch hazel distillery in Essex, Connecticut. Originally, witch hazel brush was cut locally and then transported either by boat or by horse and wagon to the distillery. The company has always obtained the witch hazel it needs from the forests of southern New England, and most of the harvest now comes from the northwestern corner of Connecticut. And today, as in the past, the brushcutters—farmers and woodcutters working their own land or land they have contracted to clear—sell directly to the distiller. Work begins in October and often continues until late spring. Sometimes only the branches are cut; otherwise, the plant is cut to the ground. But because witch hazel quickly sprouts from stumps, only a few years will pass before a plant may be harvested again. The invention of the portable chipper allowed the refining process to begin right on site, and now the brush arrives at the factory ready to be distilled in stainless-steel vats, where steam is applied for more than thirty-six hours to the chopped brush. The vaporized essence, which comes from the cambium layer just under the outer bark, is "scrubbed" in washing chambers, reheated to vapor, condensed, and filtered. Today's modern equipment and techniques still deal with three basic elements—witch hazel brush, water, and heat—and T. N. Dickinson's "formula." The clear liquid you see in a bottle of hamamelis extract is 86 percent "double distilled" witch hazel and 14 percent alcohol.

Witch hazel's applications seem to have changed as little as its manufacturing process. The explorer-botanist Peter Kalm reported the use of *Hamamelis virginiana* by Native Americans in treating eye diseases as early as 1751. They called the plant "magic water," boiled the stems and used the liquid not only for their eyes but also to treat cuts, bruises, and scratches. The many modern-day applications of aqueous witch hazel approved by the Food and Drug Administration include treating sores, minor lacerations, sprains, and tired and puffy eyes.

There is also a mystical side to *Hamamelis virginiana:* its use in the occult arts. The common name witch hazel was given to *H. virginiana* by early English settlers because they believed it possessed the ability to "divine." Our native tree was not the first plant to be called witch hazel; the colonists brought the name with them across the Atlantic. Its application is an example of how often a common name reflects an association people make with a plant, rather than an accurate description of it.

In Great Britain, dowsers used their native elm, *Ulmus glabra,* which they called the "witch hazel tree," to find hidden veins of precious metal or underground springs. In

The enduring commercial success of witch hazel may lie in imaginative marketing. Early advertising of the E. E. Dickinson Witch Hazel Company took advantage of romantic legends, as in this label for a bottle of Witchal, a stronger mix of witch hazel and alcohol: "In the early days it was believed that when the good witches boiled the witch hazel twigs in their caldrons it was a sign that the potion was ready for use when the phantomlike shape of a beautiful young woman could be seen riding through the steam." Apparently the batch in this illustration isn't quite ready.

Old English, *wice* meant "lively" or "to bend," and as a dowser approached the site of, say, a potentially productive spring, the branch would become "lively" and begin to point to the source.

The pliant branches of the elm were also used by archers to make their bows. When it was reported that the "aborigines" made the same use of *Hamamelis virginiana* for their weapons, it seems that the colonists transferred all the elm's associated powers to the New World plant. Although many plants were used for dowsing, witch hazel became the preferred one for use as a divining rod.

Sheila Connor is Horticultural Research Archivist at the Arnold Arboretum. This article is adapted from her book, *New England Natives: A Celebration of Trees and People*, published by Harvard University Press, 1994.

Requiem for a Cork Tree

Peter Del Tredici

Around two o'clock on the afternoon of Thursday, 28 September 1995, one of the best loved trees at the Arnold Arboretum died—the old Amur cork tree, *Phellodendron amurense,* which grew along Meadow Road.

It died as it lived, giving of itself freely to an adoring public: a group of twenty-two schoolchildren from the Winsor School in Boston were perched in the tree, posing for a photograph, when the weight of the group caused the tree to crack audibly and collapse. The children hastily climbed down, with no one suffering injury.

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Phellodendron amurense, AA #143–A, age 121. On 29 September 1995, the day after the "accident," the massive climbing limb is on the ground.

Without a doubt it was the most photographed tree in the Arboretum, and the most loved. In fact, it was loved to death. The tree had been in a slow state of decline, particularly over the last ten years, as a steady parade of trampling feet compacted the soil around its base, smothering its roots, and as children and adults of all ages climbed among its low, spreading limbs. Those pressures simply compounded the health problems that are normal for a tree that is over one-hundred-and-twenty years old. Over the years, the Arboretum staff had tried various techniques to keep the public out of the tree but found none that could overcome its sheer magnetism—the irresistible urge it inspired to go up and touch the soft bark that had been rubbed to a smooth polish by countless generations of Boston children. So the decision was made to let the cork tree die as gracefully as possible. It became the only tree in the Arboretum that people were "allowed" to climb.

When the end finally came, the tree was clearly on its last legs. Every year for the last ten years, Arboretum pruners had had to remove dead branches from the tree, making it ever thinner and weaker. The low, spreading limb, where all the children perched, had descended from four feet above the ground in 1983 to only two feet in 1995. This past summer's drought, bringing forty straight days without rain, was just one more problem for the tree to cope with.

The cork tree had an altogether remarkable history. It arrived in Boston as a seed from the Imperial Botanic Garden in Saint Petersburg, Russia, on September 14, 1874, just two years after the Arboretum was founded. It was assigned the accession number 143–A, indicating it was the one-hundred-and-forty-third tree to be acquired by the Arboretum and very likely one of the first trees planted on the grounds.

E H WILSON

In the prime of life in April 1924, at age fifty, the cork tree's broad, spreading crown is fully formed. Obviously, children have not yet started to climb among the branches.

WORCESTER TELEGRAPH

In July 1946, at age seventy-two, a tradition of photographing the tree with children is beginning to emerge and the cork tree's lower limb is adding girth.

When death finally came, at the hands of its friends, it had passed its one-hundred-and-twenty-first birthday only two weeks before.

One of the interesting things about cork trees is that they are dioecious, meaning there are separate male and female individuals. Our beloved specimen was a male. Despite its common name and the corky feel of its bark, *Phellodendron amurense* is not the source of commercial cork used for wine bottles and bulletin boards. (That product comes from a species of oak that grows in the Mediterranean region, *Quercus suber.*) The specific name, *amurense,* refers to the tree's origin in the Amur River Valley of Manchuria, a region with very severe winters. Many other plants from this region are growing well at the Arboretum and seem particularly well adapted to the rigorous climate of New England.

RÁCZ & DEBRECZY

By 1988, one of the cork tree's lower limbs has been removed and children are clearly comfortable climbing along its spreading limbs.

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: 27 Sept. 1995. 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 02130-3519. 5, Complete mailing address of the headquarters of general business offices of the publisher: Arnold Arboretum, 125 Arborway, Jamaica Plain, Suffolk County, MA 02130-3519. 6, Full names of the publisher: Arnold Arboretum, 125 Arborway, Jamaica Plain, Suffolk County, MA 02130-3519. 6, Full names and complete mailing address of publisher, editor, and managing editor: Arnold Arboretum, 125 Arborway, Jamaica Plain, Suffolk County, MA 02130-3519, publisher; Karen Madsen, Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130-3519, editor. 7, Owner: The Arnold Arboretum of Harvard University, 125 Arborway, Jamaica Plain, MA 02130-3519. 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: 4,531. Actual number of copies of single issue published nearest to filing date: 4,500. 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: 3,264. Actual number of copies of single issue published nearest to filing date: 3,341. C, Total paid and/or requested circulation. Average number of copies of each issue during preceding 12 months: 3,264. Actual number of copies of single issue published nearest to filing date: 3,341. 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: 105. Actual number of copies of single issue published nearest to filing date: 180. E, Total distribution. Average number of copies of each issue during preceding 12 months: 3,584. Actual number of copies of single issue published nearest to filing date: 3,566. F, Copies not distributed. 1, Office use, leftovers, spoiled. Average number of copies of each issue during preceding 12 months: 947. Actual number of copies of single issue published nearest to filing date: 934. 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: 4,531. Actual number of copies of single issue published nearest to filing date: 4,500. 11, I certify that the statements made by me are correct and complete. Karen Madsen, Editor.

Winter 1995–1996

arnoldia

The Magazine of the Arnold Arboretum

arnoldia

Volume 55 Number 4 1995–1996

Arnoldia (ISBN 004-2633; USPS 866-100) is published quarterly by the Arnold Arboretum of Harvard University. Second-class postage paid at Boston, Massachusetts.

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 orders, remittances, change-of-address notices, and all other subscription-related communications to: Circulation Manager, *Arnoldia*, The Arnold Arboretum, 125 Arborway, Jamaica Plain, MA 02130-3519. Telephone 617/524-1718

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

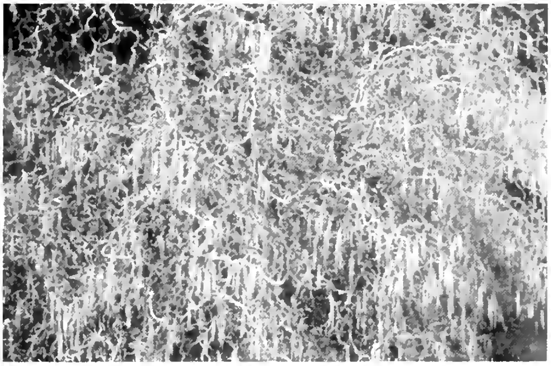
Karen Madsen, *Editor*

Arnoldia is set in Trump Mediaeval typeface.

Page

Front cover: Birches encased in ice on the lower slopes of Bussey Hill, March 1995. Photo by Peter Del Tredici.

Inside cover: Bussey Brook valley after the ice storm, March 1995. Photo by Kim E. Tripp.



Corylus avellana 'Contorta'

KAREN MADSEN

Nature's Vagaries: The Weather of 1995 and the Living Collections of the Arnold Arboretum

Todd Forrest

The result of 1995's ice storm and drought will probably be the decline of many Arboretum plants, but it's all part of the institution's mission to determine the hardiness of native and exotic species.

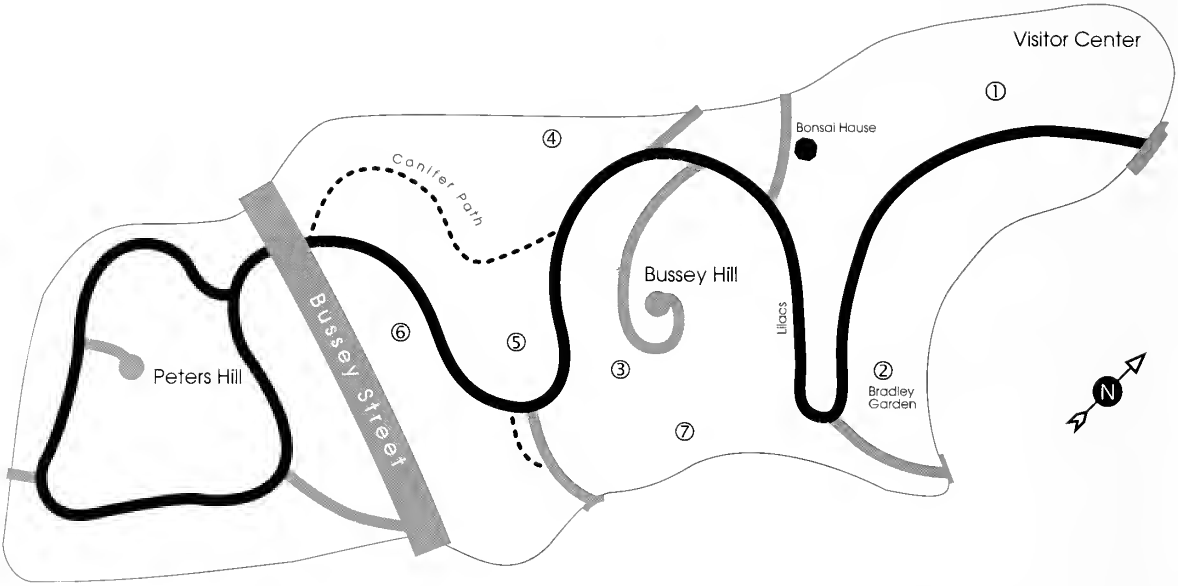
In early August 1995, as meteorologists in Boston crowed about six straight weekends of perfect beach weather, the leaves of *Magnolia macrophylla,* Arnold Arboretum accession 1041-70-D, were turning crisp around the edges and rolling inward. By mid-August, after two more weeks of hot, sunny days, the plant's desiccated brown leaves littered the ground on the gentle, east-facing slope by Centre Street. In mid-September, after nearly forty days without appreciable rain, most of the young trees and shrubs planted in the spring had dropped their foliage, the largest specimens of *Clethra alnifolia* were wilted, and the entire collection of *Rhododendron calendulaceum* looked like it had been torched. When it finally did rain on September 17, the ground was so hard and dry that most of the rainwater ran off immediately and an already scaled-down fall planting was postponed until October.

Although this injury disturbs the Arnold Arboretum's staff and visitors, it is in fact an inevitable result of the horticultural Darwinism central to the institution's mission as a place for plant research. The Arboretum's grounds are an outdoor laboratory where woody plants from around the world are tested for their ability to survive the New England climate. In order to facilitate this research, the Arboretum follows a conservative approach to plant maintenance. The vast majority of trees and shrubs are pruned only to remove dead or diseased wood and very few mature plants are watered or fertilized. While more than 120 years of this management policy has enabled Arboretum horticulturists to determine the hardiness of many exotic species, the knowledge has often come at the expense of individual plants in the collections. Favorite specimens break up in storms, mass plantings succumb to drought and disease, and tender species freeze in colder than average winters.

With an eye to monitoring plant hardiness, the Arnold Arboretum's staff has always compiled data on the weather. During the early years the curator kept records of severe weather indirectly through the plants file. If a specimen was killed by an early or late frost, suffered storm damage, or died in a drought, he recorded this information on an index card with the plant's accession number, its location on the grounds, and the date of the field check. When Arboretum director Charles Sargent or plant recorder J. G. Jack wanted to know what range of temperature a given species could withstand, they scanned the records of all the individual plants of that taxon and checked for patterns in their survival rates. Sargent and Jack used these data for their "Notes From the Arnold Arboretum" column in *Garden and Forest*—a source of some of the earliest observations of ornamental plant hardiness in American horticulture.[1]

To supplement the indirect weather records kept in the plants file, the greenhouse staff has also kept a log of temperature and precipitation.

The drought lasting from February to September was not the only weather record set in 1995. This photo, taken in early December, shows a cedar of Lebanon (Cedrus libani) *after one of the storms that helped break the record for the most snowfall before the official start of winter on 21 December.*



Seven microclimates, described below, are indicated on this map of the Arnold Arboretum.

From 1918 to 1946 propagator William Judd recorded daily maximum and minimum temperatures and made brief notes about precipitation and cloud cover. His entries were simple: he kept his comments to the point and fit his observations onto a single line in a small notebook. For example, on 21 September 1938, the day of the most destructive storm in Arboretum history, Judd noted that the minimum and maximum temperatures were 61 and 80 degrees F, respectively, and commented simply, "rain, terrific hurricane."[2]

In 1934 ecologist Hugh Raup set up thermometers and rain gauges in eight different sections of the Arboretum. His data, interpreted by Alfred Fordham in a 1970 issue of *Arnoldia*, describe seven microclimates within the Arboretum. (The equipment set up on Peters Hill was stolen one month after the project started.)

1) the slope on the southwestern side of the Administration building, across from the meadow

2) a cold, low spot on the northeastern side of Bussey Hill (the site of the present Bradley Collection of Rosaceous Plants)

3) an open site with good air drainage near the summit of Bussey Hill (the present site of Chinese Path)

4) a protected area on an east-facing slope along Centre Street, now known as the Centre Street bank

5) a flat spot in the valley where Bussey Brook and a spring converge

6) a protected cove amidst the mature hemlocks on Hemlock Hill

7) a plateau near the old site of the Bussey Institution on South Street

Each of these seven zones shows differences in average minimum temperatures (from 10.9 to 15.9 degrees F) caused by factors such as exposure and air drainage. Using this information, Raup and later Fordham concluded that the Centre Street bank—area number 4—because of its warmth in the winter and its protection from sun and wind, has the microclimate most favorable for marginally hardy specimens.[3] Subsequent horticulturists have used Raup's data to choose this and other protected locations where plants might survive the region's worst winters.

Like Judd and Raup, Donald Wyman was fascinated by the weather. While working as Horticulturist at the Arboretum from 1935 to 1970, he vigilantly observed and recorded plants' responses to various storms, droughts, and untimely freezes. This information formed the core of his many publications on ornamental

The Hurricane of 1938

One of the most common notations in the card file of plant records is the phrase "destroyed in hurricane." Over the course of the Arboretum's history, hurricanes have swept through and shaken up the living collections by snapping branches, splintering trunks, and uprooting trees of all sizes. Among the major named hurricanes to hit the Arboretum over the last half century (they weren't given names by the National Weather Service until 1950) were "Carol" and "Edna" in 1954, "Donna" in 1960, and "Gloria" in 1985. None of these storms did half the damage caused by an unnamed storm that blew in from the south at about 4:30 p.m., 21 September 1938. This hurricane followed a week of soaking rains that had permeated the ground and raised rivers and streams to flood stage, creating unstable soil conditions and making large trees vulnerable to gusting winds of up to 87 miles per hour. By 8:00 p.m., when the wind finally died down, the power was out and trees were strewn across the grounds like pick-up sticks. In total, 1490 Arboretum trees were blown down in a matter of four hours, inspiring a new phase of planting and—despite the temporary devastation—ultimately reinvigorating the collections.*

DONALD WYMAN

Devastation on the slope behind the administration building. The building in the background is the Adams Nervine Asylum, and judging by its toppled chimney, it too suffered from the 87 mph winds of the hurricane of 1938.

AL FORDHAM

Fallen trees blocking South Street after the hurricane of 1938. It took months to clean up the nearly 1500 trees that blew over, and even now, 58 years later, the hurricane's effects can still be seen throughout the collections.

* Information on the hurricane of 1938 comes from three sources: Ida Hay's book *Science in the Pleasure Ground*, William Judd's weather records in the Arnold Arboretum Archives, and the Arboretum's *Bulletin of Popular Information*, series 4, volume 8 (1940).

plants and aided in the development of the Arnold Arboretum hardiness map, the precursor to the current USDA hardiness map. Wyman observed the effects of harsh weather on plant groups such as rhododendrons, conifers, and legumes. His articles gave gardeners a sense of which plants could survive not only the "normal" weather for the region, but also the occasional extremes that must be factored into any functional description of hardiness. In a 1945 article about winter injury suffered by rhododendrons, Wyman wrote:

> If there is any one factor which can be singled out as being responsible for the injury, it might well be the rainfall, or better, the rainfall and the snowfall. . . . During November and December of 1943 there was a rainfall of only 3.15 inches—less than half the normal amount for those two months. By November there was already a 5 inch deficit in the rainfall. Hence the rhododendrons went into the winter (after the soil had frozen) in a very dry condition. With practically no snow cover, and evaporation of water from the soil surface throughout the winter, the situation was aggravated. [4]

Wyman used his observations to make recommendations for planting, caring for, and protecting those species he found prone to damage under unfavorable conditions. Perhaps his best advice was to avoid planting broadleaved evergreens in southwest-facing locations where they might suffer both in summer and in winter.

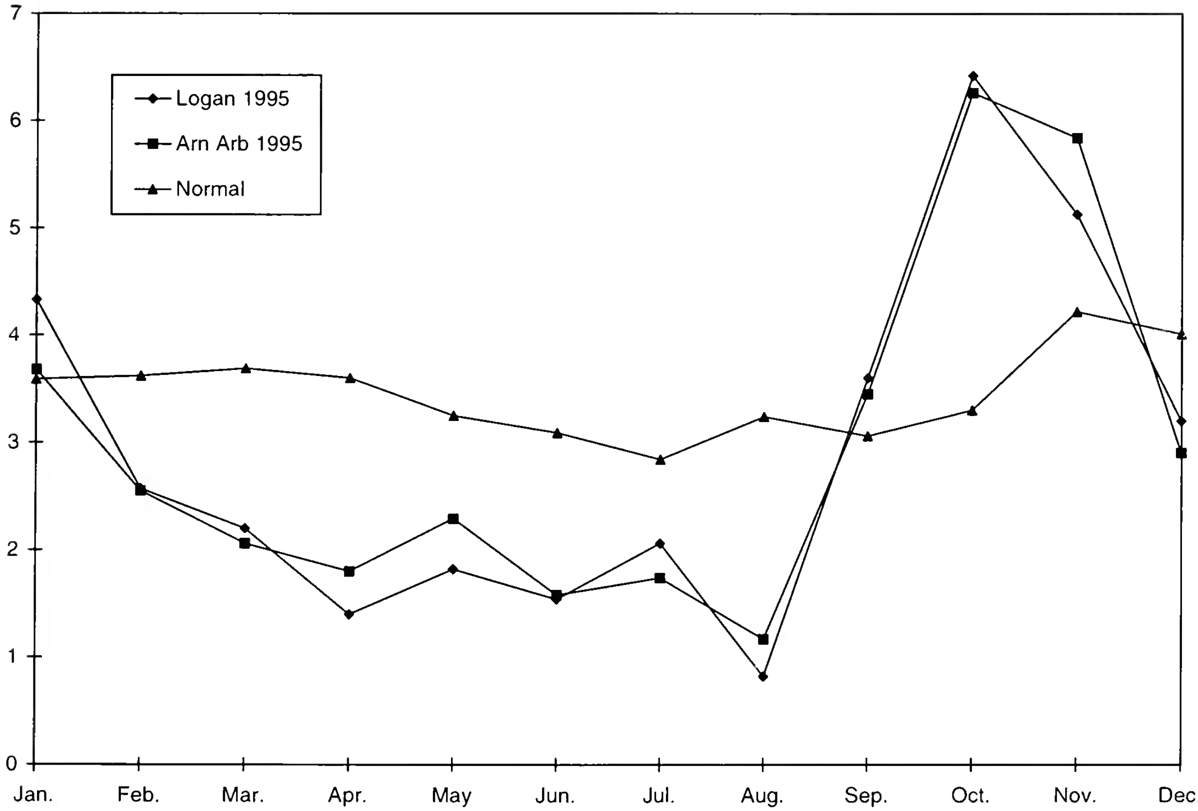
On 15 August 1962, the Arnold Arboretum became an official substation of the National Weather Service. Every morning at around 8:00 a.m., a member of the greenhouse staff reads a rain gauge and a maximum/minimum thermometer to gather data for climatologist R. E. Lautzenheiser. Each January, Lautzenheiser produces a comprehensive summary of the past year's weather, including a historical perspective, part of which is printed in *Arnoldia*. Although Lautzenheiser's observations are primarily based on data from Boston's official weather station at Logan Airport (which tends to have more precipitation and to be slightly warmer in the winter and cooler in the summer than the Arboretum), those data are similar enough to the Arboretum's to be useful in making general comparisons. According to Lautzenheiser's reports, the past three summers have been warmer and drier than usual, but this trend has been interrupted by typical New England inconsistencies and exceptions. [5]

1995: The Year in Review

Nineteen ninety-five was a remarkable year for a number of reasons: from 1 December 1994 through 28 February 1995, average temperatures were 3 degrees warmer (making the average mark 33.9 degrees F and interfering with the dormancy of many plants) and there were 17.2 inches less snow than normal. Nineteen ninety-five had the driest January 1 through September 16 on record with only 16.87 inches of precipitation—roughly 12 inches less than normal—depriving plants of essential moisture throughout the entire growing season. October was 3.6 degrees warmer and had 3.12 inches more precipitation than usual, inspiring new growth in plants that had gone dormant in response to the drought. Late November and early December brought a record snowfall of 28 inches, doubling the total for the entire winter of 1994–1995. Added to these deviations from normal weather patterns was the siren storm that coated the Arboretum in ice for six days in early March. This spectrum of extreme weather made extra work for the grounds staff over the course of 1995, and though it might take a few years to determine the extent of the injury sustained by plants in the living collections, it gave the institution ample opportunity to further its investigations of plant hardiness and drought tolerance.

Mild Winter

In early December 1994, after four days of mean temperatures of above 50 degrees F, curator Stephen Spongberg toured the collections to see how the plants were responding to the unseasonable warmth. Walking on the west side of Bussey Hill, he noticed a specimen of *Lonicera standishii* f. *lancifolia* in full flower. Although in warmer climates this species may flower in winter, at the Arnold Arboretum it has traditionally flowered in early spring. In fact, in "Notes From the Arnold Arboretum" in the 23



A graph showing normal monthly precipitation (in inches) in Boston and the actual amounts for 1995 at the Arnold Arboretum and Logan Airport. The subtle differences in rainfall between the two locations result from a combination of proximity to the ocean (Logan is closer) and elevation (the Arboretum is higher).

May 1888 issue of *Garden and Forest*, J. G. Jack mentioned that this taxon was flowering in early May.[6] Aware of the opportunity to see variation in the flowering time of similar species, Spongberg initiated a winter-long, weekly patrol of the grounds to search for other plants flowering out of sequence. This search was fruitful: fully fourteen taxa, from *Chaenomeles japonica* to *Viburnum farreri* 'Candidissima', flowered in December, with many continuing to flower intermittently throughout the winter and into the spring. The winter of 1994–1995 was also remarkable for its lack of snow. There was only one significant storm (6.5 inches on February 4), and the total snowfall for the season was 14.4 inches—6.7 inches less than Boston received in just the month of December 1995 alone.

These mild temperatures and lack of snow cover came as a relief to some after the very cold and wet winter of 1993–1994. Anyone who spent that winter in New England remembers the relentless snow, high winds, and cold temperatures that arrived in December 1993 and stayed through March 1994. With 96.3 inches of snow recorded at Logan Airport (about 57 inches more than average), that winter surpassed the previous record of 89.2 inches set in 1947–1948.[7] In 1965–1966, a season with two feet less snow than either of the winters mentioned above, Donald Wyman wrote about the effects of heavy snow on the living collections. In his article, Wyman discussed the potential damage from the weight of wet snow on densely branched plants and recommended that gardeners concerned about their plants go out with "a bamboo

Plants that flowered in winter

Chaenomeles japonica (Japanese flowering quince)

Chaenomeles speciosa 'Nivalis' (Nivalis flowering quince)

Euonymus bungeanus v. *semipersistans* (Winterberry euonymus)

Jasminum nudiflorum (Winter jasmine)

Lonicera standishii f. *lancifolia* (Narrowleaf Standish honeysuckle)

Magnolia kobus (Kobus magnolia)

Prunus nipponica (Takane cherry)

Prunus subhirtella v. *ascendens* (Weeping cherry)

Prunus subhirtella v. *autumnalis* (Autumn-flowering cherry)

Rosa 'Seafoam' (Seafoam rose)

Spiraea x *arguta* (Garland spirea)

Syringa vulgaris 'Princess Marie' (Princess Marie lilac)

Viburnum x *bodnantense* 'Dawn'

Viburnum farreri 'Candidissima'

pole, a broom, or rake"[8] and tap the snow off threatened branches. He does caution against being too rough—one might make matters worse for the tree—but neglects to warn against standing directly beneath the tree being swept.

The Ice Storm

On 28 February 1995, as a light rain fell on Boston, the temperature dropped 10 degrees overnight. The next day the Arboretum was glazed in ice. Typically, ice from a storm like this melts quickly as the sun comes out and the temperature rises, but in this case cold, overcast days prolonged the effect for a full week, ending on March 8, when the temperature rose to 67 degrees. This unusual phenomenon was a boon to photographers but destructive to the living collections. For as long as the ice remained on the trees, they were susceptible to breaking in the wind or snapping under their own weight. Indeed, the curatorial staff recorded that nearly sixty trees had to be removed or pruned heavily, and countless more lost leaders, branches, and buds to the shearing weight of the ice. Since the damage often occurred high in the crowns of trees and was not always obvious, it has been difficult to find and repair. Over time rot will set in on the jagged breaks, followed by disease, creating problems that will be visible for twenty years or more. Among the notable wounded were *Acer diabolicum*, AA 2625-A, collected by Charles Sargent in Japan in 1892 and planted near Willow Path, and two mature specimens of *Franklinia alatamaha*, AA 2428-3-A and C, growing on Chinese Path.

Drought

As mentioned above, 1995 had the driest January through September in 125 years of record keeping. The dearth of snowmelt in the spring and of rainfall throughout the entire growing season had an immediate and visible effect on the living collections. Plants initially raised in containers were especially hard hit: container-grown plants are more likely to experience stress because of their constrained root systems and differences in drainage between the soil in the containers and in the ground where they are planted. Most of the Arboretum's one- and two-year-old plantings dropped their leaves by August and many subsequently died. By early September even well-established plantings

The ice storm in early March 1995 was destructive yet beautiful. A thin layer of perfectly clear ice remained on the trees for six days, causing an off-season peak in visitation as photographers from all over Boston tried to capture the dazzling effects on film.

TODD FORREST

KIM E. TRIPP

PETER DEL TREDICI

PETER DEL TREDICI

The overwintering flowerbuds of the princess tree (Paulownia tomentosa), *encased in ice, testify to the attractions of the ice storm; at top, breakage in the collections shows its destructive side.*

showed signs of stress: the leaves of many trees wilted, some dropped prematurely, and fruit production was reduced in nearly all species. The rain that came in late September and stayed throughout the fall perked up the collections a bit, but it also inspired some plants, dormant in response to the drought, to put on new growth. This tender new growth did not get a chance to harden off and was killed in early November as temperatures dropped below freezing on two successive nights. Viewed alone, the 1995 drought was destructive; combined with a wet fall and the subsequent frost, it could prove to have been devastating.

Mature specimens of *Styrax obassia* are among the Arboretum's most handsome plants. Unfortunately, this species suffered conspicuously from the combination of last year's dry summer and wet fall. The foliage of AA 1500-77-A and B dried out in mid-July, roughly one month after flowering, and the desiccated leaves remained on the trees until the second week of September. No new growth occurred during this time and very few fruits developed, a sign the trees had gone dormant. In the early fall, a significant amount of rain fell and the average temperature was about three degrees warmer than normal. These were perfect conditions for new growth, and the trees responded by dropping their dead leaves, putting out new foliage, and flowering. In fact, 1500-77-A was flowering on November 11, five months out of schedule, when a hard frost killed all of its succulent new growth. The drought was doubly damaging to specimens of *Styrax obassia*. Kept from producing enough photosynthates over the course of the summer, the plants went dormant; forced out of dormancy in the fall they were slammed with a hard frost. It will be interesting to see how these trees will respond this coming spring.

This was not the first time Arboretum plants have experienced a combination of drought followed by deluge. After a wet and stormy 1938, the summer of 1939 was very dry. Only .34 inches of rain fell in July of that year, as opposed to 11.10 inches in July 1938.[9] Exasperated by this broad difference, Donald Wyman wrote about the condition of lilacs, rhododendrons, and viburnums in the living collections and bemoaned the unpredictability of New England weather. "[I]t would seem," he wrote, "that the plants in eastern Massachusetts are being subjected to all the vagaries which an unpredictable Nature can provide in the short period of one year."[10] His complaint did not go unanswered: after three months of drought, it rained heavily throughout August 1939, adding yet another loop to the climatic roller coaster Arboretum plants are forced to ride.

Plant Response

Of course, lack of snowmelt and rainfall relate to the amount of available water, and as any gardener who has neglected to water his plants knows, it is axiomatic that plants need water to survive. In an herbaceous plant, response to drought is obvious and immediate: plant cells—deprived of the water that provides the internal pressure to keep their cell walls rigid—collapse, and the plant wilts. Trees and shrubs, supported by woody cells used for water storage and transport, show a more subtle response, generally suffering only leaf scorch, wilting, or, in the worst cases, defoliation. When the soil is moist, fine feeder roots just below the soil surface take up water through osmosis. This water, powered by evaporation from a plant's leaves, flows in a steady stream from the roots, through the trunk and branches and to the leaves where it is used in photosynthesis and to maintain cell pressure. During a drought, transpiration occurs at a rate faster than the uptake of water from the soil, causing leaves to dry out and interrupting photosynthesis and sugar production. If drought conditions persist, severe water loss will interrupt normal growth, increase susceptibility to insects and disease, and upon the destruction of enough actively growing cells, cause death.

Why are some species better able to withstand drought than others? Some plants, particularly those native to arid climates, have developed measures to conserve water. Obvious examples are succulents and cacti with waxy, water-conserving surfaces and a large portion of each of their cells dedicated to water storage. To prevent the water and nutrients absorbed from moist soil from leaching back out when the soil dries, the root cells of nearly all plants use a


PETER DEL TREDICI

*A recently planted hickory (*Carya *sp.) showing the full effects of six months with less than normal precipitation. By September, the majority of new plantings were equally desiccated, and many will need to be replaced.*

combination of a slimy coating called mucigel on their exterior surfaces, a waxy coating called suberin on their interior surfaces, and a complex system of membranes that works like a one-way valve. Drought conditions inspire some plants to close the stomata on the undersides of their leaves during the heat of the day, reducing the intake of carbon dioxide and, therefore, the rate of photosynthesis and water consumption. Similarly, broadleaved evergreens curl their leaves during hot, dry weather and severe cold spells to reduce the surface area exposed to sun and slow the rate of transpiration. In winter, when the soil freezes and roots can't absorb water, deciduous trees in temperate regions drop their leaves and go dormant just as some dry-seasonal tropical trees drop their leaves to conserve water during the annual dry period.

Cultivated trees and shrubs are more prone to drought damage than those occurring naturally. In an artificial landscape like the Arnold Arboretum, human error in matters such as siting may expose plants to conditions that exceed the capacities of their natural defenses. Hardy, moisture-loving plants like willow or alder will suffer during a dry period if placed on a well-drained slope but will do well if planted where the water table is high. Given this potential for error, Arboretum horticulturists must look carefully at specimens in a variety of sites on the grounds in order to make useful judgments about a species' drought tolerance. Since it is impossible to ascertain the longterm physiological effects of drought based on one season of observation, the measures of plant response are limited to immediate effects like wilting leaves, reduced fruit production, and premature leaf fall.

Depending on soil type and exposure, the location of plantings within the Arboretum either limited or compounded the injury caused this past year by the lack of water. Ironically, the area by Centre Street considered to be the most favorable for planting cold-tender specimens turned out to be the location hardest hit by this year's drought. Nearly all taxa growing there showed some degree of damage, including *Clethra alnifolia, Stewartia* spp., *Magnolia macrophylla, Rhododendron calendulaceum* (previously thought to be the most drought-tolerant azalea), and *Styrax obassia.* In contrast, the native and naturalized plants growing in wooded areas (*Carya* spp., *Quercus alba, Tsuga canadensis, Betula lenta, Acer* spp.) showed less severe signs of stress—they are adapted to the extremes of this climate. The area near the

Plants that were severely damaged in the drought of 1995

Species	Extent of damage
Aesculus hippocastanum (Horsechestnut)	Leaf scorch
Clethra alnifolia (Sweet pepperbush)	Wilting, flowers aborted
Magnolia macrophylla/ashii (Bigleaved magnolia)	Defoliation
Magnolia tripetala (Umbrella magnolia)	Severe wilting, leaf scorch
Rhododendron calendulaceum (Torch azalea)	Defoliation, dieback
Stewartia spp.	Severe wilting
Styrax obassia (Fragrant snowbell)	Defoliation
Viburnum spp.	Severe wilting

Plants that resisted the effects of the drought of 1995

Aesculus turbinata (Japanese horsechestnut)

Aralia californica (California aralia)

Bumelia languinosa (Woolybucket bumelia)

Chionanthus retusus (Chinese fringe tree)

Enkianthus perulatus (White enkianthus)

Magnolia fraseri (Fraser magnolia)

Magnolia salicifolia (Anise [or willow-leaved] magnolia)

Poliothyrsis sinensis

Sorbus yuana (Yu's mountain ash)

Viburnum rhytidophyllum (Leatherleaved viburnum)

ponds, including the Bradley Collection of Rosaceous Plants and the legume collection, presented a puzzle: by late August, as the ponds became puddles, plants growing adjacent to the water—such as *Hamamelis virginiana* and *Nyssa sylvatica*—had dropped their leaves while those of the same species planted twenty feet away on higher, drier ground maintained their vigor throughout the summer.

Drawing conclusions from the condition of individual specimens in the living collections is not always straightforward. While most Arboretum plants are left to fend for themselves, there are some exceptions to this tough-love approach. To ease the transition from the nursery to the grounds, all new plantings are watered during their first two growing seasons. Given the intensity of last year's drought, the fall 1994 and spring 1995 plantings would have needed more watering than usual to survive. Limited by the size of the Arboretum and the 500-gallon capacity of our water wagon, the grounds staff could not water them sufficiently to counteract the effects of the drought. Most of these plants suffered conspicuous injury and many will need to be replaced or severely pruned. Conversely, the lilac collection, the Hunnewell Building landscape, and the Bradley collection are served by an irrigation system and were watered throughout the summer; therefore, no valid conclusions could be drawn from the condition of plants in those locations. However, the vast majority of the collections were not watered, and many established plants showed some degree of wilting, leaf scorch, or retarded growth. In general, shrubs, handicapped by their shallow roots, performed worse than trees. The table on page 12 lists species that showed signs of stress regardless of where they were planted.

While as a whole the living collections looked listless all summer, some taxa showed little or no negative effects of the dry weather. This was due to factors such as the plant's native habitat or, in the case of cultivars, improved selection. A notable example of drought-tolerant plants was a group of crabapple cultivars (*Malus* spp.)


RACZ & DEBRECZY

Chionanthus retusus *(Chinese fringe tree) on Chinese Path. In spite of the drought, 1995 was a good year for this plant. It flowered profusely in May and was covered with bright blue fruits in September, making this a good plant for fairly dry sites.*

RACZ & DEBRECZY

RACZ & DEBRECZY

RACZ & DEBRECZY

The fruits of Sorbus yüana, Aesculus turbinata, *and* Poliothyrsis sinensis. *These species held up well during the drought of 1995 and should be considered for planting in sunny, well-drained sites.*

generously donated in March 1995 by Schmidt Nursery in Oregon. These plants retained their foliage throughout the summer and actually showed a little growth. As staff waited nervously to see how mature pines, spruces, and firs would respond to the lack of rain, they were amazed to see that the majority of the conifer collection held its own—little immediate damage could be seen. Other trees and shrubs that demonstrated resilience regardless of where they were planted are listed on the preceding page. This table is meant to supplement traditional lists of drought-tolerant species (Flint 1983, Wyman 1986) and includes only trees and shrubs not already widely recommended for planting in dry sites.

If the weather sometimes seems engineered to aggravate horticulturists, it also permits us to learn more about the plants we grow. Bad weather has played an important role in shaping the Arnold Arboretum, both as a scientific institution and a public landscape. In some ways the Arboretum is a sustainable landscape: limited by insufficient irrigation and the size of the collections, the grounds staff cannot go to heroic lengths to protect plants from drought and cold, which leaves only those species tough enough to make it on their own. This laissez-faire management, along with a history of detailed weather and plant records, has aided the institution in its research by enabling Arboretum horticulturists to determine of the hardiness of many exotic species. According to the records, the spring and summer of 1995 were the driest in 125 years of record keeping—by far the most extreme year in the recent cycle of drought. The plants in the living collections showed a spectrum of responses to the lack of water, providing the opportunity to make some generalizations about their hardiness. Since the makeup of the living collections is always changing, these experiments never become redundant and new information is added with every new storm or drought.

It is too early to know the extent of the permanent damage from last year's weather, but the cumulative result of the ice storm and drought will probably be the decline of many plants in the Arnold Arboretum's living collections. In any case, the grounds staff and interns will be busy planting and pruning next year, perpetuating the tradition of testing woody plants for their ability to endure the inevitable onslaught of "Nature's vagaries."

Endnotes

[1] *Garden and Forest*, edited by Charles Sargent and published from 1888 to 1897, was a botanical and horticultural catchall. It included a mix of articles about landscape architecture, timber management, public policy, and garden history as well as descriptions of cultivated and wild plants.

[2] W. J. Judd, Arnold Arboretum Archives. The Arboretum's archives are a storehouse of information pertaining not only to the history of this institution but to the history of American horticulture, botany, and forestry. I found William Judd's notebooks next to old accession books, above Charles Sargent's personal correspondence, and across from E. H. Wilson's photographs of his travels through China. Given the well-organized, comprehensive nature of the archives, it was very easy to construct a history of recording the weather at the Arnold Arboretum.

[3] A. J. Fordham, *Arnoldia* (1970) 30(5): 186–193. Fordham's article provides a detailed description of the variations in minimum temperatures at each of these locations given a range of different wind conditions and cloud cover. It also describes the differences in temperatures and amounts of precipitation between the Arnold Arboretum Weather Station and Logan Airport.

[4] Donald Wyman. *Arnoldia* (1944) 4(4): 19.

[5] Mr. Lautzenheiser's work is a weather watcher's dream. He produces monthly and annual reports with detailed information about cloud cover, degree days, precipitation, and temperature. See page 36 of this issue for the 1995 summary of weather data.

[6] Once again, see Alfred Fordham's article on microclimate at the Arnold Arboretum, *Arnoldia* 30(5): 191. Looking at the amount of precipitation recorded at Logan versus the amount for the Arnold Arboretum, one can see how similar (but not identical) these amounts are. Using Fordham's article as a guide, one might infer that just as different sections of the Arboretum show different average minimum temperatures, they also might show variation in rainfall. One could investigate microclimates *ad nauseum*, and in order to avoid this I have chosen to use the statistics from Logan.

[7] J. G. Jack, *Garden and Forest* (1888) 1: 154.

[8] Once again, R. E. Lautzenheiser provided these figures.

[9] D. Wyman, *Arnoldia* (1966) 26(1): 2.

[10] D. Wyman, *Bulletin of Popular Information* (Arnold Arboretum), Series 4, VII (9): 41.

[11] Ibid.

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Todd Forrest maintains the plant records system for the Arnold Arboretum.

KIM E. TRIPP

Hardy Asian Alders

Kim E. Tripp

The alder, whose fat shadow nourisheth—
Each plant set neere him long flourisheth.

—William Browne, 1613, *Brittania's Pastorals,* Book I, Song 2

The search for new and unusual plants with handsome ornamental character and reliable landscape performance is as old as horticulture itself. The peak period of plant exploration may have passed with the likes of E. H. Wilson in the earlier part of this century, but at the Arnold Arboretum new plants from around the world are still being added to the living collections and evaluated as ornamentals.

Potential new ornamentals must meet a demanding set of criteria before being declared good landscape plants. They should thrive in diverse landscapes under conditions of low maintenance, with minimal supplemental water and fertilizer. They should be reasonably drought tolerant and suffer no significant pest or disease problems. They must be easy to propagate using standard nursery techniques and grow rapidly enough to be commercially profitable. Obviously they must also possess attractive ornamental features, preferably several for multiseason interest—showy flowers, fruit, fall color, attractive winter habit or bark color, or handsome foliage with useful shade or evergreen characteristics.

The great wonder of the woody plant world is the number of new plants that are continually being found to meet these criteria—either as brand-new finds from the wild or from breeding programs, or as rediscoveries from the forgotten corners of gardens and landscapes. In the latter category, one neglected but fascinating genus holds extraordinary promise for demanding modern landscapes—the genus *Alnus,* or alder.

About thirty-five species of *Alnus* are found around the world, all of them in the northern hemisphere with the single exception of *A. acuminata,* which extends below the equator into Andean South America (Furlow 1979a, b). Among the alders are some of the most cold hardy of broadleaved trees, including shrubby species in subarctic regions as well as numerous species adapted to cool mountain climates. They are most often found growing on poor soils, especially in wet conditions, and will thrive where many other woody plants cannot.

The Genus *Alnus*

Alders are of interest biologically, botanically, and ecologically. The genus comprises an ancient group of deciduous trees and shrubs in the Betulaceae (birch family), of which the closely related *Betula* and *Alnus* may be considered the most primitive members (Furlow 1979a). The Latin name *Alnus* is variously believed to derive from the classical Latin verb *alo* (to nourish, probably referring to its usual close association with water); or from the Celtic *al* (near) and *lan* (riverbank) (Furlow 1979a). Indeed, *Alnus* are most often found growing in moist or wet habitats—in or near streams, rivers, ponds, lakes, swamps, wetlands, and on moist slopes—but some species inhabit moderately dry upland sites, and others can grow in a range of environments from very wet to relatively dry. They are most often found at low to middle elevations, but a few notable exceptions climb nearly to timberline.

This pair of Manchurian alders (Alnus hirsuta) *along Willow Path at the Arnold Arboretum makes a handsome feature in the winter landscape.*

KIM E. TRIPP

The refined silhouette of Alnus japonica *is lovely in all four seasons of the year.*

Like other members of the Betulaceae, alders are monoecious, bearing separate staminate ("male") and pistillate ("female") catkins, or aments, on the same tree. (Catkins are compact aggregates of individual flowers in a single structure, like the staminate "tassles" of oak.) Both staminate and pistillate catkins develop in the axils of the leaves or as the terminal bud. Staminate flowers mature on pendent catkins similar to those of birches, while the small pistillate catkins are for the most part relatively erect and less conspicuous at time of flowering. (An exception is *Alnus firma* var. *multinervis*, which bears nodding pistillate catkins.) One related group of alders, the subgenus *Clethropsis (A. maritima, A. nepalensis, A. nitida)*, flowers in the fall, while all the others flower in the spring.

As seed develops, "female" catkins mature into small dry infructescences, oval in shape, with many woody scales enclosing single-seeded, narrowly winged nutlets that are later dispersed by wind and water. These infructescences resemble those of birches when young, but whereas the infructescences of *Alnus* are woody and persist after the seed matures, those of birches are papery and fall apart. Alders' pistillate catkins can develop into mature infructescences even when seed has not been fertilized; in that case, the seed develops into an empty, shrunken nutlet. There is some evidence of limited development of viable seed without fertilization through a process known as *apomixis* (Furlow 1979a, Santamour 1995).

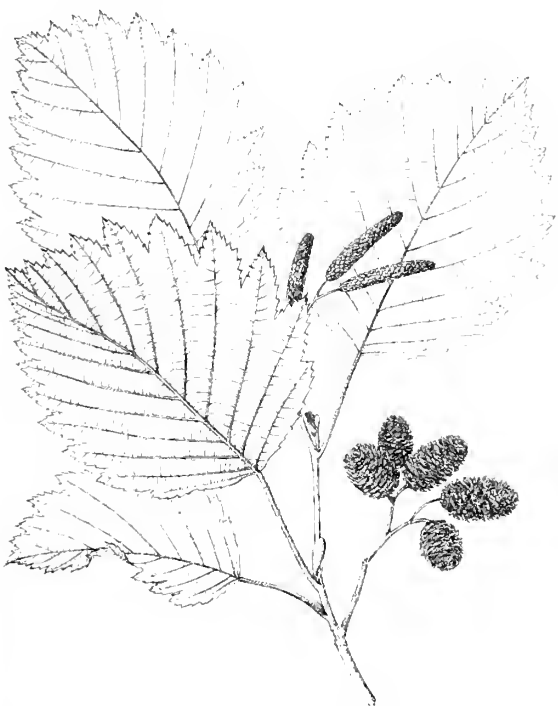
Whether filled with viable seed or not, mature alder infructescences look very much like the diminutive true cones of a conifer. On most alders of flowering age (at least two years old), the spent "cones" are conspicuously persistent long after the seed has fallen, producing a delicate ornamental feature as well as a distinctive field-key character. These attractive infructescences are sometimes gold plated and sold as jewelry.

Perhaps the most fascinating aspect of alder biology is the ability of all species to "fix" atmospheric nitrogen in a process analogous to that of leguminous plants like beans and peas. Fixing nitrogen is the process of converting atmospheric nitrogen into a form usable by plants and other biota. This unusual ability enables alders to pioneer successfully on sites of low fertility, where over time they contribute significant nitrogen to the soil, principally as leaf litter

(Binkley et al. 1994). As a result, *Alnus* is often one of the first species to establish itself after fire, clear cutting, volcanic activity, or other disturbances to forest environments (Furlow 1979a). Its vigorous growth can prevent or significantly inhibit colonizing by other plants, both wild and cultivated. For example, following the eruption of Mt. St. Helen's, vigorous hybrid poplars *(Populus)* were planted on mudflows caused by the eruption. *Alnus rubra* (red alder) seedlings rapidly established themselves naturally on these sites, however, outgrowing the *Populus* and other species to the extent that after six years the stands on the mudflows were 93% *Alnus* (Binkley et al. 1994). Alders' nitrogen-fixing ability has also been used to advantage for many years in mine spoil reclamation (Tarrant 1968).

Their ability to fix nitrogen combined with their rapid growth rate also permits alders to outperform other species in managed environments, sometimes in an undesirable way. For example, in the northwestern United States, native *Alnus rubra* was historically eradicated from recently harvested and disturbed sites by commercial forestry managers who considered it a weed in competition with high-value conifers. More recently, red alder's rapid growth and its ability to produce biomass on marginal sites is receiving the recognition it deserves, and its use—both as a "nurse crop" to provide nitrogen for higher value crops and as a primary crop whose wood value is itself on the increase—is now a major subject of research in United States forestry science (Hibbs et al. 1994).

The graceful foliage and catkins of Alnus japonica *are illustrated in this drawing by C. E. Faxon. From the Archives of the Arnold Arboretum.*



The bold foliage and catkins of Alnus hirsuta *are drawn in fine detail by C. E. Faxon. From the Archives of the Arnold Arboretum.*

Hardy Asian Alders of Ornamental Potential

From a horticultural standpoint, the alders' ability to fix nitrogen and to thrive in wet soils makes them a natural choice for many difficult sites with low fertility. The horticultural merit of ornamental alder species has been far more widely appreciated in Europe, Asia, and western North America than in the eastern United

States, possibly because the alders native to those areas include handsome, full-sized trees. In contrast, the alders native to eastern North America are generally a shrubby, disheveled lot—biologically tough and ecologically important, but less than aesthetically pleasing. This has given the entire genus an undeservedly poor reputation in the eastern half of the United States, where the vigor and attractiveness of *Alnus* could make an important contribution to gardens and other landscapes.

European species like *Alnus glutinosa* and *A. cordata* are already widely grown in Europe and the United States and each has notable cultivars. The Asian alders, on the other hand, have received little attention, although they include some of the most beautiful taxa of the genus—taxa with rapid growth rates, no significant pest or disease problems, and useful degrees of cold hardiness. Rather than attempt to treat all of the approximately thirty-five alder species in an article of this scope, I have chosen to discuss only hardy Asian alders of particular horticultural merit—plants which, unlike their European cousins, have been neglected as specimen, shade, and street trees. Herein, "Asian" refers to the regions inclusive of China, Japan, Korea, Sakhalin, the Kuriles, Kamchatka, and the eastern and central regions of the former USSR (that is, Russia's non-European regions); while "hardy" refers to plants that will survive and grow in areas with winters at least as severe as those of USDA hardiness zone 6.

Many alders fall into that nebulous category of "large shrubs or small trees," depending on where they are growing and on whether they have been pruned to one or a few main trunks. Many species that grow at both low and high

The Other Asian Alders*

Two categories of Asian alders are not included in this article: the ornamental but not hardy, and the hardy but not ornamental. Some species, like the beautiful *Alnus subcordata* of the Caucausus, which is widely grown in Europe, and the recently named white-barked *A. glutinosa* ssp. *betuloides,* fall into the former group (Ansin and Özder 1993). Also in that category are the tender but lovely *A. formosana* and *A. orientalis* and the unique but only semihardy *A. cremastogyne* of China that bears its "cones" on long pendent peduncles.

In the second group are hardy Asian alders that are of botanical, if not horticultural, interest. *Alnus trabeculosa* is a small to medium tree of southeastern China and, rarely, Japan (Ohwi 1965). Its foliage is oval and narrows abruptly to a distinctively long, pointed apex. *A. fauriei* grows as a large shrub or small tree in northern and central Japan (Ohwi 1965). The foliage of this species is its most distinctive feature. Leaves are often nearly round with a notched apex and can be 4 to 5 inches in diameter, the size of teacup saucers. Leaf size and shape are fairly variable. Its close relative, *A. matsumurae,* is a medium-sized tree (occasionally shrubby in the high mountains) that is similar to *A. fauriei,* which has an overlapping range in Japan but which grows up into higher elevations (Ohwi 1965, Sargent 1916). *A. fruticosa* is the common, widely dispersed, shrubby alder of northeast China, Mongolia, European Russia, and much of the former USSR (including Siberia). It is a plant of great tenacity that thrives in an incredible range of soils and conditions, from wet lowlands to alpine scree (Hulten and Fries 1986). Some botanists assign *A. fruticosa* to the genus *Duschekia* (noted under *A. maximowiczii,* Shemberg 1992), while others elevate the populations found on the Kamchatka peninsula to a different *Alnus* species, *A. kamtschatica* (Czerepanov 1995, Voroshilov 1966, 1982).

* See Krüssman (1984) and *The Royal Horticultural Society Dictionary of Gardening* (1992) for overviews of the entire genus.

The Arnold Arboretum

WINTER · NEWS · 1995–1996

A Wetland Restoration

Robert E. Cook, Director

The spring of 1996 will mark another milestone in the evolution of the landscape of the Arnold Arboretum. A 24-acre parcel of land known as the Stony Brook Marsh will be formally added to the grounds and incorporated into the park system of the City of Boston. It has been a century and a year since such an action was last taken. In 1895 the Peters Hill tract was placed under the original 1882 agreement whereby the Arboretum land was given to the City for parks and leased back to Harvard University as a center for the scientific study of trees.

The Stony Brook Marsh is a low-lying area of wetland vegetation marking the merger of Bussey Brook into Stony Brook. It separates the south flanks of Hemlock Hill and Bussey Hill from the Forest Hills subway station and rail tracks leading to Dedham. Originally part of the Bussey Institution of Harvard University—one of the first agricultural colleges in the country—the land has been abused and has fallen into decay over the past half century. It became a dumping ground for refuse, and its higher ridges were invaded by a heavy growth of weedy shrubs and trees.

A decade ago, local friends of the Arboretum formed the Arboretum Park Conservancy and took on the goal of incorporating this urban wild into the lease agreement with the City as part of the Boston park system. After years of political and legal maneuvering, they have succeeded in reaching a mutually beneficial arrangement between the City and the Arboretum.

Richard Schulhof

In taking responsibility for the management of the Stony Brook Marsh, the Arboretum will commit itself to restoring the habitat to a more natural wetland condition. It will become an immensely valuable part of our educational efforts—for casual visitors and adult classes, but especially for our children's educational program with local schools. In this special sense, it will be symbolic of the vision that led Charles Sprague Sargent and the City fathers to form the original partnership for the people of Boston over a century ago.

Native People, Native Trees

As part of a new Arboretum field study, Boston-area children will soon explore the meadows and conifers of Bussey Brook valley to discover how Native Americans derived vital sustenance from the northern forest. The program, "Native People, Native Trees," began in 1994 when Arboretum field study coordinator Annette Huddle set out to create field activities for grades three through five that would encourage children's interest in both trees and Native American culture.

Developed in collaboration with local schoolteachers, the program shares much of what we know about the relationships that once existed between Native Americans and the land known today as the Arnold Arboretum. Thanks to a field reconnaissance survey conducted by Boston city archaeologist Steve Pendery, we know that Native American occupation of a site near the Arboretum's Bussey Brook began nearly 8,000 years ago and continued sporadically up until the time of European colonization. "Native People, Native Trees" revisits this era and enables children to consider the challenges faced by the Arboretum's earliest inhabitants through a search for white cedar, white birch, and other species that were critical to human comfort and survival.

With pilot testing of the program now complete, we look forward to introducing the study to schools later this year. We thank the Massachusetts Cultural Council for their support of the project.

Richard Schulhof

Annette Huddle leading a storytelling session on Hemlock Hill.

New Staff

Karen Madsen

Carol Mita has joined the Botany Libraries staff as Serials Manager. She is responsible for all incoming serials, bindery operations, and the serials exchange program. Carol has held other serials and cataloging positions in the Memorial Library and the Middleton Health Sciences Library of the University of Wisconsin, Madison. She received the B.A. in zoology from the University of Wisconsin, Madison, and is currently enrolled in the M.S.L.I.S. program at the Simmons College Graduate School of Library and Information Science.

Karen Madsen

Elizabeth Kolster joined the Arboretum in December as an information systems project manager working with the biodiversity conservation project in Southeast Asia. Liz will be developing a national biodiversity database system for the Government of Indonesia, and she brings extensive experience with computers to the project. She has worked as director of information systems at Boston University and for the Faculty of Arts and Sciences at Harvard. She is particularly interested in geographical information systems that combine map-based information with data on critical natural resources, such as the biodiversity of developing countries in tropical Asia. Liz is also an avid sailor.

Error Noted: In last issue's "Cork Tree's Last Hurrah Provides a Science Lesson on Leverage," the Resistance Force should have read as 7,763 pounds (or 3.9 tons).

1996 American Landscape Lecture Series

MEMORY IN Place

This winter marks the fourth year of collaboration among the Arnold Arboretum, Olmsted National Historic Site, the Harvard Graduate School of Design, and a number of other sponsors to present a lecture series exploring our changing relationship with the American landscape. This year's series, Memory in Place, examines landscapes, museums, and literature that seek to commemorate and encourage reflection about the places, figures, and events of our collective past. The Arboretum extends its thanks to the Massachusetts Foundation for the Humanities for its special support of the series.

All lectures are free and begin at 6:30 pm in the Piper Auditorium of the Harvard Graduate School of Design at 48 Quincy Street, Cambridge. For information, call the National Park Service at 617/566–1689 x 220.

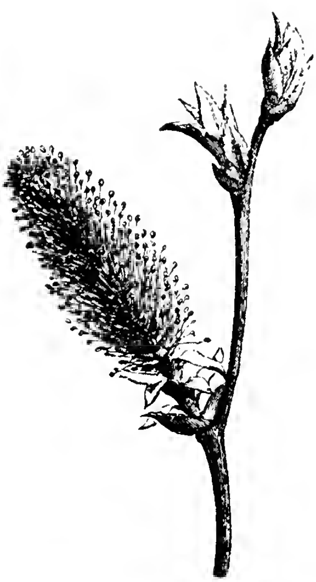
Thursday, February 22
The Power of Place: Urban Landscapes as Public History
Dolores Hayden, Professor of Architecture, Urbanism, and American Studies, Yale University

Wednesday, March 6
Preserving Memory: The Making of the United States Holocaust Memorial Museum
Edward T. Linenthal, Professor of Religion and American Culture, University of Wisconsin

Thursday, March 14
The Invention of Place: Environmental Perceptions in American Literature
Laurence Buell, Professor of English, Harvard University

Tuesday, April 2
The Garden as Narrative: Lawrence Halprin's Franklin Delano Roosevelt Memorial
Reuben M. Rainey, Professor of Landscape Architecture, University of Virginia

Monday, April 8
Memory Gardens: The Poetry and Gardens of Ian Hamilton Finlay
Alec Finlay, Poet, Edinburgh, Scotland



Free Tours at the Arnold Arboretum

Willows, cherries, magnolias, dogwoods, crabapples, lilacs, roses, mock oranges, hydrangeas, and many, many more plants will be highlighted on free monthly walking tours at the Arnold Arboretum. These tours will be offered March through September, on the fourth Saturday of each month, beginning at 10:30 am on the front steps of the Hunnewell Building and lasting approximately an hour. For further information, or to find out if a tour has been canceled due to weather, call our general information message at 617/524–1718 x 773.

date	*highlight*
March 23	witch hazels and willows
April 27	Arbor Day: great trees of the Arnold Arboretum
May 25	dogwoods and lilacs
June 22	roses and mock oranges
July 27	bottlebrush buckeye
August 24	oakleaf hydrangea and scholar trees
September 28	franklinia and witch hazels

1995–1996 Annual Appeal

Lisa Hastings, Senior Development Officer

Arnold Arboretum members and friends are responding generously to the 1995–1996 Annual Appeal, with a total of $54,159.91 in gifts received to date.

In his letter seeking annual support, Director Bob Cook reflected on the recent passing of the 125-year-old Amur cork tree. The tree died when a group of local schoolchildren climbed onto a low-lying limb for a photograph. Over time, the cork tree had come to symbolize in a unique way the many facets of the Arnold Arboretum—as scientific institution, public park, and historic landscape. As one of the Arboretum's oldest trees, its accession number was recorded by Charles Sprague Sargent in 1874 when it arrived in the form of dry seed from the Ruusan Imperial Garden of St. Petersburg. During its long life, the tree came to be loved by children of all ages.

"The generous support received from our members is most appreciated," says Bob Cook. "The Arboretum has always meant different things to different people. Gifts to the annual appeal represent a strong vote of confidence in our commitment to grow and curate an exceptional collection of trees."

PROGRAMS & EVENTS

The Arboretum's Education Department offers a wide variety of courses, programs, and lectures in horticulture, botany, and landscape design. A selection of spring and summer courses is shown here. For a complete catalog of programs and events at the Arboretum, please call 617/524–1718 x 162.

Note that fees shown in **boldface** are for members of the Arboretum. For information about becoming a member, call 617/524–1718 x 165.

HOR 498 The Collector's Garden: Designing with Extraordinary Plants

Ken Druse, Author and Photographer

In this slide-illustrated lecture, Ken Druse will take us on a journey to memorable gardens and introduce some of the people and plants that will be shaping the direction of gardening in the 21st century.

Fee: **$15**, $18

Friday, April 12/ 7:30–8:30 pm
(State Laboratories)

WAL 168 Private Gardens of England and Wales

Daphne Foulsham, Chair, National Gardens Scheme

Sit back and enjoy an armchair tour of rarely seen private gardens in England and Wales. Mrs. Foulsham's slides capture a diversity of gardens, ranging from cottage and country gardens to historical landscapes and sophisticated town gardens.

Fee: **$12**, $15

Tuesday, April 23/ 7:00–8:00 pm (HB)

Lilac Sunday, May 19, 1996

There are thousands of flowering plants to admire in the Arboretum, but only one, the lilac, is singled out each year for a daylong celebration. On Lilac Sunday garden enthusiasts from all over New England gather at the Arboretum to enjoy picnicking, watch Morris dancing (English folk dancing), take tours, and purchase lilacs. On the day of the event the Arnold Arboretum will be open from dawn to dusk with lilac plants and refreshments available for purchase from 10 am to 4 pm. For information, call the Arnold Arboretum at 617/524-1718 x 100.

elevations usually grow as trees but are shrubby at the highest elevations in their range (for example, *Alnus hirsuta, A. matsumurae*). Most of the species described below develop as trees of various heights and dimensions; an exception is the shrubby *A. maximowiczii*, which is included for its horticultural potential.

I have included the USDA hardiness zones in which the plants are likely to survive. With few exceptions, the germplasm of these species now grown in the United States originated from propagules of relatively limited geographic provenance. No doubt cold hardiness for most of these species could be improved by future collections from their coldest provenances.

The ornamental attributes of Asian alders are quiet and subtle but nonetheless effective in the landscape. None have dramatically showy flowers, but some have eyecatching and colorful catkins in spring. None have fall color, but all have persistent catkins that are delicately attractive. The arboreal alders also have very handsome winter architecture of diverse types, and some have beautiful, beech-like bark.


KIM E TRIPP

The silvery gray bark of Alnus hirsuta *is ornamental in winter.*

Alnus firma, native to Japan, is a deciduous, multi-trunked tree of small to medium size, or occasionally a large shrub, that can reach 40 feet in the wild but is generally seen in cultivation at heights of 15 to 25 feet, depending on habit. It has a narrow, graceful spread with somewhat pendent branches, and its foliage is among the loveliest of any deciduous tree. Its glossy, emerald green leaves, about 2 inches wide and 4 inches long, are regularly, slenderly oval and deeply veined. When emerging, the foliage appears pleated and is as attractive as when fully expanded. Hardiness of this species varies widely by provenance and is reliable through USDA zone 7, but its subspecies are generally hardy through zone 6. In the wild, *A. firma* is usually found in wet sites near water and does best with full sun or light shade in moist to wet soils that do not dry out significantly. In containers, however, it tolerates moderately uneven watering with no adverse effects in the Northeast.

Alnus firma var. *hirtella* is also native to Japan and resembles the typical variety except for a dense orange to light tan pubescence on the leaves and twigs. The degree of pubescence varies somewhat but where it is heavy, it is quite showy. *A. firma* var. *multinervis* (sometimes named *A. pendula*) is native to Japan, Korea, and eastern Asia. It differs from other *A. firma* taxa in bearing more numerous pairs of veins on the leaves, a trait that adds to its ornamental character. Its pistillate catkins are nodding or pendent, in contrast to the more erect catkins of other species—a characteristic that has been the basis for elevating this taxon to the species level *(A. pendula)* by some authors (Ohwi 1965).

As a small ornamental tree, *Alnus firma* var. *multinervis* offers graceful habit, exceptionally handsome foliage throughout the growing season, persistent infructescences of delicate ornamental character, and unstoppable tenacity in

PETER DEL TREDICI

KIM E. TRIPP

KIM E. TRIPP

The foliage of the Asian alders —from top to bottom, Alnus firma *var.* multinervis, A. hirsuta, *and* A. japonica*—is diverse and beautiful.*

sites of low fertility. Growth is rapid in containers and in the field. *A. firma* var. *multinervis* might make an exquisite small tree for large containers in pocket parks or urban squares, or a lovely lawn tree for small, low-fertility suburban lots where the topsoil has been stripped.

Alnus hirsuta (Manchurian alder) is a large deciduous tree reaching 50 to 80 feet in the wild and, with age, similar heights in cultivation. It has an upright, uniform, pyramidal habit similar to that of mature *A. glutinosa.* Its leaves are rounded to broadly ovate, about 3 inches wide and 3 to 4 inches long, variably toothed and pubescent. The foliage retains a good, grass-green color throughout the season, while the spent infructescences are prolific and persist attractively through the winter. Bark color is quite variable, ranging from a warm, light silvery gray to brown-charcoal, and it can be as ornamental as that of European and American beeches *(Fagus sylvatica* and *F. grandifolia). A. hirsuta* is hardy through at least USDA zone 4, but the provenance of wide-ranging species like this one can significantly affect cold hardiness; more collecting and testing is needed to determine whether plants from its northernmost provenance are significantly more cold hardy than Zone 4. This species and its botanical varieties are widely distributed throughout Russia (including Siberia, the Amur region, Sakhalin, Kamchatka, and the Kuriles), and in Manchuria, Japan, and parts of Korea (Kabanov 1937). In the wild, Manchurian alder is found in a diverse range of conditions from poorly drained river bottoms to dry upland. There are two botanical varieties (rarely elevated to species) distinguished chiefly by provenance, foliar morphology, and degree of pubescence. *Alnus glutinosa* var. *mandschurica,* found in Manchuria, has rounded foliage and is pubescent only along the veins on the undersides of leaves, while var. *sibirica* is the essentially glabrous-foliaged form of wide distribution.

In cultivation, Manchurian alder is one of the most beautiful and useful of the arboreal alders, thriving in wetlands, moderately dry sites, and sites with variable moisture. Growth is rapid in the field and in containers (as much as 5 to 6 feet per year). *Alnus hirsuta* has been grown for about twenty years at the Arnold Arboretum and has proven to be one of the most handsome and reliable of all the Asian alders here, with no significant pest or disease problems. In addition, it is the only one of several Asian species planted at the Harvard Forest in Petersham, Massachusetts, in the early 1980s that has remained vigorous in a plantation situation with low maintenance.

The handsome bark and foliage of the Manchurian alder, its persistent "cones," uniform branching pattern, and stately habit make it an excellent shade tree for parks or streets. Its tolerance of low fertility and of poor drainage or fluctuating moisture enables it to tolerate low-maintenance and urban sites that defeat other shade trees. The vigor and beauty of this species suggest that its best individuals should be selected and named and that it would be profitable to collect more plants from its coldest provenances in the wild.

Alnus japonica, Japanese alder, is a deciduous tree of small to medium size, generally reaching 30 to 50 feet, with a narrowly oval habit and slightly pendent, fine-textured branching. Its elegant leaves of a smooth, glossy, bright green are narrowly oval, about 1.5 to 2 inches wide and 3 to 4 inches long—very finely toothed but without the prominent venation of *A. firma.* The foliage remains green and glossy very late into the fall. Its bark is a medium gray, and the spent infructescences are prolific and persist through the winter with delicate ornamental character. When the staminate catkins flower in spring, many plants develop a distinctive and attractive cherry-red hue. Japanese alder can be found growing widely in Japan as well as in Manchuria, in parts of Russia (near the shore in the maritime region, on Sakhalin, and in the Kuriles), and in Korea. It is reliably hardy through at least USDA zone 6; plants from the coldest provenances may be more hardy. Two botanical varieties are distinguished by provenance (*A.* var. *koreana,* found in Korea) and by foliar morphology (*A.* var. *minor,* with leaves much smaller than the species, about 2 to 4 inches long). *A.* x *mayrii,* an especially handsome tree, is a naturally occurring hybrid of *A. japonica* and *A. hirsuta* that resembles *A. japonica* but has wider leaves and a more robust habit.

The Japanese alder has a notably narrow and elegant silhouette both in summer, with its dense, glossy foliage cover, and in winter, when its persistent "cones" and appealing habit add a Japanesque character to the landscape. It could be especially useful as a low-maintenance shade

Propagating the Asian Alders

Alders propagate readily from seed, giving best results when the seed is fresh and has not been allowed to dry out before sowing. If the seed has dried, good results can also be obtained with relatively short periods of stratification (one to two months in a moist medium at 35 to 40 degrees F). It is useful to note that alder species that flower simultaneously may hybridize readily where they are found growing in relative proximity (Furlow 1990). Such species in the wild are generally kept separated by geography and habitat, but garden plants are freed of these natural limitations. Seed collected from cultivated alders, therefore, may well give random hybrid progeny—especially as all the Betulaceae, including *Alnus,* are wind-pollinated and the pollen can travel great distances.

This tendency to hybridize in nature and cultivation has resulted in some confusing nomenclature, as well as some attractive plants. There are some naturally occurring, distinctive, consistently named hybrids (for instance, *A.* x *mayrii*), as well as many names for putative hybrids that have entered the taxonomic literature.

Alders can also be rooted successfully from softwood cuttings. Cuttings should be harvested when the wood has just begun to harden and rooted under relatively frequent mist with pretreatment of moderate concentrations of IBA hormone preparations. Best results have been obtained when temperatures in the propagation area stayed below 80 to 85 degrees F.

tree in narrow strips of poorly drained land, or in small courtyards or gardens with poor soil where an elegant deciduous tree is wanted.

Alnus maximowiczii is a deciduous shrub or occasionally a small tree that can reach surprising proportions with great age. (Richard Weaver, Jr., 1978, reported seeing trunks 3 feet in diameter from Hokkaido forests.) In the wild it generally reaches heights of 15 to 25 feet, with similar spread, but in cultivation in North America it is more often seen at heights of 8 to 15 feet, with wider spread. Leaves are about 3 inches wide and 4 inches long, heart-shaped to broadly ovate, with distinct serrations. They emerge a glossy emerald green with handsomely prominent venation and darken to a rich, matte blue-green as they mature. *A. maximowiczii* begins flowering before the leaves emerge, and both staminate and pistillate catkins are surprisingly showy. The pistillate catkins are small and erect, turning a deep cherry red at flowering time, while the staminate catkins elongate to 3 to 4 inches and turn a golden yellow. While its floral display will certainly not rival the brazen showiness of trees like the deciduous magnolias, it does offer an equally lovely, albeit quieter, spring character. *A. maximowiczii* is widely distributed in Japan (primarily in mountainous areas), in the former USSR (including Sakhalin, Kamchatka, and the Kuriles), and in parts of Korea. It grows in a wide range of elevations, climbing to alpine heights but also descending to sea level in some areas. This species has been included by Russian botanists in their split genus *Duschekia* (Czerepanov 1995), which has also included several other species of alder from time to time. The genus *Duschekia* is not widely accepted by Western botanists.

Alnus maximowiczii is a handsome shrub that will thrive in virtually any site with full sun. It is hardy through at least USDA zone 4 and grows rapidly for a large landscape shrub. With its appealing spring display and foliage that remains in good condition throughout the season, it is a good choice for embankments and other difficult sites where a tall, lush green, massing shrub is desired. It is especially useful on sites with low fertility and drastically fluctuating moisture conditions.

Alders at the Arnold Arboretum

For a century, alders have made an important contribution to the living collections at the Arnold Arboretum. E. H. Wilson was particularly interested in the genus and collected several Asian alders—*Alnus fauriei, A. firma, A. fruticosa, A. hirsuta, A. japonica,* and *A. maximowiczii* among them—as well as more tender species like *A. formosana* and *A. nepalensis.* Charles Sargent was also enamored of the genus and he too collected and wrote about alders. More recently, Richard Weaver, Jr., and Stephen Spongberg made significant *Alnus* collections in Japan and Korea.

Although championing Asian alders initially felt like an original effort, this is certainly not the first time their cause has been promoted at the Arboretum. Long ago Charles Sargent himself recognized the horticultural potential of the hardy Asian alders—offering his premier endorsement for this premier group of woody plants. It is especially appropriate, then, to close with words from his *Garden and Forest* article on *Alnus hirsuta* (then *A. tinctoria*) and to reiterate that "the object of this note . . . is to call attention to a promising ornamental tree" (Sargent 1897).

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Acknowledgments

The author gratefully acknowledges Irina Kadis for her patient translations from the Russian literature, as well as Sheila Connor, Peter Del Tredici, Mark Krautman, and Stephen Spongberg for critical discussion and recommendations, or assistance with archival literature. The author also gratefully acknowledges the support of the Willowwood Foundation for aspects of the work included here.

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A Nitrogen Fixation: The Story of the *Frankia* Symbiosis

Peter Del Tredici

Some of the plants we scorn as weeds perform important biological functions. By adding nitrogen to impoverished soils, nonleguminous nitrogen-fixing trees and shrubs play a key role in the process of forest succession.

It's a great irony of the botanical world that plant growth is often limited by the availability of nitrogen in the soil when almost eighty percent of the atmosphere is composed of dinitrogen gas (N_2). The explanation lies in the chemical stability of nitrogen gas. Before atmospheric nitrogen can be used by plants, it must be "fixed," that is, split and combined with other chemical elements. This process requires a large input of energy and can occur either biologically, within the cells of various bacteria, or chemically, in fertilizer factories or during lightning storms.

Among all living organisms, only bacteria have evolved the complex biochemical mechanisms required for nitrogen fixation. All "higher" plants and animals that are said to fix nitrogen are really only the symbiotic partners of the bacteria that do the actual work. Among plants, the cultivated legumes (peas, beans, peanuts, etc.) are the best-known nitrogen-fixers, but many plant families besides the Leguminosae can also fix nitrogen. On a worldwide scale, these nonlegumes, as they are somewhat negatively called, fix as much nitrogen as legumes, but for a variety of historical reasons they have been relatively neglected by scientists.

Quite a few of these nitrogen-fixing nonlegumes are native to North America and are mostly found in impoverished, sandy soils low in nitrogen. The most common are alder (*Alnus* sp.) in wet, open land; bayberry (*Myrica pensylvanica* in the North, *M. cerifera* in the South) on the seashore and on exposed sandy soils back from the coast; sweet fern *(Comptonia peregrina)* on exposed, dry, sandy soils; sweet gale *(Myrica gale)* in swamps; and New Jersey tea *(Ceanothus americanus)*

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This flat of southern bayberry seedlings (Myrica cerifera) *was supposedly grown both without nitrogen and without the* Frankia *bacteria. One of the seedlings, however, did manage to form* Frankia*-induced root nodules, producing a clearcut advantage over its siblings.*

in open, wooded sites. On the west coast of North America, various *Ceanothus* and *Alnus* species are the most common nonlegume nitrogen-fixers. In the arid mountains of the West, buffalo berry *(Shepherdia canadensis)*, bitterbrush *(Purshia tridentata)*, and the mountain mahoganies (*Cercocarpus* spp.) are important. In southern Florida, the introduced and somewhat weedy Australian pine (*Casuarina* spp.) is important for stabilizing beaches, and throughout the Midwest and East Coast the autumn and Russian olives *(Elaeagnus umbellata* and *E. angustifolia)* have been widely planted along highway embankments. All of these plants thrive in poor soils where little else grows. Their ability to fix nitrogen is a significant factor in their survival under conditions that would be inhospitable to ordinary plants.

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A Frankia-*induced nodule on a root of sweet fern,* Comptonia peregrina. *Note the upwardly growing roots emanating from the lobes of the nodule.*

In legumes and nonlegumes alike, the actual fixation of nitrogen is done by bacteria living inside the roots of the host plant. It is a classic example of a mutually beneficial symbiosis: the plant provides the bacteria with sugars and a variety of minerals, and the bacteria provide the host with a usable supply of nitrogen. In the case of the legumes, the bacterium may be one of several different species of the genus *Rhizobium*, a rod-shaped bacterium found naturally in most soils and available commercially in most seed catalogs as legume inoculant. In the nonlegumes, the bacterium involved is an actinomycete, or filamentous bacterium, in the genus *Frankia*. Unlike the rhizobia, which exist as discrete cells, the actinomycetes grow in long chains of cells similar to fungal hyphae, but much smaller. All of the plants infected by *Frankia*, with one exception, are trees and shrubs, whereas among the legumes both annual herbs and trees may be infected by rhizobia.

The microorganisms enter the plant through the root hairs and grow in the cells of the roots, stimulating them to grow and divide. Basically, the bacteria, by producing large quantities of the hormones that normally occur in very small concentrations in the plant, force the root cells to proliferate much faster than normal, causing multi-lobed swellings, or nodules, to form wherever the bacteria have penetrated. Among the actinomycete-nodulated plants, properly referred to as actinorhizal plants, these nodules have a well-defined structure and a rather striking appearance, being densely branched and more or less spherical. The nodules are perennial and increase in size each year, eventually becoming over an inch in diameter. In some plants, such as alder, the individual lobes that make up the nodule are very tight and compact. In others, such as sweet fern, each lobe of the nodule grows out into an upwardly growing root creating a sort of witch's broom effect.

These nodules are the site of nitrogen fixation. Both *Rhizobium* and *Frankia* bacteria possess special enzymes, nitrogenases, that allow them to transform the nitrogen gas in the air into ammonium which, in turn, is converted into amino acids. Because the reaction can only occur in a low oxygen environment, the process is often dependent on hemoglobin compounds found in the nodules, which are virtually iden-

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Several old nodules of the root system of the southern bayberry, Myrica cerifera, *growing on the sand dunes along the outer banks of North Carolina. The root, with its attached nodules, was exposed by the wind, which in this area never seems to stop blowing.*

tical to those found in the red blood cells of animals. By binding with oxygen, the hemoglobin in the nodule helps to create the microenvironment that the nitrogenase enzyme requires. It is interesting to note that when actinorhizal plants are grown in water culture, the young, succulent nodules are often pink in color, due to the presence of hemoglobin.

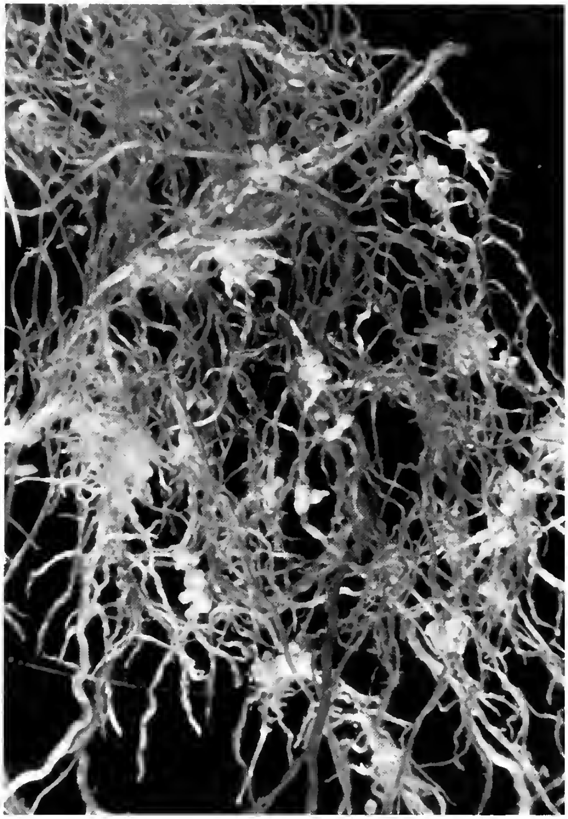
Work on actinorhizal plants took a giant step forward in 1978 when a research team that included Dale Callaham, currently of the University of Massachusetts at Amherst, the late Professor J. G. Torrey of the Harvard Forest in Petersham, Massachusetts, and the present author, successfully isolated and grew, independent of its host plant, the slow-growing *Frankia* bacteria responsible for fixing nitrogen in sweet fern *(Comptonia peregrina)*. This was the first time that the bacteria from any actinorhizal plant of the nonlegumes had been cultivated independently, and it marked the end of nearly seventy years of unsuccessful attempts to isolate the organism responsible for nitrogen fixation from an actinomycete-nodulated plant. In contrast, the faster-growing *Rhizobium* bacterium was first isolated in pure culture ninety years earlier, in 1888. This disparity is the main reason why the actinorhizal symbiosis is not nearly as well understood as the *Rhizobium* association.

In general, actinorhizal plants are sunloving pioneers in early successional stages of revegetation of the north and south temperate regions (with the exception of *Casuarina* and *Myrica* species in the tropics). They do best on sandy or swampy soils where nitrogen is scarce and their ability to extract it from the air is a distinct advantage. Usually they are not found in shady, forested situations or on rich farmland, where they would lose their competitive advantage. Most nitrogen-fixing legumes, on the other hand, are tropical and subtropical herbs that have migrated north and become important in agricultural environments.

It is primarily because the legumes are involved with food production that they have attracted the lion's share of scientific attention, but this situation is changing rapidly. People are becoming aware that the potential value of actinorhizal plants is of equal importance, if not equal conspicuousness, to the legumes. Experiments have been conducted by forestry managers in which actinorhizal plants are grown in conjunction with various economically desirable trees: red alder and *Ceanothus* with Douglas fir on the West Coast, alder with poplar for pulp on the East Coast, and *Elaeagnus* with black walnut in the Midwest. In all cases, the experiments resulted in richer soil and faster growth rates in the desired tree species. In the Northeast, sweet fern, bayberry, and *Elaeagnus* are used extensively for stabilizing roadside bankings and revegetating traumatically disturbed ground.

Actinorhizal plants have a much longer history of human use in Europe and Asia than they do in North America. In Japan, the Asian species of *Myrica* and *Alnus* are grown in association with various conifers to improve the soil and stop erosion, while along the northern coast of Europe and the British Isles, the sea buckthorn, *Hippophae rhamnoides*, is cultivated for the purpose of stabilizing shorelines, as well as for its edible fruit. Throughout the tropics, the genus *Casuarina* is not only important in stopping seashore erosion, but is also an important source of fuel and timber in areas that otherwise produce very little. The future looks bright for the actinorhizal plants, especially in the context of forestry and habitat restoration, as land managers move from experimentation into implementation.

The fact that actinorhizal plants grow where little else can makes them particularly useful for covering bare ground. Apart from this functional recommendation, however, many of these plants are aesthetically pleasing as well. Various *Ceanothus* species, which are widely grown in mild climates, are covered in springtime with blue, pink, or white flowers. Sweet fern, which is fast growing and small, is perfect for any situation with full sun and sandy soil.



DALE CALLAHAM

The root system of Comptonia peregrina *four weeks after innoculation with a pure culture of* Frankia *bacteria. The bacteria stimulated the development of over fifty-five nodules on this ten-week-old seedling.*

Bayberry is an attractive midsize shrub that keeps its leaves longer than most plants and is covered for most of the winter with waxy gray berries (the source of bayberry candles). In addition, bayberry is highly salt tolerant and performs equally well near the seashore or on highway embankments where road salt applied during the winter tends to accumulate. The arborescent alders have traditionally been thought of only in terms of land reclamation, but recently commercial nurseries have begun to recognize their ornamental potential. Finally, the autumn and Russian olives, which were widely planted in the 1970s, have a beautiful silver-gray foliage and fruits that birds love to feed on. Unfortunately, the birds love the fruits so much they have dispersed the plant well beyond its initial area of cultivation. As

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The Australian pine, Casuarina equisetifolia, *growing on the beach at Haena Point on the north coast of Kauai, Hawaii. Incessant wave action has exposed the massive, layered root system of the tree. No doubt this species' ability to fix atmospheric nitrogen is primarily responsible for its ability to survive the harsh conditions.*

a result of this weedy tendency, the olives are no longer recommended for large-scale erosion-control plantings.

Measurements of nitrogen fixation in actinorhizal plants taken over extended periods of time have shown that pure stands of alder bush are capable of fixing up to 280 pounds of nitrogen per acre per year. This is much greater than the amount of nitrogen fixed by soybeans (90 pounds per acre per year) or peas (66 pounds per acre per year), but comparable to that fixed by alfalfa. Most of the nitrogen fixed by the actinorhizal plants enters the nutrient cycle through the decomposition of fallen leaves, twigs, branches, and fine roots. This process is much slower than that which occurs in agricultural situations, where leguminous cover crops are plowed into the soil at the end of a single growing season.

It is worth keeping in mind that the greatest degree of nitrogen fixation, in legumes and actinorhizal plants alike, occurs when soil levels of nitrogen are relatively low. High levels of nitrogen, applied as fertilizer, tend to reduce bacterial activity. What this means is that the plant and the bacteria work best together when conditions are worst: the symbiosis is most effective when it becomes most necessary. To put it another way, the nitrogen-fixation symbiosis is a dynamic interaction between two independent organisms that is entered into when ecological conditions are such that neither partner could survive long without it.

PETER DEL TREDICI

The silvery gray foliage of the Russian olive, Elaeagnus angustifolia, *can be very striking in the landscape, as shown here at the Montreal Botanical Garden.*

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Acknowledgments

The author thanks Dr. John Tjepkema of the Department of Plant Biology and Pathology, University of Maine at Orono, for reviewing this article, and acknowledges the late Dr. John Torrey for his inspiration.

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The Year in Trees and Words: Book Note and Excerpt

The Year in Trees: Superb Woody Plants for Four-Season Gardens. Kim E. Tripp and J. C. Raulston. Timber Press, 1995. 204 pages with 206 color plates. Hardcover. $44.95

J. C. Raulston, director of the North Carolina State University Arboretum and a man of many adages, holds that in any given region of the United States, 40 trees and shrubs make up more than 90% of the landscape plantings. If, as he also asserts, somewhere in this country as many as 15,000 different landscape plants are available for the finding, then why do we see the same few over and over? Twenty years ago Raulston started the Arboretum at NCSU to ameliorate this situation by testing the garden-worthiness of a wide range of plants. A recent count of plants collected and evaluated numbered 9,000; having identified some of the most viable and attractive, the next task was to encourage their production and use.

To that end, during Kim Tripp's postdoctoral stint at the NCSU Arboretum, one of her weekly chores was a press release in the form of a plant portrait. Those portraits—150 in total—have been joined to 206 handsome color photos, mostly by Raulston, in *The Year in Trees: Superb Woody Plants for Four-Season Gardens.* Those who've heard either Raulston or Tripp speak know that they possess a wealth of information, especially on plant adaptation and response to climate.* This is a book for the plant lover, a celebration of trees and shrubs that's solid and informative enough for a place on the reference shelf. Although the NCSU Arboretum primarily tests plants for hardiness in the warm, moist summers of USDA zone 7, many of them grow well in New England. A sampling of Tripp's portraiture follows.

Corylus avellana 'Contorta': Harry Lauder's walking stick

There just is no escaping it—eventually, at some level or another, all gardeners succumb to the quest for the rare and unusual. This yen may manifest as the drive to find and rescue the rarest of native populations of a tiny fern with only five remaining plants that grow in only one spot on the entire planet (currently endangered, of course, by planned construction of a transglobal shopping mall) or it may develop as an insatiable hunger for a cutting of that dwarf, contorted, pink-and-gold-variegated, cutleaved, sterile, chartreuse-flowered form of a hitherto-believed-to-be-extinct, cold hardy to zone 1, heat-tolerant, broadleaved evergreen shrub rumored to now exist only in the collections of the extremely remote Atlantis Botanic Garden (a garden known only to a few seriously intrepid collectors, which refuses to participate in Index Semina exchanges).

Whatever form this yearning for the unusual takes, even the most blasé of horticulturists eventually find themselves searching for choice plants of one form or another. One magnificent plant that has long been a traditional source of choice garden character is *Corylus avellana* 'Cortorta', Harry Lauder's walking stick. This unusual shrub or small tree is a contorted form of the commercial European filbert, *Corylus avellana,* which is grown and highly valued for its delicious nuts. The

* See "Exploring the Complexities of Plant Hardiness" by J. C. Raulston and Kim E. Tripp in the Fall 1994 *Arnoldia* (54:3).

branching of this form is twisted into striking, spiral contortions throughout the entire plant. It is a spectacular addition to the winter garden, where the sculptural patterns created by the branches can be clearly seen.

Native to Europe and parts of Asia and northern Africa, the species *Corylus avellana* is a small tree or large, woody, multistemmed, thicket-forming shrub. Its deciduous dark green foliage, about 3–4 inches (7.6–10.1 cm) long and almost as wide, is rather coarse and hairy. The flowers are tiny, with the male flowers borne on long, narrow catkins, and female flowers in shorter, thicker catkins, similar to those of its close relatives the birches (*Betula* spp.) and alders (*Alnus* spp.). The catkins of male flowers are yellow and put on a handsome show in late winter before the leaves emerge. The female flowers are much more subtle and require closer inspection to see the delicate but amazingly carmine-colored floral parts emerging from the buds.

Corylus avellana 'Contorta' is much like its parent species with one important exception—its contorted growth. This fascinating plant is interesting in summer because the leaves are also somewhat contorted, but it is at its peak in late winter and early spring. It does not bear fruit. The plant will reach 10 feet (3.1 m) with some age, but it is a relatively slow grower, which makes it an excellent specimen plant for small gardens. It is completely hardy to zone 4.

Corylus avellana 'Contorta' will perform well in a range of soils in full sun or with a little shade. It is propagated by grafting scion wood of the cultivar onto rootstock of the species. The species understock tends to sucker and the suckers must be continually removed to avoid overgrowth of the cultivar.

A Celebration of Crabapples: Book Review

Richard Schulhof

Flowering Crabapples: The Genus Malus. Fr. John L. Fiala. Timber Press, 1995. 340 pages. Hardcover. $49.95

The late Father John Fiala was well known in horticultural circles for his lifelong work to improve lilacs and flowering crabapples. For a few years, his horticultural legacy endured in the landscape of Falconskeape, his garden in Medina, Ohio, but ultimately preservation efforts proved unsuccessful. Fortunately, Fiala's great devotion to crabapples has found more lasting commemoration through the publication of his book, *Flowering Crabapples: The Genus* Malus.

The crabapple, touted across much of the country as "America's favorite flowering tree," is valued for its adaptability to cold climates, ease of production, and great diversity of color and habit. Defined as those taxa in the genus *Malus* that bear fruits 2.5 inches in diameter or smaller, crabapple trees range in shape from rounded to columnar and weeping, with flower color extending from white to deep reds and purples, and fruit from black-red to brilliant gold. Interest in developing a better crabapple has, over the decades, led to an accumulation of some 900 named varieties. The story of their development and landscape use, the subject of Fiala's book, is of particular significance to the Arnold Arboretum and other institutions with a long-standing commitment to crabapple display and evaluation.

Clearly this handsome volume is much more a horticultural overview than a technical treatise, and while some of Fiala's taxonomic details may remain in dispute, the absence heretofore of any color-illustrated, near-current guide to crabapples makes it a valuable contribution to the literature. With separate sections on landscape uses, propagation, pests and disease, a solid discussion of tree form, and 245 color photographs, crabapples at last have a work that speaks to their value and versatility in the landscape. Yet perhaps the book's strongest value is its history of the events and people that have brought us the crabapple of today.

Father Fiala, also the author of *Lilacs: The Genus* Syringa, presents a highly personal perspective on crabapple history. An inveterate breeder, he admitted that, "Like most hybridizers working over a lifetime, I am certain I have named too many crabapples, but, be assured, I have discarded a hundred times more!" In profiling the key figures in crabapple breeding, Fiala discusses the commercial nurseries and university programs whose breeding efforts owe much to the wealth of raw material provided by the plant exploration and introductions of the past century.

This bounty has yielded a prolific and rather continuous stream of crabapple cultivars. While in some genera, particularly roses, the release of a new cultivar does not always signal an improved or significantly "new" plant, many recent crabapple introductions offer benefits to both the gardener and the ecological health of the landscape. Indeed, crabapple breeders deserve praise, for although initially focused on flower color, annual bloom, and other ornamental traits, they have, in recent decades, responded to growing sentiment against the use of pesticides by developing forms with increased resistance to applescab, fireblight, and other diseases. Fiala's book describes these breeding efforts and resulting cultivars in encyclopedic fashion, offering information on their lineage, attributes, and weaknesses, as well as providing generous helpings of personal experience and opinion.

As Father Fiala recounts, the Arnold Arboretum and other botanic gardens figure prominently in the development of the modern

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'Don Wyman' are among the significant cultivars developed at the Arboretum by Karl Sax, Wyman, and others.

crabapple. While any discussion of crabapples in the United States would include mention of Arboretum horticulturist Donald Wyman, who did much to evaluate the performance of cultivars and popularize the plant, Fiala also gives special notice to the work of Charles Sargent, the Arboretum's first director:

> No horticultural institution did as much for introducing and discovering new species, varieties or special clones as did the Arnold Arboretum . . . Especially under Professor Charles Sargent, who took an active interest in crabapples, the Arnold Arboretum not only sought out new crabapple materials in Siberia and Japan, but it also energetically promoted any crabapple found in its gardens or elsewhere.

Arboretum contributions include the tea crab *(Malus hupehensis)*, the Siebold crabapple *(M. sieboldii)*, and Sargent's crabapple *(M. sargentii)*, which were collected by Sargent or his agents in Asia at the turn of the century. 'Dorothea', 'Blanche Ames', 'Mary Potter', and 'Don Wyman' are among the significant cultivars developed at the Arboretum by Karl Sax, Wyman, and others.

The publication of Fiala's book gives occasion to revisit the progress of the Arnold Arboretum's *Malus* collection. It is worth noting that the work of both Sargent and Wyman survives today in the Arboretum's collection of over 170 crabapple species and varieties. The collection has been further enhanced by twenty years of systematic evaluation of disease resistance by the late Dr. Lester Nichols of Pennsylvania State University. More recently, the Arboretum's Living Collections staff has modernized and updated the collection with 20 new cultivars that will be evaluated for disease resistance and landscape performance. Eventually, after sufficient trial and testing of the most promising varieties, the Arboretum will display the best crabapples for southern New England.

Fiala's book would make a fine companion for a May trip to the Arboretum and is to be recommended to those with a serious interest in the group. Any controversies within crabapple circles over Fiala's nomenclature overlook the larger value of this book as the chronicle of one of America's preeminent horticulturists reflecting on a lifetime of dedicated involvement with one of our most important landscape plants.

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Arnold Arboretum Weather Station Data — 1995

	Avg. Max. Temp. (°F)	Avg. Min. Temp. (°F)	Avg. Temp. (°F)	Max. Temp. (°F)	Min. Temp. (°F)	Precipi-tation (in.)	Snow-fall (in.)
JAN	41	25	33	66	10	3.68	3
FEB	37	16	19	57	–2	2.55	6
MAR	46	30	38	67	16	2.06	trace
APRIL	57	35	46	69	17	1.8	trace
MAY	66	45	56	86	31	2.29	0
JUNE	80	58	69	93	44	1.58	0
JULY	86	69	78	95	56	1.74	0
AUG	84	61	73	96	47	1.17	0
SEPT	73	51	62	89	38	3.45	0
OCT	67	43	55	84	33	6.26	0
NOV	47	30	39	63	18	5.84	3.5
DEC	34	20	27	46	10	2.93	22

Average Maximum Temperature	60°
Average Minimum Temperature	40°
Average Temperature	50°
Total Precipitation	35.35 inches
Total Snowfall	34.5 inches
Warmest Temperature	96° on August 2
Coldest Temperature	–2° on February 6 and 7
Date of Last Spring Frost	31° on May 2
Date of First Fall Frost	29° on November 5
Growing Season	207 days

Note: According to state climatologist R. Lautzenheiser, 1995 was a year for the record books. It was very dry with temperatures slightly above normal and sunshine slightly below average. January set a record with 13 consecutive days of measurable precipitation. However, this was followed by several months of below-average moisture levels. The combination of both March and April was the driest since March and April of 1966, and the fifth driest on record. April was also unusual because the temperature never reached the 60-degree mark at the Arnold Arboretum. June too was very dry, with only 50% of the normal rainfall for the month, making it the fifth dry month in a row. July followed as the sixth dry month in a row, setting another record for the lowest amount of precipitation over this six-month period. The months of August and September continued the dry pattern by giving us a 41-day period, from 8 August to 17 September, in which only .3 inches of precipitation was recorded.

The drought broke on 17 September, the day of the Arboretum's annual plant sale; on that day we received 2.32 inches of rain. This made September the first month since January with above-normal moisture. October set records for combined warmth and moisture, making it the warmest and wettest October on record. November continued the pattern of welcome moisture while also being the coolest November since 1980, with the least sunshine since 1977. December seemed to round off this peculiar year. It was very snowy, quite cold, yet on the dry side with normal levels of sunshine. The snowfall in December was more than three times the norm, making it the fifth snowiest on record. Oddly, the snowfall for the year was just average, the dearth of snow early in the year offset by the bonanza at the end. In the end, we found ourselves 6.40 inches below normal in precipitation for the year.

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*Numbers in parentheses refer to issues, those in **boldface** to illustrations of the entries.*