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On the Cover: *The three trees in Jacob Van Ruisdael's celebrated picture, Three Great Trees in a Mountainous Landscape, painted c. 1655. Variously known as the "Three Oaks" and the "Three Beeches," they represent, from right to left, a beech and two oaks. The Norton Simon Foundation, Pasadena, California. Cat. No. 38.*

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Contents

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Jacob van Ruisdael's Trees

by Peter Ashton, Alice I. Davies, and Seymour Slive

This article appears in conjunction with the exhibition Jacob van Ruisdael (1628–1682) *on view in the Fogg Art Museum, Harvard University, 18 January–11 April 1982, and represents a collaborative venture between the Arnold Arboretum and the Fogg. Every one of Ruisdael's works, from which the details illustrated here have been taken, may be examined at the exhibition by the interested reader. The catalogue numbers cited refer to the exhibition catalogue prepared by Seymour Slive.*

Modern botanical illustration, in which plants are drawn from life with careful attention to those characteristics which distinguish their species, dates from 1530 when Otto Brunfels, physician to the city of Bern, published *Herbarium Vivae Eicones.* The art of illustrating plants almost certainly existed in classical times, though none of these illustrations survive. On Pliny the Elder's authority, the father of botanical illustration is considered to be Cratevas, physician to Mithridates VI, a king of Pontus in the last century before Christ, though illustrated herbals seem to have been common in the Greek world by that time. From the sixth Christian century onwards, Byzantine manuscripts exist in which plants are depicted in a naturalistic manner uncharacteristic of that artistic tradition, strongly suggesting

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Plate 1. *The* Xaxocotl, *or sand sour fruit, from the Badianus herbal, 1552, Santa Cruz. It is thought to represent a guava* (Psidium guajava). *Reprinted with permission from* The Badianus Manuscript *(Vatican Library), by Emily Wolcott Emmaret, and published by the Johns Hopkins Press, Baltimore.*

that the originals were classical. What are clearly the same illustrations were repeatedly copied and with time declined in quality and in realism, so that, by the fifteenth century, it would have been highly imprudent to have used a contemporary herbal for plant identification before ingestion! The illustrations by then were crude formalized caricatures of their classical antecedents. It is interesting that it was not Otto Brunfels himself who was responsible for the reawakening. He had initiated the *Eicones* from a strictly traditionalist viewpoint, with rather formalized, though elegant, illustrations of eastern Mediterranean plants from the classics which the townspeople of Bern would be unlikely to have seen. Soon, however, one Hans Weiditz took over the project. He and his assistants had the brashness, the sheer lack of good education, to introduce the wild flowers of the Bernese Oberland into the manuscript, plants which Brunfels dismissed as *herbae nudae* — destitute weeds. But they were drawn from life, and with a grace and accuracy never seen before. The illustration of the Pasque Flower, for instance, was of such quality that it was used for the type description of *Pulsatilla vulgaris* by Linnaeus two centuries later.

The great majority of individual plants illustrated up to that time were herbaceous. Only occasionally were trees represented, as in Serapion the Younger's *Herbolio Volgare*, which was compiled in Padua from an Arabic original during the last years of the fourteenth century. The technique used here is exemplified by the pine where a fine branch, with needles and cones, is superimposed on a grotesque tennis racquet of a tree. Here the plant is not depicted to illustrate its habit, but merely as a plinth for the presentation of one branch. More often, a branch alone would be illustrated, often with a formalized rootstock to give a sense of completion. Such is the case in several illustrations of woody plants in another exotic production, the *Badianus Herbal* of 1552 (pl. 1). This herbal, which is in the Vatican Library, was prepared by two Aztecs in the College of Santa Cruz in New Spain, and is the earliest work on the flora of the New World, and the earliest American medical text besides.

Jacob van Ruisdael (1628–1682) lived at the time when the florilegium, an anthology in the literal sense, was born. Until the seventeenth century, botanical illustration had been confined to herbals, which are treatises on medicinal plants. Now more comprehensive scrutiny was made of the entire plant world. The precise illustration of plants in botanical and horticultural compendia was greatly facilitated by the use of intaglio prints, as seen in Crispijn van de Passe II's *Hortus Floridus*, published in Arnhem in 1614. Abraham Munting's *Waare Oeffening der Planten*, published in Amsterdam in 1672, though noteworthy for the descriptions it contained, illustrates trees in the manner typical of the time with depictions of detached twigs, fruits and flowers. A rare example of the illustration of a whole tree is found in a natural history encyclopedia, *Historiae Naturalis de Arboribus et Plantis*, published in Frankfurt in 1662 by John Jonston, who also compiled volumes devoted to fish, reptiles, insects, and birds. Amid the usual depictions of separate tree parts, there is a single plate showing a whole pear tree, but it is a decorative illustration, clearly not taken from life, neither the entire tree nor its parts. As we shall see, Munting might have hastened the development of scientific tree illustration by several hundred years had he only consulted his fellow-citizen Jacob van Ruisdael.

Parallel but not entirely separated from this tradition was the awakening of interest in the natural world displayed by Renaissance artists. Leonardo da Vinci (1452–1519) south of the Alps and Albrecht Dürer (1471–1528) to the north both produced accurate drawings of herbaceous plants, done from life, that are legion today. Their studies anticipate Brunfels' *Eicones* by over a century. These artists must therefore be regarded as the true pioneers of botanical illustration. Trees crept into Renaissance paintings, first as individuals viewed through a window or in the distance behind an architectural setting, and later as components of more complete landscapes. Leonardo painted a variety of tree shapes but, apart from palms, few kinds are recognizable through depiction of diagnostic features of the whole plant. Even when details are manifest, Renaissance trees remain unidentifiable except in the most obvious cases. For example, Sandro Botticelli's (1446–1510) *Primavera* of c.1478 boasts a precocious Seville orange tree, simultaneously flowering and fruiting, and with its distinctive winged leaf-stalk indicated. A northern counterpart is found in the famous Ghent altarpiece, completed in 1432 by Jan van Eyck (c.1390–1441), where the painstaking representation of leaves and fruits betray a lumpy tree to be an apricot. When the subject is Adam and Eve in the Garden of Paradise, the apple tree is obligatory, be it in the Prado picture by Titian (1477?–1576) or in one of the many essays engraved or painted by Dürer. But these tree depictions are but a partial advance on Serapion's, for only a part of each tree is included, again apparently to show off features of leaf and fruit; the form and branching habit, features of bark and trunk remain ignored. It is curious, incidentally, that the columnar Italian cypress, *Cupressus sempervirens* var. *sempervirens*, so universal a part of modern Italian landscape, rarely entered paintings at this time, though their distinctive shapes do appear, for instance, in the formal background of Leonardo's *Annunciation*, in the Uffizi. This suggests that the tree was only widely introduced from the south relatively late, at the time when the great Baroque gardens were developed, and were still young plants during the Renaissance. This is suggested also by the modest size of the cypresses found in Giusto Utens' late sixteenth- and early seventeenth-century paintings of Florentine gardens.

Remarkably when Jacob van Ruisdael took up his brush in the mid-1640s as a seventeen- or eighteen-year-old with a keen and penetrating interest in the countryside surrounding his home in Haarlem, he became the first artist to depict a variety of trees which are unequivocally recognizable to the botanist on account of their overall habit. To be sure, ever since Dürer executed the earliest known watercolor of a fir tree about 1495–97, now in the British Museum, the occasional artist, especially in the Netherlandish school, did produce the occasional identifiable tree. Of particular note, Hugo van der Goes (?–1482) of Ghent demonstrated great skill in the winter skeletons of trees in his celebrated Portinari altarpiece. Their fluted and fissured trunks, horizontal twigs with shoots of unequal and variable length, and a few persisting leaves, suggest that they are elms, though the trees have a rigid primitive quality. By May 1483 the famous triptych was sent from Bruges by its donor Tommaso Portinari to the Hospital of Santa Maria Nuova in Florence where it remained until it entered the collection of the Uffizi in 1900. Van der Goes' work was collected also by the Medicis and became influential among the contemporary Florentine school.

In the decades preceding Ruisdael's activity, a gradual process had taken place in Netherlandish art, especially in prints, through which the tree emerged as an independent motif, eventually constituting the subject of a finished work of art. The heroic tree — a single, monumental tree standing in splendid isolation — found its supreme expression in the works of Jacob van Ruisdael. As the subject developed, the artists interested in it turned to nature for direction with increasing frequency. Roelant Savery (c.1576–1639), for example, made a sketch in black chalk of a fir tree, now in the Darmstadt Museum, which has all the appearance of a botanically accurate "on-the-spot" notation; yet the deciduous trees in his etchings and paintings are so mannered that not a single feature decides the genus. The oak was a clear-cut favorite with the Dutch landscapists for the role of heroic tree. Jan van Goyen (1596–1656) made an oak tree the subject of the Hermitage painting dated 1634, and Hercules Segers (c.1590–c.1633) devoted one of his rare etchings to a country road dwarfed by large oaks (unique impression in the British Museum). In both cases one or two characters serve in the identification of the tree. Other features, like the romantic bend in the trunk of Van Goyen's oak, have little to do with the natural specimen. We suspect that the popularity of the oak rested in no small part on the fact that it is a "characterful" tree making it easier to describe than many others. Willows are even easier to recognize in seventeenth-century landscapes, but only by inference through their siting along waterways, and on account of their being pollarded (successively lopped, for firewood and poles, above the head height of browsing cattle). Our search of the works of the Dutch school has failed to unearth a single master before Ruisdael who depicted a variety of trees using a suite of independent characters that are botanically diagnostic. In this light Holland's greatest landscape painter can be truly regarded as the father of tree illustration.

Our ability to recognize Ruisdael's trees is aided by the fact that his complete arboreal repertoire, with the notable exception of the Norway Spruce, was established during his formative years spent in the circumscribed landscape surrounding Haarlem in North Holland. Born in Haarlem between 1628 and 1629, Jacob lived there until about 1656 or 1657 when he made the short eighteen-kilometer move to Amsterdam where he remained until his death in 1682. Except for a journey to the border region between the eastern provinces of the Netherlands and western Germany about 1650 (there is an inadequately supported theory that he travelled through northern France about 1676 to study for a medical degree at the University of Caen), Jacob's travels were close to home. His paintings and drawings document visits to Egmond aan Zee, the countryside near Naarden, Alkmaar, the ruins of a castle and abbey church at nearby Egmond aan den Hoef, and of course the Portuguese Jewish cemetery at Ouderkerk on the Amstel River; all are in North Holland. During his *Wanderjahre* in the early 1650s, the artist ventured as far as Bentheim in Westphalia, about 175 kilometers from Haarlem. Besides numerous versions of the castle at Bentheim (one is dated 1651, another 1653, see pl. 2), he painted from the province of Overijssel the town of Ootmarsum and various water mills and sluices in the Twente. On this same tour he most probably travelled south to the province of Utrecht where he made several sketches of the distant view of Rhenen.

These were early times for plant introduction, and almost a century before the major epoch for the introduction of ornamental trees began. Ruisdael's limited arboreal repertoire in his early work reflects in a large measure the peculiarities, but in particular the poverty, of his native flora. Haarlem lies in sandy country immediately behind the mighty dune system which protects Holland from the fury of the North

Plate 2. *A detail of Ruisdael's painting of* Bentheim Castle *(1653, Beit Collection, Blessington, Ireland. Cat. No. 14), showing the imaginary wayfaring tree blooming at the base of an imaginary castle mount.*

Sea gales. This is poor agricultural land, and the trees of fertile and limestone country would be rare in the native vegetation. With its proximity to Amsterdam though, the Haarlem region became a center for the great hunting estates of the wealthy, and thus the oak forests that were the primeval cover to these thrifty soils were preserved, or periodically felled and abandoned after which the clearings would be invaded by beech. According to Karel van Mander (1548–1606), the Dutch mannerist painter and theorist, Haarlem also had a wood that had the character of a public park, or, in his words, was like a village fair. In his poem in praise of the town, composed in 1596, Van Mander tells us that south of Haarlem was its "forest" where young and old amused themselves, by sauntering and walking, picnicing and lying down in the green. He added: People, like clothing, sometimes must be aired. Around Haarlem there also would have been small farms, with orchards and hedgerows and derelict buildings around which elms, apples, elders, and hawthorns would have grown.

Ruisdael describes the oak, beech, elm, elder, wayfaring tree, apple, hawthorn, and the inevitable willow. Missing are the poplars, linden, field maple, and hazel, but that is not surprising as these genera of fertile or limy land would have been rare or even absent around the Haarlem of his time. One might have expected to find in his works the ash, aspen, alders, sweet-chestnut, birch, hornbeam, and the English "sycamore," *Acer pseudoplatanus;* also the small hedgerow trees including cherry and dogwood. The sycamore, a tree from south of the Alps which already had been introduced into England in the middle ages, is easy enough to distinguish with its smooth bark and its dense compact rounded crown with palmately lobed leaves. This crown and bark seem to have been the universal favorite of the contemporary French painter Claude Lorrain (1600–1682), who worked in Rome, though the leaves he placed on his trees more resemble those of the sweet-chestnut! The silver birch, *Betula pendula*, too, with its delicate foliage, pendant branches and black and silvery bark is unmistakable, as to a lesser extent is the aspen. The others, however, are more or less difficult to depict from their general habit, leaf size and disposition alone. It should be borne in mind that many of the trees in Ruisdael's paintings are unidentifiable, though rarely when serving as a major foreground subject.

One tree appears in Ruisdael's paintings that we do not believe he ever actually saw. This is the Norway Spruce, *Picea abies* (pl. 3), which is now a well-known exotic, and, since it had been introduced into England by the end of the sixteenth century, contemporary introduction to Dutch soil is a possibility. However, Ruisdael's spruces lack the detail of his other trees and we would not be able to distinguish them from other conifers were they not placed into landscapes we recognize as "Nordic." Not until about 1660, four or five years after his move to Amsterdam, did Jacob begin painting northern landscapes replete with powerful cataracts, huge boulders and towering spruces. These motifs were not known from direct observation but

Plate 3. *Ruisdael's Norway Spruce. From* Waterfall, with a Castle and a Cottage *(detail). Fogg Art Museum, Harvard University, Cambridge, Massachusetts. Gift of Miss Helen Clay Frick. Cat. No. 34. Uncharacteristically, van Ruisdael failed to capture the distinctive pendant lateral twigs of this species.*

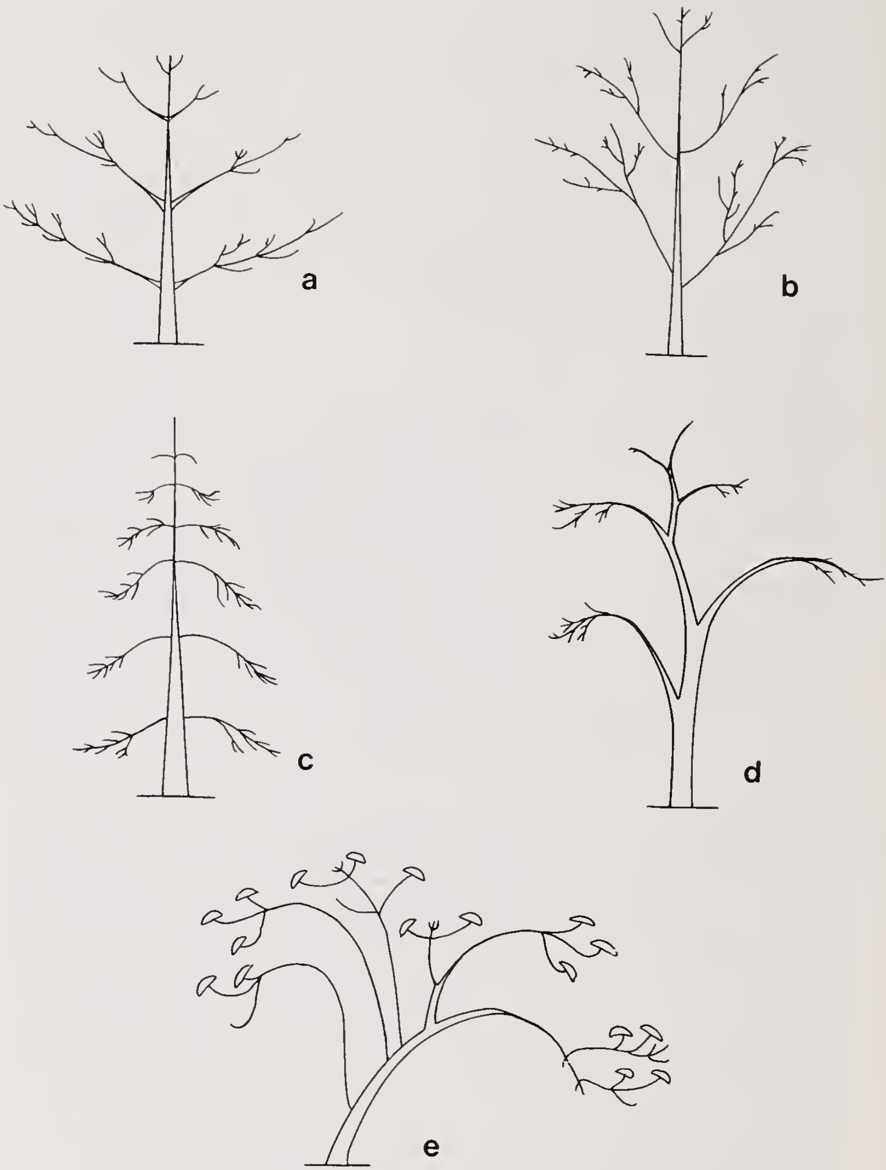

Plate 4. *The pristine branching patterns of Ruisdael's trees, which are revealed in young plants before reiteration: (a) the oak, (b) the hawthorn, (c) the spruce, (d) the beech and the elm, and (e) the elder.*

were borrowed from the *oeuvre* of the Alkmaar artist Allart van Everdingen (1621–1675) who introduced and popularized northern landscape in the Netherlands. Everdingen had travelled to southern Norway and Sweden in 1644. He settled in Haarlem in 1645 and was active there until 1652 when he moved to Amsterdam. Ruisdael probably was familiar with Everdingen's Scandinavian landscapes as a young painter in Haarlem; but he did not adopt the subject himself until the vogue for it was well-established in the leading city of the United Provinces. Market considerations seem to have played a hand. In an inventory of 1669, all three of Ruisdael's waterfalls listed fetched considerably higher prices than his lone *Haarlempje*.

The reader will be surprised to learn that the shapes of trees, which are determined by the way they grow and branch, has only been comprehensively and systematically described in the last two decades. Indeed, the botanical illustration of tree form, lacking a historical precedent in the herbal tradition, only began this century. We owe this to the French botanist Francis Hallé and his Dutch colleague Roelof Oldeman. In collaboration with Barry Tomlinson here at Harvard, they have now set their classification of tree architecture in the broader context of growth and forest dynamics. These authors recognize 23 basic architectural models to which trees can be assigned, many of which are restricted to the tropics.

We can identify Ruisdael's principal arboreal subjects to their genus because the artist depicted more than one independent character by which they can be diagnosed. Beyond the genus we cannot go, for the species too often differ in details of leaf, flower, or fruit that are not manifest at a distance.

The oak is the outstanding example of Ruisdael's skill, for the tree itself provides such a wealth of characteristics. Among Ruisdael's trees, the oak, and the hawthorn are built on the same architectural model, though they differ considerably in detail (pl. 4). Its branches arise in whorls, like the spokes of a wheel, and steeply ascend from their origins on the perpendicular trunk. The branches in turn bear their twigs in the whorled manner of the trunk itself. The flowers and fruit are borne in axillary inflorescences and do not influence the branching pattern.

In practice, the basic architectural model of a tree is lost early in life through natural damage and repair, though the ascending twigs and leaf arrangement of the oak persist as evidence as we shall see. Old oaks become stag-headed, that is to say that whole branches die back without, at least in the short run, falling off, rotting and thereby anticipating the death of the whole tree. The northern European deciduous oaks *Quercus petraea* and *Q. robur* commonly live for three centuries, and the oldest known individuals are more than twice that age. They reach full height within a century. Once the crown has fully expanded, it will maintain itself for several centuries by successive dieback and replacement of whole branches, the trunk meanwhile continuing to expand and the tree thereby assuming an increasingly

Plate 5. *An oak twig. Dead parts are black.*

venerable demeanor. The process of replacement, of dead twigs and branches, by shoots from adventitious buds from beneath the bark, is part of the process collectively known to botanists as *reiteration.* Reiteration of whole branches is a characteristic of the oak and the elm alone among Ruisdael's trees. Both trees, but the oak in particular, support an extraordinarily large and diverse insect fauna. The capacity to reiterate may be regarded as an adaptation to withstand their onslaught as may also, in the oak, the ability to put on a second flush of leaves if the first is devoured by gypsy moths or other herbivores. In Europe the second flush is called the lammas, as it unfolds in early August about the time of the ancient harvest festival of that name. These are some of the reasons why oaks bear such gnarled boughs, and why the trunks of free-standing trees bear swellings from which suckers can arise. In point of fact, even young oak twigs have a tendency to reiterate, as can be seen in our diagram (pl. 5) of an oak twig viewed from below. None of these features escaped Ruisdael's notice. Foremost an artist, he recognized the pictorial potential inherent in two aspects of the oak's capacity for reiteration. One is the venerability with which the persisting dead branches endow the tree. Fond of pairing oak and beech, he also used the uniformly brown autumnal leaves of the beech (a tree with a lower capacity for reiteration) as a foil for the lively play of green and brown with specks of yellow and white in the foliage of the oak, a result in part of its hosting leaves in different stages of maturity.

Taken from life, the diagram demonstrates a suite of further characters by which the oak is distinguished. The limbs are much

 

Plate 6 (left). *A detail from The Great Oak by Jacob Van Ruisdael, 1652. Anonymous loan to the City Museums and Art Gallery, Birmingham. Cat. No. 16.* Plate 7 (right). *The trunk of the ancient oak depicted on the back cover. Photograph by P. Ashton.*

branched and, though the twigs are many, they extend rather little each season. Though the twigs at the branch extremities tend toward the horizontal, the others ascend sharply. The leaves are borne spirally towards the end of the shoot, and it is from their axils that the next season's whorl of twigs will arise. The leaves broaden towards their apices and bear, in European deciduous oaks, a pronounced wavy but not toothed margin. Though leaves on one shoot do not overlap one another, those on neighboring shoots do, so the leaves on a branch create a wavy-margined silhouette not dissimilar to that of the individual leaf. Ruisdael captured this brilliantly. His mature technique was to paint enlarged oak leaf shapes. Each leaf is clearly shown in the Brunswick oak tree (cat. no. 17), datable to the early fifties, whereas generalized leaf clusters are noted in the Worcester College oak (cat. no. 18), painted a few years later. In both pictures, the crown of leaves is enhanced by shading and by the patchy introduction of autumn color. He demonstrated remarkable skill at describing the location of leaves in relation to the crown as a whole. They are perceived in a seemingly endless array of positions over and under the branches and twigs. Other Dutch landscapists usually failed on this very point, either brushing in branches that seem to hover unnaturally in front of the foliage, or suppressing the tree's structure as far as they dared. The most talented (Van Goyen, Jan Both, Hobbema), trying to elucidate the precise branching mode of the oak, artificially exposed the limbs by arranging the leaves in regular two-ranked fashion, but

Plate 8. *A drawing, from life, of the twig of European beech. In life, this twig would have been horizontal.*

this device falsely represents the leaf arrangement. Jacob's more impressionistic solution is an honest compromise and achieves greater botanical accuracy.

Finally, the oak has fissured bark. The fissures are rather narrow, with flat, narrow flaking intervening surfaces which, in the cool damp climate of northern Europe, accumulate moss and lichens (pls. 6,7). Again Ruisdael perceptively caught this subtle additional combination of characters.

The habit of the European Beech, *Fagus sylvatica*, stands in stark contrast in almost every respect, even though it belongs to the same family as the oak. It shares its architecture with the elm. The sapling leader, starting erect and with spirally arranged leaves, early grows into a horizontal position when the leaves become distichous, that is to say in two ranks. Though this axis will straighten up to some extent as it matures, the trunk will be built, season by season, from successive axillary shoots each of which terminate growth with a horizontal apex in the same way. This cumbersome procedure is, surprisingly, the most widespread mode of growth among broad-leaved trees. It is remarkably versatile though. In the beech the tendency for the trunk to branch, and the absence of vertical twig endings, even in the top of the crown, are the only vestiges of the model in the mature tree. Because each successive axial shoot contributes the greater part of its length to the trunk, which straightens up as it expands, its mode of growth is

Plate 9. *Detail of beech twigs in Ruisdael's painting of the Portuguese Jewish cemetery at Ouderkerk. The detail has been rotated to facilitate comparison with plate 8. Courtesy of the Detroit Institute of Arts, Detroit, Michigan (Gift of Julius H. Haass in memory of his brother, Dr. Ernest W. Haass. Cat. No. 20).*

soon obscured. The only architectural feature shared by beech and oak is the lateral position of the inflorescences.

Beeches have a lower capacity for reiteration, and dead branches are brittle, falling early. Our diagram of the twig (pl. 8) indicates the pattern of branching, which is more regular than in the oak. The shoots are of two distinct types. Most apical, and some lateral, extend many centimeters a year, whereas the majority of lateral shoots extend less than two centimeters each season. This gives the impression that beech twigs branch less frequently than those of oak. What our diagram cannot clearly indicate is that the lateral branches of twigs are horizontal. In combination with the entire margins of the shiny, elliptic leaves, the greater annual extension of the terminal shoots relative to those of the oak, the decline in the size of the leaves towards the twig endings, and the tendency of the principal branches to bear horizontal or slightly ascending twigs on declining or recumbent limbs, the detailed structure of the crown is very different from that of the oak. Ruisdael emphasized the sweep that this combination of characters gives to the outermost branches of the beech, and frequently also, as in the tree overarching in the Detroit version of the *Jewish Cemetery* (pl. 9), by describing the individual leaves. In forest-grown beech, the horizontal banks of leaves tend to form a dense single carpet at the top of the crown. In the absence of reiteration from the trunk, they form tiers of discrete leafy platforms in

Plate 10. *Details of the beech (right) and oak trunks from the painting on the front cover. The Norton Simon Foundation, Pasadena, California. Cat. No. 38.*

Plate 11. *Mature Beech at Mark Ash, New Forest. The tree on the left was coppiced in the seventeenth century. Photograph by P. Ashton.*

free-standing trees, and were thus depicted by the artist. The trunk itself is, of course, extraordinarily smooth, finely but distinctly hoop-marked and, in the relative absence of lichens and mosses, ashen (pl. 10). The character of the beech trunk is unmistakable in Ruisdael's paintings (pl. 11).

The architecture of elm, its pendant branches, and the branching pattern of its twigs are similar to those of the beech though the architectural construction often remains more manifest in the arching trunks and branches of the mature tree. But it is not for these reasons alone that, as Jacob indicated in his drawing (pl. 12) of a specimen of this tree, the crown has an irregular untidy appearance. This untidiness is, in part, a result of the tendency for elm branches to die back and reiterate as in the oak. In contrast to those of beeches, elm leaves are also asymmetrical, hang, are curled up along the midrib or down at the ends, while it is the largest leaves that are concentrated at the twig endings (pl. 14). These together impart a different and ragged appearance to the crown. Elm trunks are fissured and often twisted (pl. 13). The surfaces between the fissures are wide and flake irregularly, as Ruisdael so deftly exploits in his painting (pl. 15) of a shattered elm, its identity confirmed by a few persisting leaves.

The many small European trees of open places which belong to the Rosaceae, including the hawthorn, *Crataegus monogylnia*, the crab, *Malus sylvestris*, and cultivated apples and pears, share a distinctive habit. Their architecture, though resembling the oak, differs because the side branches are arched and turn towards the horizontal. Even

Plate 12 (left). *A drawing by Ruisdael of an elm. Detail from* Sun-dappled Trees at the Edge of a Stream. *The Pierpont Morgan Library, New York. Cat. No. 66.* Plate 13 (right). *Trunk and branch of an old English elm,* Ulmus procera, *at Kings College, Cambridge. Photograph by P. Ashton.*

without pruning, the leader soon loses its dominance, often also growing over to a horizontal position. Successive side branches arise, often from the upper surface of existing members, and themselves arch over to give the whole crown its distinctive appearance. Like the beech and elm, but not the oak, twigs bear dimorphic shoots, some of which in hawthorns are modified as thorns. Ruisdael painted several such trees (an example is found in *Pond in the Forest* in the Fogg, not in the current exhibition). It is only from their habitat in this case that we can guess whether they are thorns or unpruned fruit trees, though his pruned apple (pl. 16) is recognizable at once. Similarly, pollarded trees may be presumed to be willows (pls. 17,18), although they could be poplars or even elms, all of which have been commonly pollarded since the middle ages. In a very few cases though, willows in full leaf also are illustrated (see cat. no. 10 and pl. 18; cat. no. 75). It is interesting that pollarded trees appear infrequently in the work of this painter in comparison with that of many of his contemporaries. They abound in the etchings, drawings and paintings datable to the first year of his activity; thereafter his interest apparently shifted to the more complex trees of the old forests.

The habit of the Norway Spruce with its monopodial, that is perpendicular unbranched, trunk developed from a single annually extending leader; with its whorls of plagiotropic, that is horizontal or descending, branches which, unlike the trunk, bear distichous leaves

Plate 14. *An elm twig in leaf. This is the European smooth elm,* Ulmus carpinifolia. *Photograph from the archives of the Arnold Arboretum.*

and branches; and its dark foliage is unmistakable from broad-leaved trees, even when painted at second hand (see pls. 3,5)!

In addition to these trees, Ruisdael unmistakably depicted the shrub *Sambucus niger*, the elder (pl. 19). The botanist would identify this plant by its opposite pinnate leaves and by its broad flat inflorescences bearing dense masses of tiny tubular cream flowers (pl. 20). The habit too is characteristic. The trunk is built up by a relay of shoots much as in the beech and elm, but here each sappy shoot, standing erect, comes to arch over at its ends under the weight of its fruit, following which one or several new vertical shoots may sprout from the upper side. Unlike the beech and elm, therefore, it is the inflorescences which enforce sympodial growth through the sprouting of axillary buds. Ruisdael's elder shrubs are recognized by their disc-like white inflorescences, by a general impression of their habit, and by the pains he took to set them against a dark background, offsetting their distinctively pale green, narrow leaflets. He could have, but did not, indicate the characteristic opposite branching and pinnate leaves. Nevertheless, there is no other native shrub in the Haarlem region with which his plants could be confused.

Some of his "elders," though, have narrower, more domed inflorescences than is usual for this species. Examples may be found in several paintings (see pls. 2,21). Our suspicion that these are not elders is further strengthened by their dark foliage, the clearly indicated broadly elliptic-ovate simple leaves, and their placement as small

Plate 15. *The blasted elm in Ruisdael's* View of Egmond aan Zee *(1648), in the Currier Gallery of Art, Manchester, New Hampshire. Cat. No. 7.*

dense shrubs in open places. There is only one other northern European genus to which these plants could belong: *Viburnum,* in the same family as elder. *Viburnum*, like elder, is a glutton for good fertile ground, but keeps to old vegetation and is not associated with habitations. The architecture of *Viburnum* is complex, as Michael Donaghue explained in his recent article in this magazine, but Ruisdael's small bushy plants, which appear to have been lopped or browsed as is still customary, reveal nothing of their branching pattern. These plants clearly match the lime-loving *V. lantana* (pl. 22), the wayfaring tree. The wayfaring tree is very local in Holland. In Heukel's flora of 1911, it is recorded from some seven localities, one of which was Haarlem, another Santpoort a few kilometers to the north. The 1980 atlas to the Netherlands flora provides a map, and commentary by R. W. J. M. van der Ham who concludes that the only reliable records prior to 1950 are the two near Haarlem and three, hundreds of kilometers away, in the chalk hills in the extreme southeast of the country. The species has since then spread to several other localities down the coast (see pl. 23). By including this plant in his coastal scene of 1648 (pl. 21), where it is shown near the base of a dune where rich flushes of groundwater, arising from shell accumulations in the old beach sand, form limy patches, and in precisely the habitat at which it occurs at present, Ruisdael seems to have demonstrated exceptional mastery of his local flora. The great Linnaeus, who stayed as a young

Plate 16. *An old apple tree, with the shoots following pruning in the previous spring clearly indicated. Detail from* Winter Landscape with a Windmill, *Foundation Custodia (Coll. F. Lugt), Institut Néerlandais, Paris. Cat. No. 53.*

man at Hartecamp, estate of Georg Clifford, to compile the celebrated *Hortus Cliffortianus*, completed in 1737, included this species. However, he cited it from Alsace, England, France, Switzerland, Etruria, and Italy, but apparently was not aware that it grew within a few miles from where he wrote! Indeed, it was first recorded in the Netherlands only in 1861, and then at St. Pietersberg in the extreme southeast.

We evaluate Jacob van Ruisdael's achievement as a botanical illustrator fully cognizant that the trees executed by the eager youth differ both technically and thematically from those of the seasoned artist. His development as a painter of trees is, of course, part and parcel of his artistic development as a whole. If we were asked to designate the handful of years when he peaked as a scientific illustrator of trees, it would be from the end of the sixteen-forties into the mid-fifties.

In his very first pictures, those of 1646 (see pl. 18), Jacob lavished particular care on trees and shrubs, recalling the almost microscopic attention to detail exhibited by Dürer in his watercolors of herbaceous plants. The young artist applied his paint from a laden brush point in miniscule but distinct thick dabs. He gives the impression of each leaf accounted for in the foliage and builds up moss and lichen on bark with layers of paint so sculptural in quality that our tactile senses are aroused. Yet, he still was learning how to translate the forms he saw

Plate 17 (left). *An old pollarded willow, and behind it an oak, on the banks of a stream. From* Landscape with a Cottage, *1646. Kunsthalle, Hamburg. Cat. No. 1.*
Plate 18 (below). *A pollarded crack willow,* Salix fragilis, *near Weston Zoyland, Sedgemoor, England, which, as its name suggests, was settled by Dutch drainage engineers in the era of Jacob van Ruisdael. Photograph by P. Ashton.*

in nature into paint on canvas — these first efforts are on a par with Van Goyen's best oaks, falling short of complete botanical accuracy. In the next few years, as Jacob mastered the various characters that identify trees, they assumed a more assertive role in his landscapes.

Frederick Law Olmsted used to comment on the sedateness of west European woodlands. This quality is largely attributable to the persistence until modern times of venerable oaks in the landscape, particularly as isolated trees but also in ancient woods and forests. *Grandeur* is the outstanding quality of Ruisdael's trees. And the grandest of his trees, usually oaks, appear in the early sixteen-fifties. Botanically accurate and enlarged to heroic proportions, they dominate the compositions. By the mid-fifties, we find these giants pushed back from the foreground into the middle distance where they create an impression of sedateness and help serve in the clarification of a more orderly space. Jacob's paint continued to be grainy and his colors relatively vivid. The skill he had acquired as botanical illustrator is well exemplified by his handling of the tree trunks in the forest scene at Worcester College, Oxford (cat. no. 18). Here, oak is placed next to beech. Where ravaged bark has peeled away, the paint is thin; light brown or brownish-orange is used to represent the tree core. Then a viscous paint, applied more broadly than in those first years, gives shape to the bark. On the oak touches of white on dark brown suggest moss and lichen; on the beech a range of pigment from black to dark grey to light grey to white captures the ashen character of the tree.

In the sixties Ruisdael continues to stress the heroic quality of massive trees but they no longer seal off the middle ground (see front cover). Their powerful forms are now combined with the effects of distant vistas. By the seventies their use as compositional accents grows more restrained. During the course of the following years the artist concentrates on panoramic views, seeking the ultimate degree of openness and height. Less interested in the confining space of deep forests, he paints marines, beach scenes, cityscapes and views of the open countryside. His paint grows thinner, his color less resonant. The mood of his landscapes shifts from heroic to idyllic. No longer is there a role for a mighty tree. Its strong vertical accent would have disrupted the subtly gradated spatial recession of his extensive vistas. The fate of the Norway Spruce is a case in point. By the early seventies firs virtually disappear from his paintings of waterfalls, their overt verticality was incompatible with the sought effect of great distance.

What we have seen, in brief, is the artist shifting his tree motifs from foreground to middle distance to background in the course of his career. And as obviously is expected, the descriptive care that went into the early trees and shrubs which served as major foreground subjects no longer is at work in the late years when they are but incidental elements observed from afar.

Our designation of the years around 1650 as the apogee of Ruisdael's career as a scientific illustrator of trees is based on several criteria. The most obvious is the accuracy with which he charac-

Plate 19 (left). *This elder sprouts from the* Ruins of Egmond Castle *in Ruisdael's early 1650's painting, now in the collection of the Art Institute of Chicago. Cat. No. 19.* Plate 20 (right). *This modern elder sprouts from the kitchen garden wall at Cliveden, the Astor's former English home. Photograph by P. Ashton.*

terizes his various trees at this time. A second involves the question of habitat. Jacob's fondness for the wayfaring tree is manifest by its prominent position in the foreground of his most impressive painting of Bentheim castle, dated 1653 (see pl. 2). According to Hegi, the wayfaring tree has not been recorded in the Bentheim region. This raises an important point regarding Ruisdael's approach to landscape during his early maturity. At least from the early fifties onwards, total veracity is not an end for him. He continues to render the specifics with astonishing truth — the habit of a tree, the outline of a church or town, the properties of clouds and water — but he begins to embellish the whole and, more important from our viewpoint, to ignore ecological propriety to suit the dictates of his own imagination. In the case of Bentheim, as Jakob Rosenberg demonstrated with a photograph of the site published in 1928 (see cat. no. 14, fig. 24), Ruisdael aggrandized his subject by placing the castle on a lofty mountain, whereas its true location is but a gentle hill. And now we discover the painter importing a lime loving shrub from the dunes near Haarlem to the Dutch-German border region to enliven his foreground. He took other liberties with trees. A striking example is Cleveland's landscape with a windmill of 1646 (see cat. no. 10, pl. 17), a scene Ruisdael sketched and painted again in the early fifties (cat. no. 10 and pl. 18), but with a willow replacing the oak. In an etching datable to the first half of the fifties (cat. no. 108), a powerful oak rises out of the stagnant water of a swamp. By the mid-sixties, beech joins oak in the water in some of his most celebrated wooded scenes (cat. nos. 36,37). Neither tree thrives with water-logged roots. The romantic habitat was provided by Ruisdael. (Incidentally, these trees also depart from strict botanical accuracy by exhibiting Savery-like mannnerist contortions in their trunks and branches.) A similar process took place regarding the borrowed tree, the Norway Spruce. An important motif in the early Nordic scenes, it soon acquired a foreign partner, the half-timbered house of the Bentheim region (cat. no. 34). Oddly enough, Everdingen painted "Nordic" log cabins until he was enticed by Ruisdael's example to introduce Westphalian architecture into his own waterfalls. By the end of his career, Ruisdael took the Norway Spruce out of its mountainous setting and placed it in the park of a Dutch country house (cat. no. 54), but his tendency to depart from biological veracity prevents us from confirming whether he was representing a genuine introduction.

One wonders, of course, why this painter, alone among his contemporaries, took so much trouble to make his trees identifiable. Was he motivated by interest in the tree solely for its own sake, or were the trees he painted charged for him with other levels of meaning. Long before Ruisdael's day, the studies of the Dutch humanists provided a ready vehicle for general awareness of the classical tradition. Interest in the ancient world in northern Europe reached its horticultural culmination in the first half of the eighteenth century in the allegorical landscapes contrived in English parks by William Kent (1685–1748), whose web of vistas and artfully juxtaposed scenes tested the visitor's knowledge of the ancients as if a participant in some gargantuan crossword puzzle.

The trees which Ruisdael painted are very widespread in Europe and Russia, and have been associated with the Caucasian tribes since before they spread westwards. The tree most steeped in history, allegory and ritual is without doubt the oak. It was regarded by the Romans as the first of all trees having sprouted from Rhoecus, one of the giants slain by Jupiter. Acorns are said to have once provided a staple, and are still a famine food. The oak is the tree of Zeus, and the myth that its stag-headed crown attracts lightning has persisted to the present day. The most celebrated of the sacred groves of classical Greece, at Dodona, was a mixed stand of oak and beech. The oak would have been the evergreen Mediterranean, Q. *ilex*, but its reputation would have been translated to the deciduous northern species without difficulty. Besides, oaks were already the leading tree in northern lore. They were favored by the druids, who worshipped in groves of oak and fed on acorns. Hollow knotted trees, in an ancient stand that once existed at Stove Heddinge, Zeeland, were known as the Elle-King's soldiers: By day they were indeed trees, but at night they marched off to fight for the elves. The beech, though less celebrated was nevertheless the vehicle, according to Lucian, through which the oracle was delivered at Dodona. In medieval times elders were regarded as guardian trees, and their natural tendency to establish near houses was encouraged. This custom may have originated from pre-Christian mythology. In German and Scandinavian tradition, the tree harbors a Hylde-moer, or Earth-mother: a wood spirit which avenges all harm done to the plant or its abode. In the *Voiage and Travaile* of Sir Richard Mandeville, however, it is claimed that Judas hung himself on an elder.

A clearer component of seventeenth-century Dutch consciousness than the humanists' study of the classics is derived from the popular enjoyment of emblem literature. This practice encouraged the reading of moralistic and religious meanings into the simplest objects of everyday life. Recently, Michael Loren Perlmutter, a Fine Arts graduate student at the Fogg, searching for sixteenth- and early seventeenth-century emblems of trees that might have bearing on Ruisdael's trees, came up with a wealth of examples. He linked the tall Norway Spruce in the Fogg's *Waterfall* (pl. 3) to an emblem labeled "Erectae ad Sydera Crescunt" ("They grow straight up to the stars"), showing trees growing from a mountain top and, in propounding the ideal of steadfastness, metaphorically equating height to virtue. Exposed roots, like those of the great oak tree clinging fast to an eroded bank in the Brunswick painting (cat. no. 17), he associated with an emblem entitled "Virtutis Radices Altae" (Virtues of Deep Roots"), in which the roots hold a tree firm against a storm, an analogy made with the strength of virtue resisting adversity. He pointed out the more obvious *vanitas* or *momento mori* connotations inherent in the dead or broken trees that abound in Ruisdael's landscapes, and he examined a host of Christian ideas concerning allegorical contrasts of Life and Death, Good and Evil evoked by any pairing of dead and live trees.

Besides the generalized tree iconography presented by Perlmutter, there exists a body of emblems that are specific to tree genus, which ought to be more to the point when dealing with an artist who has an unusual talent for accurate tree description. Of particular interest is Andrea Alcinati's *Emblematum Liber*, first published in 1531, and frequently reprinted. The edition published at Lyon in 1550 includes fourteen tree emblems in the customary form of motto, picture and Latin epigram. In it the oak, *Quercus*, is identified as a symbol of honor; the willow, *Salix*, as a symbol of infertility; and the fir tree, *Abies*, as signifying strength through resistance. With the exception of the oak, Ruisdael's trees are infrequent emblem subjects, more usual are trees with stronger biblical or classical identities, such as the palm, laurel, olive tree, cypress, and fig.

Despite the demonstrable richness of tree imagery, we lack clear evidence that the artist himself ordinarily intended his trees as allegorical symbols of any kind. The two versions of the famous *Jewish Cemetery* (cat. nos. 20,21) provide an important exception. (Another may be the Budapest *Oak*, see cat. no. 4.) Jacob's sketches of the actual gravesite in the Portuguese Jewish cemetery at Ouderkerk, now in the Teyler Museum (cat. nos. 76,77), show the tombs surrounded by unassertive shrubs and low trees of unspecified type. The tombs alone reappear in the Detroit and Dresden paintings; and they are set into quite a different milieu. Into both compositions the painter adds a small waterfall, a rainbow and a large ruin, and also a dead beech prominently displayed in the right foreground against a stand of living trees, a broken oak or oak stump near the rushing water, and unmistakable elder bushes as a backdrop for the central tomb. This suggests that these pictures were intended as moralizing allegories on the transience of all earthly things. And in the case of the elders, perhaps plant genus is significant. If not a specific reference to Judas, the elder has enjoyed a long history as a symbol of sorrow and death.

We may hesitate to accept Ruisdael as a persistent painter of allegorical landscape. No such qualms disturb our acceptance of him as a pioneer naturalist, antedating Gilbert White by a century. At the onset of his career he displayed a perspicacious grasp of the close marriage between native trees and their chosen habitat.

Oliver Rackham has described how the oak was the dominant tree in the primeval *urwald*, or wildwood, of northern Europe on freely draining soils; and how surviving giants often indicate where fragments have persisted. Some that remain in the great estates about Haarlem are thought to be examples. Beech is generally associated with oak in these old forests, but when abundant is indicative of past felling or natural disturbance. The elm, on the other hand, is very much a village tree; in nature confined to the fringes and gaps of the forest. Frequently pollarded in former times, its foliage provided fodder, its fibrous inner bark bast for matting, rope, baskets and, in ancient times, sandals. The hawthorn shares this habitat, while the elder, which is confined to fertile limy patches and may not have occurred in the wildwood of Haarlem, has a penchant for cracks in mortar, in walls and ruined buildings, and the middens of derelict farmyards. The wayfaring tree though, like the oak, is a plant of ancient vegetation, but of a very different and characteristic type as the painter noticed himself. Whatever the reason for Ruisdael's interest in trees, his early paintings are a valuable, unequivocal testimony of the flora in the Haarlem region of the seventeenth century, for his ancient oaks and beeches, his elms, wayfaring trees, and elders can only have been taken from life. For instance, Dr. van der Ham (personal comment and in the *Atlas*) believes that the wayfaring tree, which was first recorded in the Dutch coastal dunes in 1877, owes its origin there to relatively recent escape from gardens, in which it is frequently cultivated in Holland. The berries are avidly eaten by birds who disperse the seeds. Ruisdael's paintings provide evidence that the plant is more likely a native, and has existed there for centuries longer than previously realized.

We have made several other discoveries from our interdisciplinary study of Ruisdael's trees. First, the "stock" of trees he learned to depict as a young artist in the 1640s served him for the rest of his career. The only later addition was a tree we believe he never saw, the Norway Spruce encountered in the Scandinavian landscape paintings of Allart van Everdingen. Second, by the early 1650s, as the creation of a wider range of moods became increasingly important to him, he felt free to take liberties with a tree's natural habitat. This enabled him to transport a coastal shrub to a hilly region and to soak the roots of a giant beech or oak in murky swamp water. Third, we are missing something. Where are all the drawings, the studies made out-of-doors of the trees growing around Haarlem? Were they deemed so unimportant that they went out with the daily trash? Ruisdael's rare etchings executed between 1646 and about 1655 (only thirteen are known) afford us a clearer impression of his linear vocabulary for tree forms than the few drawings we can cite. Finally, the ease with which the botanist can identify Ruisdael's trees has several uses. There have been frequent errors concerning the genus of Ruisdael's trees which stem from ignorance of botany rather than from ambiguity in the artist's description. His beeches sometimes are identified as birches, a tree, to our knowledge, he never painted. Beeches also are confused with oaks. The detail of the great landscape illustrated on the front cover of this issue is a case in point. Actively traded in this century under the title *The Three Old Oaks*, it recently was redubbed *The Three Old Beeches*. This still is off the mark, for represented in this huge landscape is but one beech and two oaks in an almost paradigmatic exhibition of the differences between the two trees. The botanist is able to identify the foreground trees in almost all of Ruisdael's paintings, and to learn to anticipate the characters by which the painter distinguished them. It should be of more than casual interest to art historians that the instances in which the botanist is unable to identify the prominent trees in works attributed to Ruisdael's hand, like as not, involve attributions already considered dubious on purely stylistic grounds.

We became increasingly uneasy, as we prepared this article, that we were making claims for our artist in excess of his real talent. Nevertheless, these claims center around one quality of his which is rare in an artist, and so extraordinarily difficult to attain, that he does in our view possess an artistic stature greater than his current reputation. During one brief period of his life, between 1647–1651, young Ruisdael depicted trees and their landscape with such precision, such penetrating perception of the reality itself, that even the botanist today can see no distortion or schematic generalization, but a real tree as he perceives it. Yet Ruisdael, as we have seen, was no mere substitute for the photographer, for his method was to approximate on the basis of careful selection. He made conscious choices of the attributes he wished to use in order to encapsulate an arboreal character. His choices have proven right for all centuries, and are validated through the independent conclusions of the systematic botanist.

In conclusion, the painter's perception of the color and form of familiar trees can lead us to new discoveries. For instance, our realization that Ruisdael carefully coupled multicolored oaks with uniformly brown beeches sent us outside to look afresh at the autumnal

Plate 21 (below). *A flowering wayfaring tree at the base of a dune, topped by an oak, from* Dunes by the Sea *(1648), one of Ruisdael's earliest paintings, now in a private collection. Cat. No. 8.* Plate 22 (right). *A coppiced wayfaring tree, in fruit, on a chalk hill in Dorset, England. Photograph by P. Ashton.*

Plate 23. *Distribution map of the wayfaring tree in the Netherlands. The two coastal blocks represent Haarlem and Santpoort. Asterisks indicate the current natural range; blocks the confirmed natural range prior to 1950. Reproduced with permission from* The Atlas of the Nederlands Flora, *Vol. I, published in 1980 by Kosmos, Amsterdam.*

oak and beech. He had signaled for us an important phenomenon caused in part by the different capacities of the two trees for reiteration. Jacob van Ruisdael, who lived a full century before Linnaeus' *Species Plantarum* and therefore knew nothing of our modern descriptive system in botany, combined unprecedented truth to nature and pictorial genius to give us an insight which the botanist can still value. He forces us to look more carefully at what it is that gives each tree its distinction. Had botanists and artists worked more closely, the mysteries of tree architecture might have been unravelled two centuries earlier. He can even help casual visitors to a gallery be more discriminating when they next visit the nursery for a plant with which to embellish the view from their garden window.

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The Beech in Boston

by Cornelia Hanna McMurtrie

The European beech, *Fagus sylvatica* L. Fagaceae, is a majestic tree indigenous to the moist, densely shaded forests of England and Europe, which graced royal parks and grand estates. It is not surprising then that *Fagus sylvatica*, despite its beauty and widespread use in Europe during the 17th and 18th centuries, was not found in America until the early 1800's. The early American settler depended on plants for food rather than ornamental value, as indicated by planting lists of early American nursery catalogues which offer primarily fruit trees, fruit-bearing shrubs and herbaceous material. It was not until the romantic, picturesque landscape movement and real estate development in 19th century America that the European beech appeared in American nurseries.

It is not entirely clear exactly when the European beech was introduced into America. The noted Swedish botanist and horticulturist, Peter Kalm, reports seeing *Fagus sylvatica* in the woods outside Philadelphia in 1748 (Kalm, 1972), and both Washington and Jefferson include it in their planting lists. This is undoubtedly the native American beech, *Fagus sylvatica americana* (*F. sylvestris*), now

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Figure 1. *The famous beech planted in the 16th century at Newbattle, Scotland, shows the wide spreading form. On the left hand side of the tree, the pendulous lower branches have taken root, giving rise to a thicket of new stems. Reprinted from* The Trees of Great Britain and Ireland *by Henry Elwes and Augustine Henry. Edinburgh, 1906. Plate 8.*

named *Fagus grandiflora* Ehrh. (Loudon, 1842). In his 1814 and 1824 editions of *A Collection of Plants of Boston and its Environs*, Jacob Bigelow mentions only *Fagus ferruginea* or the red beech. In 1859, however, Andrew Jackson Downing, the great 19th century horticulturist, describes "the finest Copper Beech in America, fifty feet tall" (Downing, p. 150), growing on the grounds of Thomas Ash, Esq., Throgs Neck, N.Y. It would seem then that the copper beech, *Fagus sylvatica f. atropunicea* must have been introduced earlier than 1820. According to Professor Charles S. Sargent, the European beech first appeared that year in an American nursery catalogue. Another source notes that the copper beech originated first in England in 1830 with George Loddgeis (Wyman, 1971). David Hosack, founder of the Elgin Botanic Garden in New York City, America's first botanic garden and the present site of Rockefeller Center, planted the magnificent weeping beech, *Fagus sylvatica pendula* at Hyde Park, New York in the early 1800's. The exact date is undetermined.

The native range of *Fagus sylvatica* is from northern Europe to the western frontier of Russia, south to the Mediterranean and Crimea. It usually grows in pure stands as its dense shade and shallow root system suppress the growth of other species. In Europe it is found commonly on limestone soil but when planted will grow on almost any soil type.

The history of *F. sylvatica* (Figure 1) is an interesting one.

Neolithic and preglacial deposits in England show remains of the beech. It was known to the Greeks and Romans. Sixteenth century British writers speak of the beech nuts being used to fatten deer and swine. It also offers food to wildlife, shade to cattle, and was an important timber tree and source of fuel. For centuries it has been recommended for shady walks, avenues and hedges.

Literature abounds with references to the beech. Both Virgil and Pliny mention it. The Roman muses of Virgil lie beneath the shade of "beechen boughs." Pliny writes of a grove of beech trees consecrated to Diana. Crispus, a celebrated orator, considered one of these trees of such surpassing beauty that "he not only delighted to repose beneath its shade but frequently poured wine on the roots, and used often to embrace it" (Loudon, 1838, p. 1956). Robin Hood leads his merry men through beechen woods, and Germanic legends tell of the purple beech springing up from the blood of five brothers murdered in the forest. The beech is a trysting tree. Its smooth bark has recorded the names and poems of lovers from Roman times to the present: "Or shall I rather the sad verse repeat which on the beech's bark I lately writ?" (Virgil), "Who shall grave on the rind of my smooth beeches some beloved name?" (W.C. Bryant). Although Shakespeare does not mention specific tree species in any of his works, he must have had the beech in mind when Orlando says, "These trees shall be my books and in their barks my thoughts I'll character . . . Carve on every tree" (As You Like It, Act III Scene 2). Keats' nightingale sings in "some melodious plot of beechen green." From America Robert Frost describes the beech in his poem "A Boudless Moment":

"He halted in the wind, and what was that
Far in the maples, pale, but not a ghost?
. . . . A young beech clinging to its last year's
leaves."

Perhaps the most famous poetic reference is Thomas Campbell's (1805) "The Beech Tree's Petition":

"Oh, leave this barren spot to me!
Spare, woodman, spare the beechen tree!
Though bud and flow'ret never grow
My dark unwarming shade below;
Nor summer bud perfume the dew,
Of rosy blush, or yellow hue;
Nor fruits of autumn, blossoms born,
My green and glossy leaves adorn,
Nor murmuring tribes from me derive
Th' ambrosial amber of the hive;
Yet leave this barren spot to me
Spare, woodman, spare the beechen tree!
. . . .

Figure 2. *A 1903 photo of beech woods at Slindon Wood near Petworth, Sussex. One of the trees is 90 feet tall. Once acre of 60 trees averaging 150 feet yields 9000 cubic feet of timber to the acre. Reprinted from* The Trees of Great Britain and Ireland *by Henry Elwes and Augustine Henry. Edinburgh, 1906. Plate 6.*

Since youthful lovers in my shade
Their vows of truth and rapture made,
And on my trunks' surviving frame
Carved many a long forgotten name . . .
. . . .
As love's own altar, honour me:
Spare, woodman, spare the beechen tree."

Such quotations already give a good description of the form of the beech. Of all the forest trees, it is the most recognizable for its smooth, silvery-gray bark. In its native habitat, it is known for its wide spreading form (Figure 1) or as a smooth, tall column if growing closely together with other beeches in a forest grove (Figure 2). *F. sylvatica* was used as an avenue tree in Europe in the 17th and 18th centuries, but its tendency to branch down to the ground necessitating laborious pruning brought an end to this landscape use of beeches. The beech is attractive at every season. In the spring the new foliage of the beech is "one of the most beautiful objects in nature in May — a tender, shimmering green of a shade not quite matched by any other tree" (Bean, 1951, p. 5). In summer, the shade it provides also has no equal. The fall foliage of the many varieties of *Fagus sylvatica* turns brilliant hues of orange, red, purple and russet brown in comparison to that of the American beech which turns a rusty-yellow color. There are other differences as well. The leaves of *F. sylvatica* are shorter and less coarsely toothed, ovate or elliptic-acute versus the ovate-oblong and acuminate leaves of *F. grandifolia*. The petiole of *F. sylvatica* is more pubescent and the buds are smaller. The trunk and the whole tree is shorter, and the color of the bark is slightly darker gray. It does not sucker like the American species, and the exposed roots of the mature *F. sylvatica* form great swellings at its base. The wood of the European beech is hard and brittle. It is prolific in varying forms, lasting for centuries, which include many purple varieties, and also cut-leaved, columnar, weeping, round-leafed and twisted forms. The weeping form (*F. pendula*) has several magnificent examples in the New York area which are over 150 years old.

Because of the richness of variety of *Fagus sylvatica* (Bean, 1976, in his monumental encyclopedia, lists 23 clones), I will limit my observations to the typical form of *Fagus sylvatica* and two of its most widely used color variants, the purple beech and the copper beech, both now classified as *Fagus sylvatica* f. *atropunicea** (Rehder, 1949). The examples used are limited to Boston, Brookline and Cambridge. It is obvious that many other magnificent specimens exist in Boston and environs which could not be mentioned here.

It would be difficult to describe the European beech's attributes for landscape use any better than J. C. Loudon, the well-known English horticulturist:

> "As an ornamental tree for the park and lawn, especially near the mansion, the beech has many important advantages. Though its head is more compact and lumpish than that of the oak, the elm or the ash, yet its lower branches hang down to the ground in more pliant and graceful forms than those of any of these trees. The points of these branches turn up with a curve. which though not picturesque, has a character of its own, which will be found generally pleasing. The leaves are beautiful in every period of their existence; nothing can be finer than their transparent delicacy, when expanding, and for some weeks afterwards. In summer their smooth texture, and their deep, yet lively green, are highly gratifying to the eye; and the warmth of their umber tint, when they hang on the trees during the winter season, as contrasted with the deep and solemn green of pines and firs, has a rich, striking, and most agreeable effect in landscape" (*Arboretum Britannicum*, 1838, p. 1965).

The European beech played an important role in the 19th century

* In the nursery trade the purple beech is often called variety *purpurea* and the copper beech variety *cuprea*.

landscape movement in America which brought the English landscape into American suburbs, 'rural cemeteries' and city parks. The influence of 19th century American authors in their writings about the American wilderness, forests and agriculture, and about their travels abroad shaped an attitude toward nature and design of the land. Frederick Law Olmsted, Washington Irving and James Fenimore Cooper all recorded their trips abroad, including descriptions of English park scenery and the gigantic trees in the landscape. The 19th century American romantic view of nature as a work of art, growing out of the 18th century English view of the picturesque, classical and naturalistic landscape, called for the use of large trees with beauty, distinctive form, foliage and color. The smooth-barked beech with the soft and flowing lines of its branches set against a smooth, crisp lawn, embodied the picturesque and beautiful (or classical) attributes applied to the landscape by the 18th century landscape gardener, Humphrey Repton. Downing and his followers recommended the use of large ornamental, exotic shade trees for the American front yard. The copper beech was often used.

Boston and its environs provides an excellent example of romantic landscape and picturesque parks. In fact, Robert Morris Copeland, the 19th century landscape gardener and town planner, and author of *Country Life*, who emphasized the design and maintenance of ornamental grounds, wrote a pamphlet about Boston entitled "The Most Beautiful City in America." Downing, who through his writings and journals, had a great influence on the American landscape, was enormously impressed by Boston. "The environs of Boston are more highly cultivated than most of any other city in North America. There are here whole rural neighborhoods of pretty cottages and villas, admirably cultivated . . . The owner of a small cottage residence may have almost every kind of beauty and enjoyment in his grounds that the largest estate will afford so far as regards the interest of trees and plants" (Downing, p. 37). Downing encouraged the planting of large forest trees, acknowledging that "we Americans are proverbially impatient of delay, and having the feeling that it requires 'an age' for forest trees to 'grow up' . . . . (but) we can hardly conceive a more rational source of enjoyment than to be able to walk, in the decline of years beneath the shadow of umbrageous woods and groves, planted by our own hands, and whose growth has become almost identified with our own progress and existence" (Downing, p. 39). The new suburban homes, according to H. W. Sargent in 1875, represented for Americans, a "country-place" as the ancestral estate had done in the past (Downing, p. 576). He recommends, in an appendix to Downing's *Treatise*, new trees for the villa gardens which are "striking and distinct" (Downing, p. 585), among them the purple and weeping beech.

The expansion of Boston and subsequent development of subdivisions was greatly enhanced by connecting parkways and parklands. Frederick Law Olmsted, the great landscape architect and parkmarker, was also a town-planner. He believed that development should be sensitive to topography and natural planning and provide "a tasteful and convenient disposition of shade trees" (Reps, 1965, p. 344). To Olmsted, the informal and picturesque was greatly preferable to the rigid grid pattern of many cities across America. His design plans provided room for large trees and a park-like atmosphere in the city's midst. Several neighborhoods in Brookline were laid out by Olmsted in this manner.

Downing was equally enthusiastic about Brookline: "The whole of this neighborhood is a kind of landscape garden, and there is nothing in America . . . so inexpressibly charming as the lanes which lead from one cottage, or villa, to another . . . the open gates, with tempting vistas and glimpses under the pendent boughs, give it quite an Arcadian air of rural freedom and enjoyment. These lanes are clothed with a profusion of trees and wild shrubbery . . . and curve and wind about, in a manner quite bewildering to the stranger who attempts to tread them alone; and there are more hints here for the lover of the picturesque in lanes, than we ever saw assembled together in so small a compass" (Downing, p. 40). Downing advocated the use of the beech in cities: "its thick and impenetrable mass of foliage . . . and density . . . makes it well suited to shut out unsightly buildings or other objects" (Downing, p. 149).

David Sears, a Brookline developer in the 1830s, and known for building the Sears Chapel which overlooks the Boston Park System, provided one of the finest and earliest examples of the use of *Fagus sylvatica* in America. Between Kent Street and Hawes Street in Brookline is Longwood Mall (or Square), listed now in the National Register of Historic Places, where 15 *F. sylvatica* and *F. s. atropunicea* were planted by Sears (Figure 3) between 1826 and 1838. Since then, 14 additional beeches have been planted. All of them are substantial trees with the original trees averaging heights of 70 feet. Figure 4 shows the magnitude of these impressive trees. For anyone who does not know this idyllic setting, it is worth a visit, not only to see some of the oldest *Fagus sylvatica* in America, but for a unique and pleasurable walk in a beautiful small park surrounded by lovely, historic houses (Figure 5). The trees are informally grouped creating spaces of varying sizes and allowing passage and viewing throughout the area. Considering the small size of the mall (35 × 300 yards), the variety of visual experiences is significant.

C. S. Sargent served on the Brookline Park Commission while he was director of the Arboretum and took a great interest in these trees. He describes them in a 1925 *Horticulture* article as "probably the finest grove of the European Beech in the United States."

Many other specimens of grand beeches grace the streets and front lawns of Brookline and Boston. Two outstanding examples of *F. s. atropunicea* (copper beech) stand on the lawn of the Elisha T. Loring house at 21 Mill Street in Dorchester. Figure 6 shows the immensity of one of the trees which measures over 6 feet in diameter and is approx-

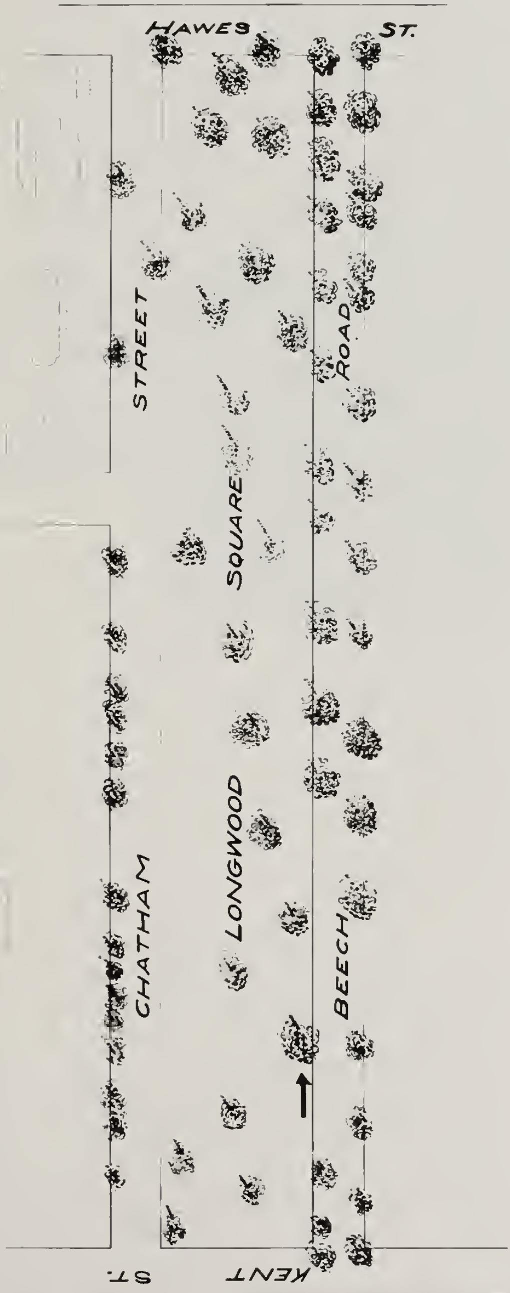

Figure 3. A 1918 plan showing the 15 original beech trees planted by David Sears in the 1830's. The arrow points to the largest tree, 36 inches in diameter in 1918; its diameter as of November 1981 was 5½ feet. Twenty-nine specimens now stand in the mall, including the original 15.

Figure 4. *One of the larger specimens of* Fagus sylvatica *on Longwood Mall in 1981. Photograph by P. Del Tredici.*

imately 70 feet tall. The spread of the mass of roots at the base is over 8½ feet, and the branches which engulf the front yard and hang over the entire street spread 70 feet. There are several other beeches in this historic neighborhood which, according to residents, remains much the way it was almost 150 years ago. It is conceivable, since the house is placed in the middle of the lot, that the house was planned around the larger of the two beeches, which now flank the entrance walk. It is more likely, however, that the trees were planted shortly after the house was built in 1845.

The creation of 'rural cemeteries', forerunners of city parks, in American cities was a direct result of the picturesque landscape movement, the growing economy, and the rise of technology and of a middle class. They were one of those "grand improvements in civilization", according to Downing. Literary people and captains of industry were instrumental in their establishment. These cemeteries became sylvan retreats for the public, a more tranquil environment outside the city in which to take Sunday walks and drives, meet with friends and visit the graves of departed ones. The scale and opulence of the cemeteries were symbolic of the times. The emphasis on the planting of beautiful majestic trees assured a place to the noble beech. At Mt. Auburn Cemetery in Cambridge, consecrated in 1831 as the first rural cemetery in America, and a gathering place for literary figures of Boston, the large avenues are all named after large trees, and there are several great, old specimens of European beech. A particularly beautiful *F. s. atropunicea* which is over 100 years old and measures

Figure 5. F. sylvatica *in relation to one of the houses built during the 19th century development of Longwood Mall. Photograph by P. Del Tredici.*

5 feet in diameter lends grandeur and stateliness to its environment. The weeping beech, *F. s. pendula*, is a particularly fitting choice for the setting. Forest Hills Cemetery in Boston, founded in 1848, echoes the same magnificence. As at Mt. Auburn, the grounds contain huge lofty European beeches which spread their protective branches over the gravestones below.

Early in the 19th century, the public outcry for green open space within the city of Boston brought about the opening of the first public Botanic Garden in America in 1828. It was run by a group of private citizens until 1852 when the city offered a competition for a landscape plan which was won by George V. Meacham. The plan was executed and by 1880, 1500 trees had been planted in the Public Garden. Among them were four European beeches.

The relationship of the garden suburbs to the adjoining parkland was part of Olmsted's master plan for the park system. An excellent example of this is Jamaica Park and the houses which bordered it. Because of the tree lined, connecting parkways and abutting parkland, it was difficult to tell where front lawns left off and parkland began. Ample space was provided for large trees. These provided a shelter and effective screen from the turmoil of city traffic.

Although Olmsted was not against the use of some exotic trees in the Boston Park System, as mentioned elsewhere in this issue, his planting lists for the Boston Park System indicate only the American beech. On the Pine Bank, the former site of the Perkins Estate, overlooking Jamaica Pond, there are a few *F. sylvatica*, one of which was most likely planted by the Perkins family. John Pettigrew, the park superintendent of Boston, who took over the planting of the Boston

Figure 6 (left). Fagus sylvatica atropunicea *(copper beech) at 21 Mill Street, Dorchester, in the front yard of the 1845 Elisha T. Loring House. The author stands next to this tree to show its immense size. Photograph by P. Del Tredici.* Figure 7 (below). *A grove of European beeches bordering Scarboro Pond at Franklin Park, Boston. Photograph by C. McMurtrie.*

Park System from the Olmsted firm in 1897, appears to have included the European beech for Franklin Park, surely because it blended harmoniously with the native woodlands. A beautiful grove of *F. sylvatica* overlooks Scarboro Pond and provides the desired bordering effect (Figure 7). These trees were probably planted around 1900. On the southern edge of Country Park Meadow along Circuit Walk is another stand of beech. The silvery trunks and great branches spreading high above the rolling smooth meadow are a magnificent sight.

Another famous Olmsted park, the Arnold Arboretum, boasts a superlative collection of *Fagus sylvatica*. The 20th century horticulturist, Donald Wyman, a staff member of the Arboretum for 33 years, wrote that *F. sylvatica* and its varieties should head the list of desirable shade trees. Curiously, E. H. Wilson does not mention the European beech collection in his book on the Arnold Arboretum, *America's Greatest Garden*, although we know he is an enthusiast of beeches from his other writings. The Arboretum's collection, on the slope near the South Street Gate, comprises 56 individuals including 20 varieties. One of the largest trees in the collection, *F. s. atropunicea*, is on the other side of the slope, on the former site of the Bussey Institute. Its origin is unknown but its huge size (70′ × 70′ and 5′ in diameter), suggests that it is at least 100 years old. The oldest tree in the collection is the typical form *F. sylvatica*, grown from seed supplied by Meehan & Co. in 1875. The illustration on the inside back cover of this issue shows the elephantine, silvery smooth trunk with the typical spreading roots of a venerable tree.

The role that the European beech played in the American landscape movement of the 19th century is captured well by Henry W. Sargent: "One can hardly imagine, without having seen it, the sensation of entering a place through dark Yews, the dwarfer Weeping Hemlock, the Purple Oak, Purple Beech, the deep, red Atropurpurea Maples, and gradually driving into the sunlight effect of the Silver and Golden Retinisporas, Golden Yews (and) Golden Arborvitae . ." (1977, pp. 587–8).

Acknowledgments

I wish to thank the following people for their work on this project: Peter del Tredici who collaborated with me and took many photographs, Ida Hay, Helen Shea and Katherine Grant of the Arboretum staff, Ty Siegler, Brookline Planning Department, and Eleanor McPeck, Radcliffe Seminars.

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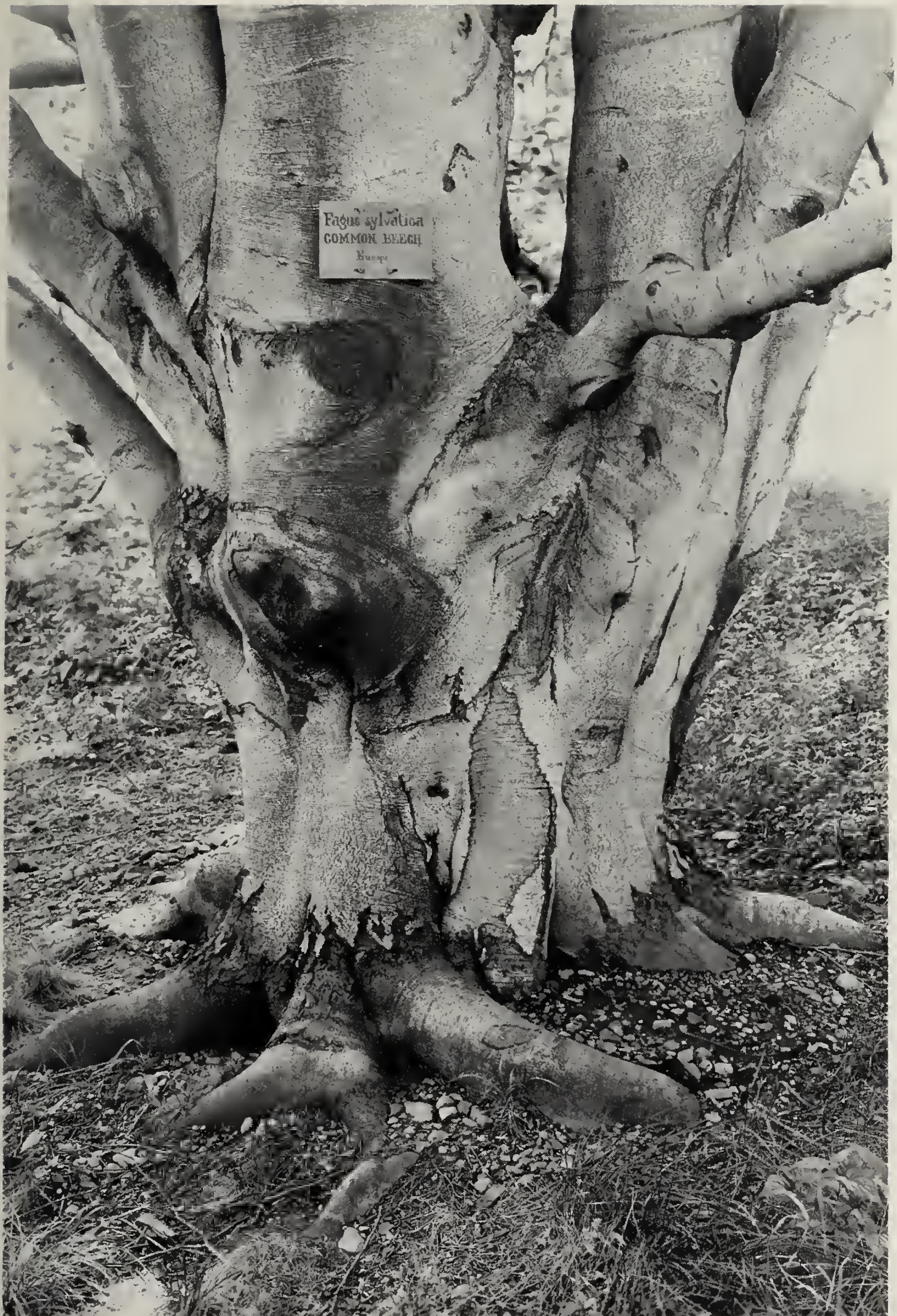
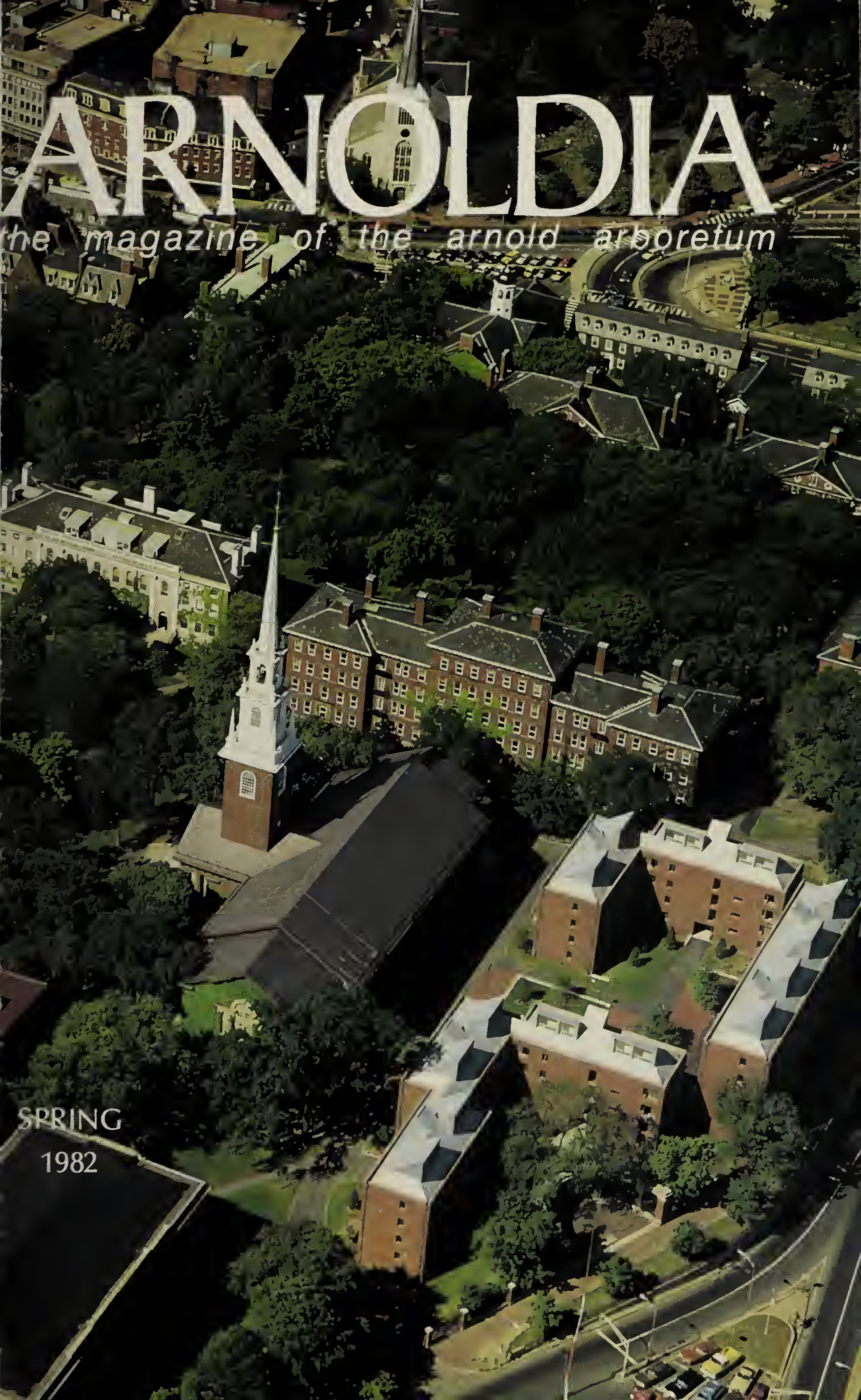
Right: *Trunk showing the magnificent size of a specimen of* Fagus sylvatica *at the Arnold Arboretum.* Back cover: *An ancient pedunculate oak,* Quercus rober, *in Pinnock's Wood, New Forest, England, one of the few relics of the primeval Northwest European English wildwood. Photograph by P. Ashton.*


Fagus sylvatica
COMMON BEECH


ARNOLDIA
the magazine of the arnold arboretum
SPRING
1982

A beautiful American elm in Conway, New Hampshire, showing the classic vase shape. The tree is 100 feet tall with a trunk girth of 22 feet. The photo was taken in 1930 by E. H. Wilson.

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Contents

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Front and back covers: Harvard Yard with its famous elms 10 years ago — a good example of the traditional use of the tree in New England. Photograph by Lawrence Lowry, courtesy of Harvard Magazine.

Introduction

This spring issue is dedicated to the American Elm — most elegant, tolerant, and thrifty citizen — and to its preservation in the face of Dutch elm disease and phloem necrosis.

The introductory piece reviews an illustrated article from the heydey of our subject in the last century. There are then three papers by specialists on aspects of the tree and its afflictions. Finally, twelve alternatives to the elm are evaluated.

You will find our symposium controversial. It is meant to be! There is no instant and permanent cure to Dutch elm disease; nor is there another tree that combines the rapid growth, the graceful spreading limbs and broad open crown, and the extraordinary urban hardiness of the American elm. You will find some differences of opinion among the experts, too. Research continues and differences should, therefore, still be expected. We did not attempt to negotiate a false unanimity on your behalf. Nevertheless, our authors all agree with the view expressed in Gerald Lanier's Postscript: with dedication and care, this disease can be kept in check.

PETER S. ASHTON

Typical Elms of Yesterday

The Dutch elm disease fungus, along with its dispersal agent, the European elm-bark beetle, arrived in North America in 1930, hidden under the bark of a shipment of European elm burl-logs that had been imported into the United States for the manufacture of veneer. The disease killed American elms so quickly and spread so rapidly that people were at first afraid that the American elm was headed for extinction. Fortunately, this dire prediction has not materialized. The fact is that the species still thrives and reproduces as a wild tree in wet woods and along stream banks throughout eastern North America. As a landscape plant, however, the American elm is close to extinction. Grand old specimens that were once an integral part of the New England landscape are mostly gone now. What was once the graceful giant of every town common, 4–5 feet in diameter, has become a not-so-common tree, not much more than 2 feet wide. Tragically, the Dutch elm disease kills a tree just as it is coming into the prime of its life. Indeed, a fanciful statement from Henry Ward Beecher, from a book entitled Norwood, *published in New York in 1867 by Fords, Howard, and Hulbert, prophetically describes the situation in which many towns now find themselves as a result of Dutch elm disease: "New Haven without elms would be like Jupiter without a beard, or a lion shaved of his mane."*

Typical Elms and Other Trees of Massachusetts, *by L. L. Dame and Henry Brooks, with an introduction by Dr. Oliver Wendell Holmes, was printed in 1890 and still serves as a fitting tribute to the greatness of the American elm. The principal purpose of this beautiful book was to document not only the histories of the great elms, but also their sizes and shapes. After considerable soul-searching, the authors of the book decided to include in each photograph "two white wands, each five feet in length, put together in the form of a T," so that the dimensions of the trees could be accurately compared to one another. The device was the idea of Dr. Holmes, who was as insistent upon a fixed scale of measurement in 1890 as he had been in 1858, when he first presented the idea for the book in his column in* Atlantic Monthly, "The Autocrat of the Breakfast Table":

> *— I wish somebody would get up the following work: —*
>
> *SYLVA NOVANGLICA*
>
> *Photographs of New England Elms and Other Trees, taken upon the Same Scale of Magnitude. With Letter-Press Descriptions, by a Distinguished Literary Gentleman.*
>
> *Boston: __________ ______________ & Co., 185______.*

The Rugg Elm at Framingham, Massachusetts. This unusual tree, showing what is known as the oak-tree shape, is 70 feet tall with a crown spread of 145 feet. Photo by E. A. Richardson.

Typical Elms *is notable not only as the fulfillment of Holmes' inspiration, but also for the quality of the photographs and the deep affection that the authors held for the trees they described. The data they present are unique and irreplaceable, given that the elms of today will never match those of yesterday. It is particularly interesting to note that even before the arrival of the Dutch elm disease, the American elm was not considered an exceptionally long-lived tree. According to Dame, the tree's great size was achieved more by virtue of its rapid growth than by its longevity.*

Here, then, is an excerpt from Typical Elms, *portraying the American elm, at the height of its glory.*

Peter del Tredici

THE AMERICAN ELM

ULMUS AMERICANA, L.

by L. L. Dame and Henry Brooks

The early settlers of New England inherited from their English ancestors the love of liberty and the love of home: for the maintenance of the one they planted the common school, and for the adornment of the other, the wayside tree. In front of the new house for the bride, the bridegroom placed the memorial elm. Bride and bridegroom have passed away, and generation after generation of their descendants; the old houses have mostly made way for less substantial but more showy successors, or else have been modernized out of existence; and the trees themselves of colonial date are fast disappearing.

The reasons that led to the frequent choice of the elm as a shade-tree are obvious: it is a comparatively rapid grower, is safely transplanted, requires little care, admits of the severest pruning, and combines in a remarkable degree, when old, size and beauty.

No tree varies more in general aspect. A stroll among the elms in winter, when the foliage that partially concealed their vagaries has fallen, reveals the sturdy individualism of the species.

The *vase* is the form most often assumed by the elm, when, standing in open ground, it is left free to follow its inclinations. The main trunk, reinforced in old trees by huge buttresses, and rising entire from ten to twenty-five feet, separates at length into several nearly equal branches. These rise, diverging but slightly, in straight lines or in broad curves, for thirty or forty feet farther, when they sweep outward, in wide and lofty arches with a pendent border of terminal twigs. The primary limbs, repeatedly subdividing, dissolve into a fine, leafy spray, forming a flat or slightly rounded head. The great eleva-

Reprinted from *Typical Elms and Other Trees of Massachusetts*, published in Boston in 1890 by Little, Brown, and Company.

THE BIG ELM, LANCASTER.

tion, the disposition of the principal limbs, and the extreme elegance of the summit make this form of elm, in the language of Michaux, "the most magnificent vegetable of the temperate zones."

The Lancaster Elm and the Brooks Elm are fine examples of this type. The vase varies according to the height of ramification.

In the *weeping-willow* form the main trunk seldom exceeds ten feet in height; the branches are more slender and diverge more rapidly, describing broader arches in proportion to the height of the tree; the border of long, flexible, pendulous twigs, swaying with the slightest breeze, comes down within reach of the browsing cows, or even sweeps the ground. In summer a great tree of this form resembles simply a large shrub; it is only when the obscuring leaves have fallen that the marvellous grace of the framework is revealed. The Clark Elm, Lexington is a perfect illustration.

In the *oak-tree* type, ramification usually takes place within ten or fifteen feet of the ground; the long curves give way to straight lines and abrupt turns, the spray, even in old trees, sometimes retaining its pendulous character; the regular arches disappear, grace and symmetry being transmuted, as it were, in the alembic of Nature, into sturdiness and strength. This form is exemplified in the Pratt Elm, Concord and the Boston Elm.

As a forest-tree, the elm runs up to a great height in a single stalk, or in two or three parallel limbs, terminating in a small but graceful head, with a border of slender, pendent spray. Trees of this character, spared now and then by the early settlers in the general clearing up of the forests, standing solitary with naked trunks suggest palms stranded from the shores of tropical seas. Under this head comes the Pittsfield Elm, which fell in a gale some years ago, — a remarkable tree, which rose about a hundred feet before branching. These trees have been classified under the *plume* type; but this term is more felicitously restricted to those trees whose single stem or scarcely diverging limbs sweep out at a considerable height in long, one-sided curves, insensibly tapering to their tips, and clothed with very slender secondary branchlets and fine spray. These do not seem to be survivors of the forest, as they are not uncommon throughout the State on open land, especially on the borders of meadows. There are very few large trees among them.

All elms have a tendency to throw out small reversed branches at the point of ramification, giving rise to the appellation of *feathered* or *fringed* elms. The extent of the feathering varies from a few scattered branchlets to a net-work of short, leafy twigs, which transforms the sober trunks and sometimes the great limbs into shafts of living green.

Feathering is found in all types of elms, but noticeably less in those with broad, spreading tops, as in the oak-tree type, while it is often a conspicuous feature of the true plume type. The cause is not well understood; but wherever there are few secondary branches, with their numerous subdivisions and consequent expanse of leafy surface, it seems to be more frequent and more extended, as if it were an effort

THE BROOKS ELM, WEST MEDFORD.

of Nature to maintain the equilibrium between root and leaf development.

These graceful appendages are often lopped from the wayside trees, in cheerful unconsciousness of their aesthetic value; less frequently because it is thought they retard the development of the top.

Notwithstanding this amount of variation, no tree is more easily recognized, summer or winter; and there appear to be no forms distinctive enough for good varieties, the various types running into each other by imperceptible gradations.

In fixing the approximate age of living trees, the first requisite is the determination of the rate of growth at different periods of existence. As the range of statistics given is narrow, and the number of cases small, the results reached, while not without value within certain limits, are presented simply as a contribution for future investigation.

A comparison of over a hundred trees, ranging from ten to fifty years of age, shows an average annual increase in diameter of .48 of an inch. Of six trees in Medford forty-three years old, the smallest shows an average annual increase of .28, and the largest of .65.

In elms that have attained a longer life and greater size than usual with the species, three periods of life may be roughly outlined.

The first period covers about seventy-five years, during which the growth continues with scarcely abated vigor.

The average annual increase ranges from .22 to .70 in young trees. The Hammond Elm, it will be noted, maintained to the age of eighty-three an average of .60.

The second period extends from seventy-five to one hundred and twenty-five years, during which there is a gradual decrease in the rate of growth, the annual increase ranging from .25 to .50.

The third period covers all life beyond one hundred and twenty-five years. Within the first fifty years of this period, — often within the first twenty-five, — the annual increase falls off very rapidly, so that it can be determined only by careful measurements taken at long intervals. Under this head come the Washington and Waverly Elms, with an increase respectively of .08 and .10.

The age of trees cannot be absolutely settled by the application of an inexorable law of averages. Great size is of itself only *prima facie* evidence of great age. The ordinary conditions that govern tree-life must be taken into account.

1. *Soil.* Cold and clayey soils retard development, while the warm, deep loams of alluvial bottoms are especially favorable. The greater average increase of the Deerfield Elms is thus accounted for. Trees transplanted from the nursery or meadow can never do themselves justice in the made land of streets.

2. *Proximity to water.* The neighborhood of ponds, streams, and meadows gives us the noblest examples of the elm. Their roots often run a hundred feet or more to water, tainting wells and choking drains

THE PRATT ELM, CONCORD.

FEATHERED ELM, LANCASTER.

with compact fibrous masses. Concrete walks diminish the water supply, and dwarf, if they do not eventually kill, adjacent trees.

3. *Proximity of other trees.* Sunlight from all sides is essential to symmetrical development. Street elms are generally planted much too near each other, and the same fault is repeated, with less excuse, in private grounds. The slow growth of the Quincy Elms is largely due to the crowding of these trees within narrow limits. The Dexter Elm has undoubtedly exhausted the soil in its immediate vicinity, for most of its younger companions have attained, at their maturity, only a very moderate size, and already show signs of decadence.

The elms of one hundred and fifty years, however youthful a front they put on, disclose somewhere within their vast periphery, in broken branch or incipient decay, an age past their prime. Their powers of resistance have reached the maximum, although the girth and spread slowly increase, almost to the last.

Many of the noble elms mentioned by Emerson in 1846 have disappeared altogether. "The broad, magnificent head" of the elm near Breck's Garden, Lancaster, lies low; the great elm at Springfield, that enlisted in its praise the ready pens of skillful writers; the lofty elm on Pittsfield Common, — these, and others as great if not as well known, have vanished from among trees, and their place knows them not.

Others are in ruinous condition, toppling to their fall. Among them is the old elm on Heard's Island, Wayland, the "great Sheffield Elm," and the "fine old tree still [1846] in perfect vigor which" stood "by the painted gate of the Botanic Garden," Cambridge, and which was cited as an example of the "*Etruscan vase type*," forming a flat head, with pendent border.

Others, though still grand and symmetrical, afford unmistakable indications of approaching decrepitude. Few, if any, of the trees mentioned in Emerson's book give the impression of undiminished vital force.

There seems to be no reason, in the laws of tree-growth, why an elm may not live on indefinitely, stretching out its buttresses with an ever-mightier hold on earth, and expanding its summit in ever-widening arches. Considered, however, in the light of evidence, it does not rank among long-lived trees. Two hundred years is a great age; few reach two hundred and fifty; while it may be doubted if any vestige, stump, or root is to be found of an elm born three hundred years ago.

The day of destiny may be put off by minimizing the natural causes that tend towards dissolution. The exhaustion of the soil can be remedied by the restoration of the elements taken from it. When decay has already set in, the dead portions may be thoroughly removed, and the cavities filled with cement; extensive injuries have thus been treated successfully, and the cavities themselves obliterated. But the greatest peril of the tree lies in the operation of causes foreign to its own constitution. The wider the spread of its leafy sails, the more likely it is to go down before the sweep of winter's winds; and if,

THE CLARK ELM, LEXINGTON.

THE OLD ELM ON BOSTON COMMON.

happily, it escapes the resistless tornado, there is no escape from the terrible pull of gravity. The constantly increasing tendency of the great diverging limbs to split asunder may be overcome for a while by bolting them together with iron rods, or propping them up with pillars, like the Neustadt lime; but there comes a day in the steady roll of the seasons when increasing weight overcomes diminishing resistance, and the shapely arches lie prostrate.

The sun of a winter morning shines down upon no spectacular display that rivals a big tree, its vast skeleton, down to the minutest twig, encased in glittering ice. This gorgeous effect is brought about at a ruinous expense. The ice-coat probably doubles the weight of the top; twigs are everywhere torn from their supports; limbs are broken off; the strain at the separation of the primary branches from the trunk — the point of greatest structural weakness — is prodigious.

A serious injury once received, the elm breaks up with great rapidity. Fifty years hence most of the elms figured in this volume, it is likely, will have become like the wrecks and memorials of a stately past.

The roadside elm will probably become less common in agricultural districts than at present, — the farmer has suffered too much from its predatory roots; but there will never be a dearth of noble trees. Thrifty elms of seventy-five to a hundred years old, ranging from nine to fifteen feet in girth, are scattered in favorable situations over the State. These will, in their turn, put on the mien of sovereignty and receive the homage of men.

The trunk of the Wethersfield Elm, Wethersfield, Connecticut. In 1924, when this photo was taken, the tree was considered the largest elm in the United States, with a girth of 28 feet. Given that the Dutch elm disease arrived in this country in 1930, this tree was probably the last of the truly giant elms. Photo by E. H. Wilson.

Dutch Elm Disease: What an Arborist Should Know[1]

by D. Newbanks,[2] D. N. Roy,[3] and M. H. Zimmermann[4]

I. UNDERSTANDING THE TREE

In order to control Dutch elm disease, one must be aware of a few essential facts concerning the anatomy and function of elm wood. It is amazing how ineffective the most strenuous efforts can be if these facts are ignored.

First of all, elm is a ring-porous tree, like chestnut, oak, and ash (Fig. 1). This means that the bulk of the water is carried to the crown via the wide earlywood vessels of the xylem (wood) of the most recent growth ring (Huber, 1935). In other words, most of the water moves in a very thin layer of wood, immediately beneath the cambium. Wide and long vessels, like those of elm, are extremely efficient: those of a single growth

[1] Commercial sources appearing in this publication are for the purpose of providing specific information. Mention of a source does not constitute an endorsement or warranty of products available, nor does it signify approval of this product to the exclusion of other comparable products.

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ring can supply the entire crown with all the required water. However, they are so vulnerable that they only remain functional during one growing season. The tree must therefore produce a new set of vessels every year, before the leaves unfold (Zimmermann and Brown, 1971).

The second fact to remember is that water is usually pulled up into the tree. This means that when the water-conducting vessels of the wood are injured, xylem water does not leak out as it does, for example, from sugar maple stems in late winter. The opposite happens: air is sucked into the system, and air-blocked vessels cease to function. Normal physiological conditions of water conduction are such that even a minute injury — one not even visible under the microscope — can be sufficient to admit air and render the vessel useless (Zimmermann, 1978).

The water-conducting system of ring-porous trees is extremely vulnerable. This becomes obvious when we compare, for example, an elm with a maple tree. The vessels of elm are some 4 times wider and 30 times longer than those of sugar maple. We know that the conductivity of capillaries is proportional to the fourth power of their diameter (Zimmermann, 1978). From this we can calculate that maple, when compared to elm, needs about seven thousand times more vessels to carry the same amount of water to the crown. If one vessel is accidentally lost, due to an insect bite for example, the damage is seven thousand times more serious in elm than in maple. Moreover, in ring-porous trees the functioning vessels are located very near the surface and are in a vulnerable position. Spring is the most dangerous period. During the course of the summer, as the functioning vessels are gradually covered with latewood, vulnerability decreases. Young, vigorous trees are somewhat less likely to be damaged than old, slow-growing ones, because they produce more latewood.

II. UNDERSTANDING THE DISEASE

Dutch elm disease is caused by the fungus *Ceratocystis ulmi*. The disease is known to affect four of the seven North American elm species: American elm (*Ulmus americana*), rock elm (*U. alata*), red elm (*U. rubra*), and winged elm (*U. serotina*) (Campana & Stipes, 1981). The fungus comes in contact with the tree in two ways: it is either carried to the tree by insect vectors or is introduced into the tree via root grafts from diseased to healthy trees.

The beginning and development of Dutch elm disease symptoms is dependent upon two major factors: the time of year in which infection occurs and the site where it occurs. For reasons described above, spring and early summer infections, as well as large branch and multiple site infections, are generally more threatening to individual trees than are late season and small twig infections (Sinclair and Campana, 1978). With this in mind, we can generalize and say that the first symptoms consist of the drooping, curling, and yellowing of leaves on one or more of the smaller branches. These symptoms spread more or less rapidly throughout the tree's crown, leading to the death of the tree. Disruption of the water flow from the roots to the

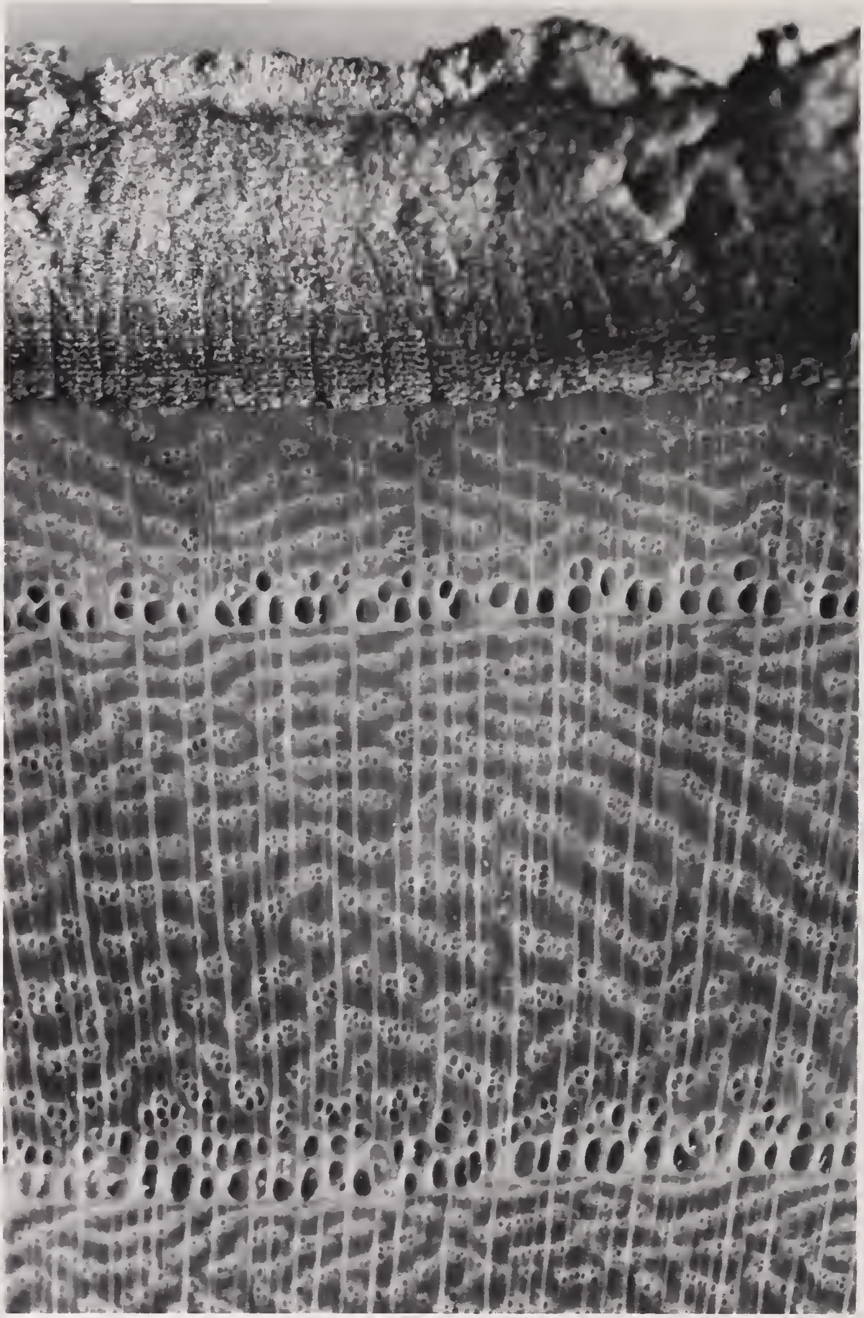


Figure 1. A transversely cut stem of a young, vigorous American elm (Ulmus americana), *showing two (and part of a third) growth rings, the cambium, and the bark. The bulk of the water moving from roots to crown is transported through the large earlywood vessels of the most recent growth ring. The large vessels of previous rings do not function any more; in fact, the photograph shows tyloses in some of them.*

crown of the tree is believed to be the primary cause of symptom development and the death of the tree.

The elm bark beetles, both the lesser European (*Scolytus multistriatus*) and the American (*Hylurgopinus rufipes*), are the primary vectors of the Dutch elm disease fungus in North America. They carry the spores of the fungus from tree to tree, which accounts for the rapid spread of the disease throughout the countryside. The bark beetles are attracted by weakened and dying trees. They bore into the inner bark, where they breed and lay their eggs. The larvae hatch, feed, mature, and emerge from the tunnel galleries, carrying microscopic spores of the fungus that stick to their bodies. They may briefly feed on healthy elms, but then return to weakened trees to breed and complete their life cycle (Sinclair & Campana, 1978).

Spring and early summer infections of American elms by the Dutch elm disease fungus are usually fatal to the tree. Death often occurs within the same growing season for smaller elms and within two growing seasons for larger trees. Occasionally a tree may die slowly, a branch at a time, over several years. The vulnerability of the large springwood vessels to injury is one of the primary reasons for the high susceptibility of the elms during the early season. The probability of vessel wounding by bark beetle feeding or by direct penetration of the fungus is greater during the spring because the ring of large springwood vessels is just beneath the bark.

Transpiration pulls water into the crown of the tree. The water in the xylem vessels is therefore normally under tension. When vessels are wounded by a feeding beetle, air is immediately sucked in as water recedes to both vessel ends. The microscopic spores of the fungus, which have been introduced into the beetle feeding site, may be sucked into the wounded vessel and carried up and down to the ends of the vessel along with the inrushing air. In large branches many vessels are as long as 15 feet, some may be considerably longer. In smaller branches and twigs they may be only several inches in length (Zimmermann, unpublished). In either case, the fungus can be introduced into the tree far beyond the point where a beetle is feeding.

Fungal spores germinate within the bark-beetle feeding tunnels, grow through the wood, and penetrate the vessels by dissolving the walls enzymatically. Such direct penetration may result in the vessel becoming air filled, as in the case of bark-beetle wounding, or the fungus may be able to enter the vessel without introducing air. In either case, once the fungus has established itself in the large springwood vessels, it is able to spread rapidly throughout the tree using the vessels as its pathways. During the later stages of infection, when the tree is weakened and dying, sticky spores are produced by the fungus inside the tunnels containing the newly hatching beetle larvae. The spores are carried on the bodies of the newly emerging beetles as they fly to new feeding sites on healthy elms.

There are several theories as to what actually causes the interruption of water flow through the vessels. Introduction of air into the vessels, as the fungus penetrates from the bark-beetle feeding sites and grows from vessel to vessel, has been suggested (Zimmermann and McDonough, 1978). Physical plugging of the vessels by the fungus and by gums produced by the fungus, as well as outgrowths of neighboring cells (tyloses), have all been shown to play a role (Dimond, 1970). Toxic substances produced by the fungus may also interfere with water movement in a more indirect way (Van Alfen and Turner, 1975). It is a complicated picture, and it is quite probable that all the above-mentioned factors are involved to varying degrees. Regardless of the relative importance of these factors, it remains that the large size of the springwood vessels and their vulnerable location just beneath the bark during the early growing season are two of the primary reasons for the susceptibility of American elms to Dutch elm disease.

III. CONTROL OF THE DISEASE

Successful Dutch elm disease control or management programs employ a combination of pruning, sanitation, insecticide spraying, and therapeutic injection as control measures. Such control programs have been quite successful in reducing the tree mortality due to disease.

1. Pruning and sanitation

Traditionally, control of Dutch elm disease has involved pruning and sanitation. Pruning simply involves the removal of diseased branches. One difficulty with this is that vessels are very long in elm. When infection occurs by the mechanism explained above, air enters an injured vessel and water retreats — in both directions. This can carry spores both up and down from the place of injury, and the fungus can be present considerable distances below a dead branch. It is therefore important that the pruned sections be long enough to eliminate the entire length of air-blocked vessels. As very few vessel-length measurements have been made so far with elm, the best guide is information from the Extension Service or the arborist's own experience.

Sanitation involves the removal of dead elm trees (i.e. cutting and burning) as early as possible so as to deny the bark beetles easy access to food and breeding ground. Pruning and sanitation can be quite effective, but it must be done promptly and consistently.

2. Chemical control

a. Spraying

The target of spraying is the adult bark beetle. Use of insecticidal spray in early spring has been a common practice. The most commonly used insecticide, until about 15 years ago, was DDT. This is banned now because of the strong environmental concern of the public. It has been replaced by a less effective but biodegradable product called Methoxychlor. Another recently marketed insecticide in use is Dursban 4E (Dow Chemical Co.). These insecticides are effective only for a short period of time; repeated spraying may be necessary.

Little information is available in the literature on how much insecticide is present on the tree after spraying. Recent work using insecticidal spray (Dursban 4E [0.5%]), applied with a mist blower and a hydraulic sprayer, has shown that coverage of the tree was not uniform. Insecticide concentration in some areas was well below the effective dose necessary to kill the beetles (Roy, unpublished). Specific insecticides should be tested independently.

b. Injection

The target of injection into the tree is usually the fungus. The ideal chemical to control Dutch elm disease should be highly toxic to the fungus but harmless to the tree; it should be water soluble to allow for systemic distribution within the tree and yet be environmentally safe. Numerous chemicals have been tested throughout the years with little success until recently. A major breakthrough was the discovery of the fungicidal activity of a class of synthetic organic compounds called carbamates.

Benomyl (methyl 1-[butylcarbamoyl] benzimidazol-1-yl carbamate) (Delp and Klopping, 1968) and a chemically related compound, thiabendazole, 2-(4-thiazolyl) benzimidazole, have shown the greatest promise in the control of Dutch elm disease (Biehn and Dimond, 1971; Smalley, 1971, 1978).

There are numerous difficulties associated with the chemical injection and distribution in trees. How some of these problems relate to chemical effectiveness and tree physiology will be discussed using the active fungitoxic compound of Benomyl, MBC, and its phosphate salt (MBCP), as an example. It should be kept in mind that MBC-containing compounds have proven most promising, and that the problems discussed are common to a greater or lesser extent in all Dutch elm disease control chemicals.

Benomyl reacts with water and is slowly converted to a more stable, water-soluble, and weakly basic compound called MBC (methyl benzimidazole-2-yl carbamate) (Clemons and Sisler, 1969). Insolubility of MBC in water (8–10 ppm at pH 5–6) was a problem because uptake and distribution in the xylem of the tree after injection is only possible if the substance is water soluble. This was achieved by the production of acid salts of MBC with inorganic acids (Kondo et al., 1973). Phosphate salts appeared to be particularly suitable, because they are both soluble in water and fungitoxic. Upon breakdown, phosphate acts as a nutrient for the tree. The phosphate salt is marketed under various names: MBCP, Lignasan P, Lignasan BLP (DuPont trade name), carbendazim phosphate (British Standards Institute), and others. They all have the same active ingredient and concentration (0.7% or 7000 ppm). The fungicide is stable, has a very low phytotoxicity, and is not toxic to the environment.

Fungicides may be injected into the trunk, the roots, or the root flare. The best distribution has been reported for root injection of dilute solutions under low pressure. Information on concentration, volume, tree diameter and the period of injection is available in the literature (e.g. Kondo, 1972). For larger trees, the root flare area should be injected in addition to roots for proper coverage. If the root system is not accessible, such as under urban conditions, then the tree might be injected in the root flare area only. Trunk injection is considered the least effective option.

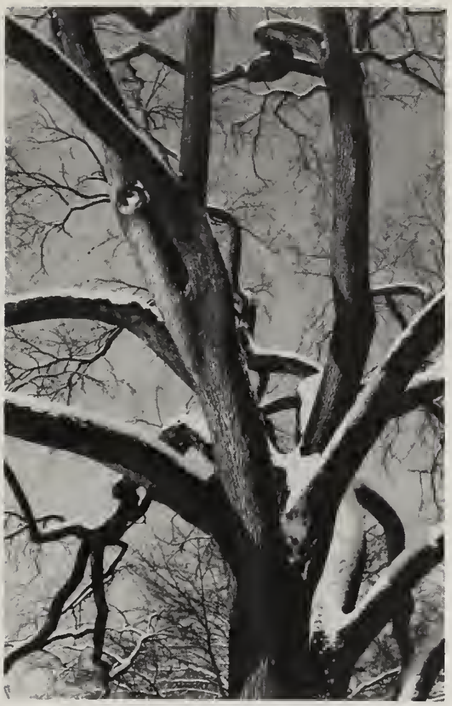
Injection and distribution of the fungicide is a very complex problem that has received some systematic attention (e.g. Day, 1980). First of all, xylem water is normally under tension. As soon as the xylem is injured, air is drawn into vessels, and if liquid is not applied quickly, the air pockets will prevent sufficient uptake. This problem can be overcome by applying positive pressure that decreases the size of the air pockets. But forcing fungicide into old, non-functioning vessels might be useless and wasteful. One method that has reasonable potential, but has only been used in the laboratory for fundamental research, is vacuum infiltration. Air can be removed from the wood with a vacuum pump (small, hand-operated pumps are inexpensive). Once the air pockets are removed from the functioning vessels, liquid is taken up by the xylem without applied outside pressure.

The chemical nature of fungicides may pose problems with regard to distribution. For example, the structure of MBCP is such that it is strongly adsorbed to the vessel walls and thus becomes immobile. In contrast, acid dyes move easily into the entire crown. Acid dye injections are therefore not good indicators for the effectiveness of an injection method; distribution of injected MBCP is often quite erratic when checked with chemical analysis of twig samples taken from the crown (Roy et al., 1980). Another important factor is the pH of the injected solution. For example, MBC is very active at low pH (very acid), but this is injurious to plant tissue. If the pH is raised (the solution made less acid), MBC precipitates out of solution. In addition, the pH is also slightly raised along the translocation path, and MBC may precipitate along the vessels. The problem of solubility may be solved by using a slight excess of phosphoric acid, but too much acid damages the wood. For these reasons, many compromises must be made to optimize injection procedures (Kondo, 1972).

There have been justifiable concerns about injection wounds (Shigo, 1977). Drilling into the wood destroys some of the conducting tissue, in addition, the holes can serve as points of entry for other micro organisms. From this point of view, root injections are also best because roots are easily regenerated (Lyford, 1980).

It has been reported that the effectiveness of chemical therapy is good for one growing season when it is done by root flare or trunk injection, and for almost two growing seasons if injection has been made into the roots. This is probably due to poor radial movement of MBCP. Once new vessels have formed in the stem, there is no MBCP

The branch structure of an American elm in the Public Gardens, Boston, Massachusetts. Photo by P. Del Tredici.



available to them. In the roots, however, vessels often function for a number of years and precipitated MBC can be very slowly dissolved a year or so later. For a reliable therapeutic program, injection should be done annually, once the tree has been injected.

3. Outlook

To overcome the limitations associated with MBCP, a host of other fungicides have been marketed that are chemically related to Benomyl. Thiobendazole (Mertect, Arbotect, ME II6), Fuberidazole, Mecarbinzid, Thiophenate methyl, M2B21914 and NF 48 are being tested.

In the belief that the insecticide will translocate to the crown area and protect the tree from insects, attempts were made to control beetles feeding on elms by systemic insecticide injection. Bidrin (Trade name of Shell Co.) was extensively field tested using trunk injectors but was found to be highly phytotoxic; in addition distribution was very poor. Recent reports indicate the same type of effect using well-known systemic and reportedly non-phytotoxic insecticides (Aldecarb, Diazinon, Dimethoate, Meta-Systox R, Phosphamidon) as well as mixtures of MBCP and these insecticides. When injected into the root system or the root flare of elms, these mixtures were found to be extremely phytotoxic (Roy et al., 1980).

Certain chemicals can be used to control the movement and population of elm bark beetles. These include sex attractants, repellants, confusants, and antifeedants (Strobel & Lanier, 1981). They are generally very expensive and depend to a large extent on climatic conditions such as wind direction and rainfall.

At present, injection treatment of elms is quite expensive and only affordable in the case of high-value elms. It is possible to achieve reasonably good levels of protection using injection of therapeutic chemicals into the roots or root flare under diligently controlled conditions as a part of a comprehensive tree care program that includes sanitation, insecticidal spray, and fertilizer.

Scientists may come up with a spray-on fungicide with the effectiveness of MBC. This would necessarily involve transport of the chemical through the phloem to ensure distribution. Spraying would eliminate the wounding problem. On the other hand, injection is relatively pollution free, whereas spraying might create environmental problems. Another recent development is the use of a fungitoxic bacterium (Stroble & Lanier, 1981).

In conclusion, we can say that although much progress has been made, we are still far from being able to protect our precious elm trees effectively. It is hoped that the development of more suitable chemicals, and a better understanding of how the tree functions, will bring improvement in the future.

Acknowledgments

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Double Jeopardy for Elms: Dutch Elm Disease and Phloem Necrosis

by David F. Karnosky[1]

American elm (*Ulmus americana*) populations across the United States are in double jeopardy. The Dutch elm disease, caused by the fungus *Ceratocystis ulmi*, continues to spread in North America and has developed more aggressive strains in recent years. Now, a second major disease is threatening elms. Called phloem necrosis, it is caused by mycoplasma-like organisms.

Dutch Elm Disease

Dutch elm disease is a vascular wilt disease transmitted primarily by bark beetles. It was first found in northwestern Europe around 1918. The disease was identified, and the causal agent described, by Dutch scientists. Rather unfortunately for the Dutch, the common name for the disease came to be "Dutch elm disease." Actually, the disease is thought to have originated in the Far East.

By 1939 Dutch elm disease had spread rapidly across Europe, killing over 50% of the elms in Holland alone. The Dutch countryside was particularly vulnerable to the ravages of Dutch elm disease because the vast majority of elms planted in Holland belonged to one susceptible clone, *Ulmus* × *hollandica* 'Belgica'.

[1] New York Botanical Garden Cary Arboretum, Millbrook, New York 12545.

A specimen American elm (Ulmus americana) *tree, showing the vase-shaped crown characteristic of the species. Photo by D. F. Karnosky.*

The first report of Dutch elm disease in North America came from Ohio about 1930. The causal fungus and its primary vector, the small European elm bark beetle (*Scolytus multistriatus*), had been carried to the United States on elm logs imported from Europe. The knots in its wood made it popular for making a burled veneer for furniture. Large ports and the railroads that transported the logs inland were the points of entry and routes of spread of the disease.

After its rapid initial sweep across Europe, and apart from local "flareups," Dutch elm disease came to be regarded there as an endemic disease of little importance. However, this tranquil situation came to an abrupt end in the late 1960's, when a new and more devastating Dutch elm disease epidemic began. The new epidemic appears to have originated in Britain and, as in the United States, can be traced to the importation of elm logs. This more aggressive and far more pathogenic strain of *Ceratocystis ulmi*, which developed via mutation in North America, was introduced into Europe on elm logs imported from Canada for boat building.

This second Dutch elm disease epidemic is now widespread in Europe and threatens to be more serious than the original one of the 1930's, since there appears to be much less resistance among European elm species and selections to the aggressive strain of Dutch elm disease than there was to the non-aggressive strain that had developed in Europe.

During the approximately 50 years when Dutch elm disease has been present in the United States, its range has steadily increased and it has devastated elm populations from coast to coast killing an estimated 50 to 100 million elms. Elm losses in metropolitan areas have been particularly severe (see Table 1) because the American elm's elegant vase-shaped crown, rapid growth rate, and urban-hardiness had made it a favored urban planting.

Table 1. Elm losses in some cities of the United States.

City	Estimated Number of Elms Prior to 1950	Estimated Number of Elms Remaining in 1977
Binghamton, NY	5,000	100
Buffalo, NY	180,000	10,000
Champaign-Urbana, IL	14,000	40
Chicago, IL	159,000[1]	88,000
Des Moines, IA	252,000	14,000
Evanston, IL	22,000	13,000
Milwaukee, WI	145,000	28,000[2]
New York, NY	55,000	33,000
Poughkeepsie, NY	5,000	50
Rochester, NY	15,000	200
St. Paul, MN	132,000	83,000[3]
Syracuse, NY	53,000	400
Washington, D.C.	20,000	20,000[4]
Yonkers, NY	12,000	200

[1] Greater Chicago area parkway elms.
[2] The Milwaukee figures include many non-diseased trees removed to begin reforestation efforts following the inevitable devastation by Dutch elm disease.
[3] The number of elms remaining in St. Paul has been dramatically reduced since 1977, because the disease has only recently reached epidemic proportions there.
[4] Washington, D.C., lost about 7,000 elms due to Dutch elm disease but has replaced them with additional elms.

Phloem Necrosis

Phloem necrosis, also commonly called "elm yellows," is indigenous to the United States and was first reported over 30 years ago. It now occupies a range from New York to Nebraska and south to the Gulf Coast states. It seems unlikely that the disease will move farther north since the pathogen does not appear to be adapted to cold climates. Transmitted by leafhopper insects, phloem necrosis kills the tree's phloem cells; the rest of the tree usually dies within one year after symptoms appear, except in the case of resistant species such as Chinese elm (*Ulmus parvifolia*) and Siberian elm (*U. pumila*).

Epidemics of phloem necrosis can rapidly destroy elm populations. However, the disease often remains endemic for several years between flareups, as did Dutch elm disease in Europe before the 1960's. Dutch elm disease and phloem necrosis sometimes infect the same elm populations, as occurred, for example, in several Illinois communities. In these situations, trees killed by phloem necrosis provide plentiful breeding sites for the bark beetles that transmit Dutch elm disease.


Left: Dieback of the upper crown of an American elm (Ulmus americana), *a symptom of the early stages of Dutch elm disease. Right: Advanced stages of Dutch elm disease on an American elm in Central Park. Photos by D. F. Karnosky.*

Symptoms

The symptoms of Dutch elm disease and their sequence and rate of development are variable depending on a number of tree, fungal, and environmental characteristics. However, the drooping or wilting of foliage (commonly referred to as flagging) in the upper crown on small twigs is the most common indicator of the presence of Dutch elm disease. Elms are usually infected between late spring and early summer. Brown streaks in the outermost xylem of twigs, exposed by a slanting cut or by peeling of the bark are good indicators of the presence of Dutch elm disease in branches showing flagging. Symptom progression through a given American elm tree may occur in one year or may take several years to occur.

Phloem necrosis generally kills small fibrous roots before foliar symptoms develop. As the phloem is destroyed by the disease along the length of the tree, infected tissue first becomes flecked with brown and then turns uniformly brown. This discoloration is best seen beneath the bark of the lower trunk and root-flare areas. The first external symptoms of phloem necrosis usually develop in mid– to late summer and include yellowing, leaf droop, and premature leaf drop. In contrast to Dutch elm disease, where the disease begins in a small number of branches, nearly all branches on a tree with phloem necrosis show symptoms at once. The discolored phloem of phloem necrosis-infected American elms may also have a faint wintergreen odor, especially if small branches are warmed by cupping them in the palm of the hand for a few minutes. Elms resistant to phloem ne-

Table 2. Relative Dutch elm disease (DED) and phloem necrosis (PN) resistance of elms.

Species	Origin	DED Resistance[1]	PN Resistance[1]
Ulmus alata	North America	– –	– –
U. americana	North America	– –	– –
U. crassifolia	North America	–	– –
U. rubra	North America	– –	– –
U. serotina	North America	– –	– –
U. thomasii	North America	–	?
U. carpinifolia	Europe	–[2]	+ +
U. glabra[3]	Europe	– –	+ +
U. × hollandica	Europe	–	+ +
U. laevis	Europe	–	+ +
U. plottii	Europe	–	?
U. procera	Europe	– –	?
U. bergmanniana	Asia	–	?
U. davidiana	Asia	+	?
U. densa	Asia	–	?
U. elliptica	Asia	–	?
U. japonica	Asia	+	?
U. laciniata	Asia	–	?
U. macrocarpa	Asia	+	?
U. parvifolia	Asia	+ +	+ +
U. pumila	Asia	+ +	+ +
U. turkestanica	Asia	–	?
U. villosa	Asia	+	?
U. wallichiana	Asia	+ +	?
U. wilsoniana	Asia	+ +	?

[1] (– –) very little resistance; (–) little resistance; (+) moderate resistance; (+ +) much resistance; (?) unknown.

[2] While *U. carpinifolia* is generally thought to be not very resistant, some clones of this species (such as 'Christine Buisman') have shown moderate resistance.

[3] *Ulmus glabra* includes *U. campestris.*

crosis (Table 2) sometimes develop witches' brooms (tufts of growth with short internodes) when infected but are not killed by the disease.

Control

While there are no guaranteed cures for either Dutch elm disease or phloem necrosis, there are control measures that have proven effective in slowing the spread of these diseases through elm populations. The most important control measure and the cornerstone of all successful programs is sanitation, including the prompt removal and disposal of dead and dying elms and the pruning of dead wood from healthy ones. Elimination of the dead wood decreases bark beetle breeding sites and prevents buildup of disease inoculum. Elm logs that are going to be used for some later purpose (e.g., for firewood) should be either debarked or sprayed with Lindane[2] to make them inimical to bark beetles.

Besides spreading the Dutch elm disease fungus, elm bark beetles can become a nuisance for homeowners if they are allowed to develop

[2] Reference to products does not imply product endorsement, nor are these necessarily the only ones available.

Dr. David F. Karnosky is shown attempting to hybridize the Siberian elm with American elm pollen. Photo by R. Mickler.

large populations. I recently received a call from a distraught homeowner whose house was being invaded by thousands of elm bark beetles; because of their small size, they had passed through his window screens, entered through his attic vents, and clogged his air conditioner. The cause of this localized problem was a large pile of elm logs and branches left with the bark on after the removal of a number of large American elm trees.

Left uncontrolled, Dutch elm disease can destroy a city's elm population within 10 years. When phloem necrosis is also present, the time may be even shorter. However, sanitation programs can effectively reduce the rate of loss from Dutch elm disease and phloem necrosis. For example, the city of Syracuse, New York, maintained elm losses at less than 2% per year from 1951 through 1964 by conducting strict sanitation for Dutch elm disease control. After the program was dropped in 1965, Dutch elm disease quickly reached epidemic proportions and the elm population in Syracuse was reduced from about 46,000 to less than 1,000 within 14 years. United States Forest Service researchers have established the fact that it is more economical in the long run to minimize elm losses with a sanitation program than to allow the disease to run its course.

Spraying elms with Methoxychlor to reduce twig-crotch feeding by the small European elm bark beetle is a good supplemental control procedure. New York City has long maintained a Dutch elm disease control program based on sanitation plus Methoxychlor spraying. The effectiveness of this program ranks among the best in the nation. Some 33,000 elms still grow in New York City and the annual loss rate is less than 0.5%. Results from Evanston, Illinois, also confirm the effectiveness of sanitation in combination with spraying for bark beetle control. The results are particularly impressive when compared to the devastation of other Illinois communities such as Champaign-Urbana (Table 1), where little or no control was attempted.

Pheromone trapping to determine when bark beetle broods (especially the summer broods) appear is useful in determining when insecticide sprays should be applied. Pheromone trapping may eventually become a practical means of reducing bark beetle populations in areas of low population densities. Recently, the use of cacodylic acid to kill elms has also been suggested for reducing bark beetle populations, especially in "non-control" areas surrounding control areas. Cacodylic acid rapidly kills elms and renders them useless to bark beetles as the beetles' larval development cannot be completed in the dry conditions created below the bark of treated trees.

When a small number of highly valuable elms are endangered by Dutch elm disease, a series of stop-gap measures may be attempted for control. These measures are all expensive, however, and should only be considered in special situations. Pruning as a therapeutic measure to remove Dutch elm disease from elm trees is possible if the disease is detected and treated early enough. Preferably, an infected branch should be pruned back a minimum of 10 to 15 feet from all sapwood showing fungal discoloration.

Fungicide injections may also be used therapeutically, either alone or in combination with pruning. Again, only trees showing early stages of disease infection should be treated, and even then there is no assurance of success. Fungicide applications should not be used as preventive treatments because the wounds created by drilling the holes necessary for injection can be damaging. Recent reports that the bacterium *Pseudomonas syringae* have therapeutic antifungal activity have given hope for a biological control for Dutch elm disease. However, additional research is needed to determine the effectiveness of these bacteria.

When elm trees are growing in close proximity to one another as they often are along streets, in parks, and in hedgerows, both Dutch elm disease and phloem necrosis can be transmitted from tree to tree by root grafts. The frequency of root-graft transmission can be substantially reduced by either chemically killing (with Vapam) tree roots in a narrow zone or mechanically trenching between infected and healthy trees. Both methods are expensive, and neither can be effectively utilized in the narrow tree lawns commonly found along street sides where tree roots are found below cement or blacktop.

Planting disease-resistant trees is an indirect method of controlling Dutch elm disease and phloem necrosis. The effects of these two diseases on elms have emphasized the highly vulnerable nature of single species planting programs in cities. Further diversification of plant material is clearly indicated because Norway maples, honeylocusts, and London planetrees are currently being overplanted in many cities.

Although the American elm and other elms native to the United States are very risky plantings because of their high susceptibility to both Dutch elm disease and phloem necrosis (see Table 2), there are elms that have excellent disease resistance. They include the species *Ulmus parvifolia, U. pumila, U. wallichiana,* and the recent selections 'Sapporo Autumn Gold' and 'Urban' elm. Unfortunately, these trees do not have the vase-shaped crown of the American elm. Furthermore, *U. wallichiana* and *U. pumila* selections are needed with improved cold hardiness and better resistance to *Nectria* canker. *Ulmus pumila* trees are also weak wooded and suffer storm breakage.

The task before the tree breeder is to develop hybrid elms with the disease resistance of the Asian elms and the ornamental characteristics and the urban hardiness of the American elm. Work has begun at several research stations to develop improved Asian elm selections and hybrids. A species that has excellent urban hardiness and that often has a very attractive exfoliating bark is *Ulmus parvifolia.* This species should be more commonly planted in the United States.

Recently released Dutch clones such as 'Groenveld', 'Plantyn', 'Dodoens', and 'Lobel' are only moderately resistant to the aggressive strain of Dutch elm disease, while 'Commelin', an early Dutch selection, has no resistance to it. Thus, these elms should be used only sparingly in the United States.

In conclusion, there are no simple solutions to the diseases affecting some of America's finest elms. The best hope lies in hybridization experiments that may produce a hardy, resistant hybrid elm with outstanding ornamental characteristics. In the meantime, planting selected alternatives and pursuing an integrated program of pest management and sanitation, are the disturbing facts of life for the elm in America.

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Dutch Elm Disease: A Postscript

by GERALD N. LANIER[1]

Dutch elm disease (DED) is the preeminent shade-tree problem in North America and Europe. The enormous economic loss and the aesthetic desecration wrought by DED make it the most widely known of all plant diseases. Recent articles on this infamous malady include those by Newbanks *et al.* and Karnosky in this issue of *Arnoldia*. Together, these papers provide a rather complete picture; yet some important points remain unmade, and a few of the statements printed are, in my opinion, misconceptions. This postscript to the *Arnoldia* articles ventures a few amendments to the previous papers and presents my view of the state of the art of DED control.

Differences of Opinion on Specific DED Control Operations

An important problem confronting the DED-control practitioner is the apparent controversy among "experts" on the effectiveness of specific practices. Another is lack of knowledge of new developments.

One perspective in consideration of DED control measures arises from the desire to protect or cure individual trees; another from the wish to minimize tree losses within a population. The owner of a magnificent elm will probably concentrate on prophylactic protection

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Top: The European elm bark beetle is about 3 mm. ($\frac{1}{8}$ in.) long, shiny, with a sharply up-sloping abdomen. Its elytrae (wing covers) are dark red-brown and the rest of the body is black. Bottom: The native elm bark beetle is about $2\frac{1}{2}$ mm. ($\frac{3}{32}$ in.) long, rough, uniformly dark brown, and shaped like a Volkswagen "Beetle."

or therapy for that particular tree. The city arborist, on the other hand, must be concerned with limiting elm losses while keeping costs within an operating budget. Like the practices of public health and medicine, the personal and population approaches to DED control are compatible and often synergistic. However, the specific measures effectively employed for the attainment of one objective are not necessarily efficient for fruition of the other. Hence, some of the differences of opinion about which particular DED operations should be applied often originate from different perspectives.

A second major source of controversy about specific DED control measures is that their effectiveness often must be gauged by the number of DED infections that do not occur. Rigorous proof of cause is elusive when many factors contribute to an effect. For example, it is possible to show quickly that a certain concentration of an insecticide kills a specific proportion of the elm-bark beetles exposed to it, yet several years of evaluation may be required to assess the contribution of operational spraying to DED control.

A third reason for confusion about the value of various DED control practices is the inherent variation among many of the factors that influence the DED loss rate. These include regional climate, local weather, soil characteristics, and genetic variation within beetles, elms and fungus. Many of the elm strains bred by Dutch workers for resistance to the prevalent DED fungus quickly succumbed to a more virulent strain imported from North America via Britain (Brasier and Gibbs, 1973).

Finally, variability in the effectiveness of specific practices arises from the different ways that they are applied. Effectiveness may be serendipitous for one application, while a similar approach may not yield the same benefits. For instance, DED rates rapidly declined when sticky traps baited with the aggregation pheromone of the European elm-bark beetle were positioned around isolated elm groves (Lanier, 1981), but a variation of this technique for city-wide application of mass trapping had no discernible impact on DED rates (Peacock *et al.*, 1981). The techniques as actually used may vary from guidelines developed by researchers, as in the case of a major mid-Atlantic city which for several years has applied the insecticide methoxychlor by mistblower at the concentration recommended for hydraulic application (2% rather than 12.5%). In addition, most of the trees were treated later than is necessary to protect elms from twig feeding by the spring generation of elm-bark beetles.

Earlier in this issue, Karnosky cogently reviews histories of DED and elm phloem necrosis and describes symptoms of both diseases. Newbanks *et al.* detail the infection process. Both articles deal with control tactics. Aside from a short description on the biologies of the two principal vectors, I will focus my specific comments on DED control strategies and tactics.

The Disease Vectors

The two known vectors of DED in North America are the native elm-bark beetle, *Hylurgopinus rufipes*, and the European elm-bark beetle, *Scolytus multistriatus*. Both insects breed in the inner bark of weakened or moribund elms and transmit DED when adults of contaminated broods feed on the bark of healthy elms. European beetles overwinter as larvae in brood trees, while native beetles spend the winter predominantly in the adult stage, in the bark at root collars of healthy elms. Native beetles leave their overwintering niches in the early spring and walk up their host to feed on limbs. European beetles emerge about a month later (when the first leaves are fully expanded) and fly to moribund elms, where they breed, or to healthy elms, where they feed in twig crotches.

In urban areas where the climate is milder, the more aggressive European immigrant has displaced the native species. The less winter-vulnerable native beetle is the only vector in the coldest regions where elms grow (much of Canada, northern plains states, Maine). In the intermediate areas such as New England, New York, and Minnesota, the relative abundance of the two beetles fluctuates with the severity of the preceding winter.

Determination of the relative abundance of the two DED vectors is important because some operations used to control one species are useless against the other. Removal during the winter of recently dead elms may decimate the European beetle population but will have little impact on the overwintering native beetles. Although spraying with methoxychlor just prior to foliation may prevent twig feeding by the European beetle, much of the feeding by the native beetle will already have occurred. Conversely, chlorpyrifos sprayed on lower boles of healthy elms will have no impact on the European beetle. Finally, the aggregation pheromone of European beetles is not attractive to the native species.

DED Management Strategies and Tactics

Basic strategies for limiting losses to DED include the following:

1. Reduce populations of disease vectors (i.e., elm-bark beetles);
2. Apply measures for prophylactic protection of individual trees against feeding by elm-bark beetles or colonization by the DED fungus;
3. Cure infected trees;
4. Increase disease resistance of the tree population.

Various tactics or practices can be employed under the above strategies. A DED management program may invoke more than one strategy and almost necessarily employs a combination of tactics. Karnosky and Newbanks *et al.* state that integrated programs are most effective. Enlightened integrated management should attempt to

Left: Wood engraved by the European elm bark beetles shows the vertical mines bored by egg-laying females. Right: Bark mined by native elm bark beetles shows the horizontal mines made by the egg-laying females.

maximize the cost effectiveness of the entire program. Therefore, an evaluation to determine which tactics to employ must consider their cost of application and their collective contribution to the net result. These elements are contrasted with the expenses of removal and replacement, plus the aesthetic value of trees expected to be saved by each tactic. Because disease severity, tree values, operating costs, and available expertise differ widely, DED management programs should also vary.

DED Control Tactics

Survey. One tactic not mentioned either by Karnosky or by Newbanks *et al.* is survey and inspection of the elm population. This operation is essential in order to maximize benefits of the more expensive tasks of sanitation, root-graft control and therapy. It is necessary for surveyors to be trained to recognize new infections. Frequency and intensity of inspections may vary with the level of control desired. If the control objective for a rather dense elm population is less than 1% annual loss, inspections must be made frequently and on foot. If the objective is 3–5% loss annually, two inspections during the growing season may be adequate. Binocular scanning of the elm population from aircraft or vantage points is very helpful in detecting new infections in the upper peripheral crowns of trees. A relatively small increase in funds spent for upgrading survey methods may yield high returns via improvements in the results of the entire program.

Sanitation. Karnosky calls sanitation "the cornerstone of all successful programs," yet Newbanks *et al.* say that "it is only effective if done promptly and consistently." Removal of *any* dead and dying elms before new beetle adults emerge from them will have some impact on DED rate. Prompt removal is important because infections in adjacent trees are caused by beetles attracted by elm wood being colonized, as well as by the brood that emerges later. Prompt removal reduces the opportunity for the fungus to move to the roots, through which infection may occur via grafts to adjacent elms. Expenditures to remove elms after beetles have emerged and fungus has invaded the roots contribute nothing but a reduction in the hazard from falling limbs. Optimal DED control programs mandate elimination of all potential beetle-breeding material, including diseased wild elms in green spaces within and adjacent to the elm population being managed. Elimination could also be accomplished by the trap-tree technique or by felling and spraying.

Prophylactic spraying. Since the ban on DDT, methoxychlor has generally been the insecticide used to protect twigs from feeding by the European elm-bark beetle.

There is no doubt that this material prevents feeding and can reduce risk of infection (Barger, 1976). However, there is considerable disagreement about the usefulness of methoxychlor in general practice. Neely (1972) found no difference in the level of DED control when Illinois communities sprayed or did not spray with this insecticide. The statement by Newbanks *et al.* that "these insecticides [including chlorpyrifos, used against the native beetle] are effective only for a short period of time" is contrary to analysis of insecticidal activity by Cuthbert *et al.* (1973), and to our bioassays (Rabaglia, 1980) which show that the recommended 2% dormant hydraulic spray of methoxychlor completely inhibited twig feeding by the European beetle for at least 10 weeks after treatment. The apparent lack of effectiveness in reducing DED rates by prophylactic sprays probably results from one or more of the following: 1) coverage is inadequate; 2) beetle feeding has occurred before the spray was applied; 3) new shoots produced after spraying are not protected; 4) the principal vector in the area may be the native elm-bark beetle, for which methoxychlor is not very effective.

The insecticide of choice against the native beetle is chlorpyrifos (Gardiner and Webb, 1980). An exemplary DED program in Sault Ste. Marie, Ontario, utilizes treatment of the lower boles of healthy elms with chlorpyrifos in fall or spring to virtually eliminate the adult beetles that attempt to overwinter in the root-collar region. Spraying whole trees will protect them from beetle feeding in the spring, but as is the case for methoxychlor, adequacy of coverage may be a problem.

It is my opinion that prophylactic treatment of elm crowns at $25–$100 per tree should be undertaken only after expenditures for alternative operations are considered. The much less costly operation of treating the lower boles against overwintering adult native beetles is likely to be economically justifiable because it is inexpensive, easily accomplished, and necessary only once every two years. If a spray program is undertaken, there should be some evaluation of both conformation to standards (including concentration and timing) and thoroughness of coverage. Municipal spray operations usually cost

Example of a diseased American elm (Ulmus americana).

tens to hundreds of thousands of dollars annually; it seems that at least 1% of the amount spent could be devoted to evaluation of the operation.

Preventing infection through root grafts. Prompt detection and removal or therapy of diseased trees will usually preclude movement of the DED fungus through root grafts between adjacent elms. Preemptive trenching about once every five years should be considered for protection of valuable elm groves wherever conditions permit it. Trenching or chemical severance of roots around trees that have systemic DED is justifiable only after careful inspection of the diseased tree for DED-caused discoloration indicates that the fungus has not yet infected the root-collar region. Too often, disruption is done after the trees to be protected are infected.

Pheromone-baited traps. Sticky traps baited with Multilure, a synthetic copy of the aggregation pheromone of the European elm-bark beetle, have recently been registered for aid in the control of DED. Traps placed on utility poles and trees other than elms capture large numbers of beetles and cause many others to exhaust themselves in fruitless flights to areas devoid of elms. Newbanks *et al.* are incorrect in implying that the method is expensive and subject to interference by weather. Traps may be positioned long before the first possible beetle flight. The pheromone bait remains attractive for at least 100 days, regardless of temperature, and the trap remains effective until it is covered with beetles (about 25,000) or debris. The cost of traps plus deployment and removal should be about $0.50 to $5.00 per tree per year. In addition to eliminating beetles that might otherwise transmit DED fungus to healthy elms, pheromone-baited traps monitor beetle flight and relative population. Trapping beetles is no substitute for sanitation; in fact, the effectiveness of trapping appears to increase as the number of competing pheromone sources (elm wood being colonized) decreases (Lanier, 1981).

Tree-trap Technique. Perhaps the greatest detriment to DED control has been an enormous supply of brood wood in green spaces where wild elms proliferate. In addition, removal of diseased trees from streets and yards has been delayed due to fiscal, mechanical, or political reasons. The trap-tree technique is an extremely powerful tool for coping with either situation. Hopelessly diseased trees and unwanted "weed" elms are injected with an herbicide, cacodylic acid. Treated trees are very attractive to both the native and the European elm-bark beetles; attraction of the latter can be enhanced by baiting the tree with Multilure. Attracted beetles colonize the tree, but the beetle brood substantially (average more than 90%) fails due to herbicide-induced desiccation of the bark (O'Callaghan *et al.*, 1980). Treated trees do not have to be removed immediately, and no special provisions must be made for disposal of the wood. Trap trees in green spaces can be left standing to fill the ecological role of a naturally dying tree.

Because it is inexpensive, effective and quick, the trap-tree technique is probably the most efficient means of gaining control in a DED outbreak or of managing an area that includes large numbers of elms in green spaces.

Fungicide injections. Fungicides injected into elms can provide a high level of prophylactic protection; they can also arrest symptom development if distribution of the DED fungus within the tree is not advanced. Newbanks *et al.* reviewed the development and application of Benomyl derivatives and thiabendazole and cited the problem of Benomyl products being tightly held by the vessel walls and not easily moving within the tree, especially not into wood produced after the injection. Thus, the trees would have to be treated annually for continued protection. Very recent work (Stennes, 1980) confirmed the lack of perennial effect even for very high dosages of a Benomyl derivative (MBC-phosphate) but demonstrated that excellent protection could be maintained for three years by injecting thiabendazole (Arbotect®) in the root collar at three times the registered therapeutic dosage. Registration of this dosage is apparently being undertaken by Merck & Co., producers of Arbotect.

Injection of fungicides for prophylaxis is probably the best means of protecting one or a few elms within areas where incidence of DED is very high, but the expense of this practice may make it a relatively inefficient way to spend DED control funds on a municipal level. On the other hand therapeutic treatments should usually be cost effective. A program employing frequent survey and proper technique for therapeutic pruning and injection should be able to cure 70% of the newly infected trees. Assuming costs of $200 per tree for therapy, and a total of $750 for tree removal and replacement, only 30% of the treated trees must be cured in order to realize a savings in direct program costs.

Antibiosis. Regardless of the reliability of injections of chemical fungicides, prophylaxis by this means faces the prospect of substantial expense over the lifetime of a tree (which itself might be shortened by injection wounds). An exciting possibility for the attainment of long-term protection is the development of a strain of the bacterium *Pseudomonas syringae* that can maintain itself within the sapwood of elms while it produces antibiotics that kill the DED fungus (Strobel and Lanier, 1981). The concept has worked well enough in research tests for Chevron Chemical Company to undertake its commercial development.

Replanting. Karnosky reviewed the development of a number of DED-resistant elm varieties. Planting these is common practice in Europe, but except for Siberian (*Ulmus pumila*) and Chinese elms (*U. parviflora*), DED-resistant stock is not commonly available in North American nurseries. Keeping in mind the generalization that diversity promotes stability, I believe that in areas largely devoid of wild elms, even DED-susceptible American elms can be prudently planted as scattered individuals to compose 5–10% of the tree population.

Outlook

The advent of new technologies has brightened the prospects for maintaining existing elm populations and reestablishing elms in devastated areas. Yet, there is no *cure* for the DED problem. Individual trees may be cured of the disease, but DED within an area must be *managed.* Management involves the enlightened application of a combination of practices that optimize the cost effectiveness of the entire program. Because uncontroverted data may not be available, because available information on cost and effect of various technologies is rarely mustered, and because efforts devoted to evaluation and management seldom match the magnitude of the problem, the majority of DED control programs are less effective than they could be and more costly than necessary.

From a study considering only the cost of tree removal (not aesthetic value or replacement cost) Cannon and Worley (1976) concluded that good DED management was cheaper than poor management, which, in turn, was cheaper than no management. Removal costs have increased since this study, and development of cost-powerful tactics such as tree therapy, mass-trapping beetles, and trap-tree technique should increase the difference in relative costs. With the reiteration of the value of traditional DED tactics and the advent of new techniques, there is seldom economic justification for a community not to manage DED.

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Replacing the American Elm: Twelve Stately Trees

by Gary Koller and Richard E. Weaver, Jr.

The majesty of the American elm begins with its straight, simple, relatively slender bole rising 30 feet or more before diverging into major upswung branches; it climaxes in the great, full, arching canopy that reaches across wide lawns or streets, allowing one tree to touch its neighbor, thus forming a continuous ceiling. Two secondary characteristics enhance the vaulted, noble impression of mature trees. One is the visual effect of the tall, thin stems of trees planted in lines or groves; they seem to gain stature from each other. The other is due to the way the trunk branches with the secondary limbs first rising upward and then in many cases drooping downward at the outer perimeter. Beneath the lower canopy, they enclose a spacious, inviting and often spiritually uplifting green.

Adding to the aesthetic considerations of the American elm are its relatively rapid growth, longevity, structural strength, and adaptability to a wide range of environmental conditions, soil types and soil conditions. It is hardly surprising that the American elm was the premier street and lawn tree until 50 years ago. Despite the relatively recent advent of Dutch elm disease, one can still find magnificent specimens.

However, in spite of the elm's desirable shape and stature, the tree

These silver maples (Acer saccharinum) *show the elmlike form and stature of this fine native tree. Photograph by E. H. Wilson.*

has drawbacks as a landscape plant. The elm has no ornamental flower, fruit, or bark. The foliage is unremarkable in its form, texture, and color. Unfortunately, the leaves are sought as food by a multitude of insects.

Many people seek a suitable tree that will duplicate the form and adaptability of *Ulmus americana* without its limitations. However, at present no single tree, including all the modern elm hybrids, has the positive architectural qualities and the environmental flexibility of this plant. Therefore, before we begin to look for substitutes, we should first consider if the elm is a lost cause as a plant for modern landscapes. The authors have discussed the status of *Ulmus americana* in relation to disease with several authories. It is our combined opinion that it would be unwise to cease planting American elms completely. However, prior to planting, we would recommend that the trees be planted singly rather than in masses or rows. The trees that survive tend to be lone or isolated specimens or those distant from sites of infection. Once a tree in a stand is infected, the disease spreads rapidly from tree to tree via root grafts, rather than above ground via insect vectors. Isolated trees can be sprayed to control the elm-bark beetle and the elm-leaf beetle. On large sites several elms could be planted, but they should be widely spaced so that at maturity there would be little likelihood of root grafting.

In selecting a site one should survey neighboring properties to determine if and where other elms exist. New plantings should be carefully sited and are best situated in locations where their loss would have minimal impact on the total landscape. People who plant elms should take into account the future maintenance that will be required to protect the tree. One must be prepared for the cost of removing trees that die prematurely, and must clearly balance the aesthetic and architectural value of the tree against the costs of maintenance.

Those who fear the complete loss of the American elm as a species should take heart. It is still common as a wild plant because Dutch elm disease affects only the older specimens — specimens which have already produced multitudes of seeds annually before succumbing. Seedlings continue to sprout in great numbers in woodlands, at field edges, and in open city spaces. Therefore, whether we plant this tree or not, it will continue to invade our man-made landscapes and to flourish in natural ones.

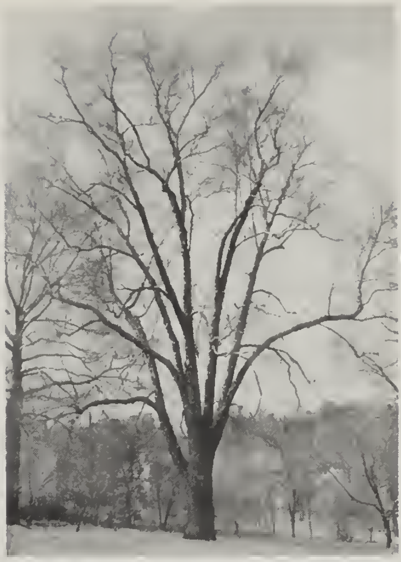
However, any future landscape use of *Ulmus americana* will be limited because of the tree's susceptibility to disease. At present, modern science has no easy, effective, or reliable cure for Dutch elm disease or phloem necrosis, the two major afflictions of the American elm. Therefore, we are suggesting the following tree species as alternate plantings to the American elm. None is a substitute, but all have at least some of the major aesthetic characteristics that have made the American elm noteworthy.

Acer saccharinum
Silver maple

In many ways the silver maple comes closest in habit to the American elm among native trees. Typically, this species is characterized by a short, stout bole separating into several enormous, gradually ascending trunks. The result is a tall, somewhat narrow vase shape. Many individuals of the species will assume this shape naturally, without much remedial pruning.

Silver maples are handsome, rapidly growing trees, often reaching a height in excess of 100 feet. The silver-backed foliage is attractive during the growing season and typically turns a beautiful clear butter-yellow in the fall. Visual as well as textural variation can be obtained by using the laciniate-leaf forms of this tree.

Although the species was formerly widely planted as a shade tree, it has fallen into disfavor because of its supposedly brittle wood and its consequent susceptibility to injury in storms. Actually, in standard tests to determine the strength of wood, it compares favorably with the American elm. If judged from the specimens in the collections of the Arnold Arboretum, it is not particularly susceptible to storm damage. In fact, the collection as a whole fared much better during a snowstorm on May 10, 1979 (when many trees were well leafed-out), than did most other large tree collections. Not a single large branch was lost in a collection of silver maples averaging 95 years of age, with one individual standing 110 feet tall.

Left: A fine specimen of the Ohio buckeye (Aesculus glabra) *in the Arnold Arboretum. If the lower branches had been removed, the crown would have been narrowly vase shaped. Right: With its arching branches and twiggy crown, the river birch* (Betula nigra) *gives an elmlike effect, but on a smaller scale. Photographs by H. Howard.*

Although relatively tolerant of city conditions, silver maples are not particularly good street trees because their shallow root systems wreak havoc with pavement. However, this tree remains a superb choice for parks, schools, or any landscape with sweeping, open spaces.

Acer saccharum
Sugar maple

Both in the wild and in cultivation, the sugar maple is a variable tree. In uncrowded situations it normally forms a relatively short bole, but the width, shape, and structure of the crown vary enormously. Many specimens develop a broad, rounded, regularly branched crown, while others have a crown that is narrower and oval in outline. Still others produce a dense crown of stiffly ascending branches. The first of these three types is the best to plant for an elmlike effect.

Unlike the American elm, the sugar maple has ornamental characteristics in addition to its form. In fact, it is one of the most beautiful large, native American trees. It is difficult to imagine what the autumn landscape would be like without it. The tree itself is moderately fast growing; in cultivation it seldom exceeds 80 feet in height.

Although sugar maples are not particularly elmlike in form, in an avenue planting, if the lower branches have been carefully removed, they can give the same effect. Unfortunately, the trees cannot tolerate very dry soils or roadway salt so they cannot be recommended for planting along city streets, but they are excellent street trees in areas where the roads are not regularly salted in the winter. In fact, in rural upstate New York and Pennsylvania they fill the same role as the American elm in New England.

Aesculus glabra
Ohio buckeye

Although it may grow taller in the wild, the Ohio buckeye seldom exceeds 50 feet in cultivation. The trees are distinctive in their form, with a moderately tall, thick bole, a slender, rounded crown, strongly down-curving branches, and thick twigs. If properly pruned, they will assume a vase shape, although a rather slender one.

This is a better all-around tree than the related and much more familiar horsechestnut (*Aesculus hippocastanum*), except for its relatively inconspicuous greenish white to yellowish flowers. The foliage is less coarse, and in most years it turns a good orange in the fall. The leaves also expand very early in the spring, and they are less susceptible to the scorch that so disfigures horsechestnuts. Although reasonably tolerant of city conditions, it is probably better not to plant them along busy streets because the large nuts could pose a hazard to traffic or pedestrians. However, the walls of the fruit lack the formidable prickles of horsechestnuts, so they do not pose a hazard to bare feet.

Betula nigra
River birch

As is the case with most birches, *Betula nigra* has a conical to pyramidal shape while young but develops a rounded crown with maturity. The bole is normally short, but the major branches arch gracefully upward, and the smaller branches and twigs at the end of the canopy tend to droop. The effect produced is vaselike, and this can be enhanced by removing the lower branches while the tree is still young.

River birches are graceful, fast-growing trees with relatively strong wood. Once established, annual growth rate can range from 3 to 4 feet. They have a moderate life span, and 100-year-old specimens at the Arnold Arboretum are beginning to show signs of decline. With a maximum height of 70 feet in cultivation, they bridge the gap between medium- and large-size trees.

This is rather different from other birches. Since it is widely distributed in flood plains and other lowland areas of the southern United States, it is tolerant of heat and oxygen-poor soils. The bark is pale creamy-brown on young trees, but it becomes dark and picturesquely scaly with age; the cultivar 'Heritage' has been selected for its attractive near-white bark color. The trees are seldom bothered by the bronze birch-borer.

Although this tree will never assume the proportions of a mature

Specimens of the black walnut (Juglans nigra). *Above: An isolated specimen in the now-defunct Harvard College Botanical Garden. Below: The group planting at the Arnold Arboretum. Photographs by A. Rehder and H. Howard.*

Left: With its tall, straight bole and massive, spreading crown, the tulip tree (Liriodendron tulipifera) *is one of the largest and most majestic of native American deciduous trees. Photograph by R. Horsey. Right: An avenue of red oaks* (Quercus rubra) *at the Arnold Arboretum. The clear trunks and the overlapping canopies give the same effect as would a group of American elms in a similar planting. Photograph by E. Gray.*

American elm, its shape and its graceful, twiggy crown make it an acceptable substitute for less grand landscapes.

Fraxinus americana
White ash

The white ash is one of the largest and most majestic of native American deciduous trees, and specimens nearly 100 feet tall are not uncommon. A mature specimen typically has a massive bole and a broad, rounded crown supported by a few very large branches.

The white ash is already extensively planted as a street tree for it has proved itself adaptable to urban conditions. One disadvantage is that it often seeds prolifically, becoming a nuisance. The species is dioecious, and several staminate (and therefore nonfruiting) clones are available. These include 'Autumn Purple', 'Autumn Applause', and 'Rose Hill'. Planting of these clones is recommended to avoid the abundant fruits and the numerous volunteer seedlings.

This is one of the finest trees at the Arnold Aboretum for autumn foliage color. Beside being one of the first trees to turn in the fall, the color is a beautiful blend of yellows, gold, reds and purples. It has been described as resembling a bed of glowing embers.

The green ash (*Fraxinus pennsylvanica*) is a similar species and one equally tolerant of urban conditions. It tends to be smaller in stature than the white ash, and its fall color is generally yellow. Several staminate clones of this species are also available.

Gymnocladus dioica
Kentucky coffee tree

The open, picturesque crown of the Kentucky coffee tree casts a light dappled shade that is desirable in many garden settings. While this tree is substantially different in form from the American elm, it can be trained to create an unbranched stem rising 30 feet or more. The potentially tall trunk and the open, sparse canopy can be utilized in groups to create a lofty spatial enclosure reminiscent of the American elm. *Gymnocladus dioica* has bold, bipinnately compound leaves that are medium green in summer and pale yellow in autumn. Groups of this tree create a similar shade density to the honey locust.

The only notable disadvantage is that the pistillate plants produce a broad, lima-bean-like pod. These are light green in summer but at maturity turn dark, chocolate brown. When they fall from the tree, they can create a litter problem.

While growth rate can vary, the tree tends to be upright and rather slow growing. It may not be a good choice as a planting for an immediate effect, but for long-range planning for a future landscape, the Kentucky coffee tree deserves top consideration.

Juglans nigra
Black walnut

With its tall, straight bole and open, umbrellalike crown, a mature black walnut often strongly resembles an American elm in its form. However, some individuals branch close to the ground, and in these, pruning off the lower branches is necessary if a tall, straight bole is desired.

Black walnuts are magnificent, slow-growing trees, but they are best known for the edible nuts and beautiful lumber that they produce. They do have a number of drawbacks as ornamentals: the leaves appear late in the season and then fall off early before most other trees have assumed their autumnal coloration; the nuts, although pleasant to eat, have messy husks that stain sidewalks and roadways as they decay; and the trees develop a deep taproot, making them difficult to transplant. However, the allegation that their roots and litter are deleterious to the growth of other plants appears to be unfounded.

With all of these drawbacks, many would ask "why plant a black walnut?" To these we would suggest a look at the group of these trees in the Arnold Arboretum, where they are planted as an informal grove. We have few trees more beautiful in form, and few groupings that show the beautiful form of a tree so well.

Liriodendron tulipifera
Tulip tree, tulip poplar

This species is one of the largest native American deciduous trees, and individuals well in excess of 100 feet tall, with diameters of 7 feet or more, still survive in our southern mountains. Young trees are quite uniform in their narrowly conical shape, and many individuals mature with a tall, somewhat narrow crown. Others, however, develop a tall, massive bole with a broad, rounded crown, and these are the ones that give more of the effect of an American elm. Near the Arboretum are several specimens, grown on small residential lawns, that can be described as grand elements of outdoor architecture.

In many ways the tulip tree is the handsomest large tree native to the United States. The foliage is of excellent texture, and it is little bothered by insect pests. It turns bright yellow in the fall. The leaves are distinctively shaped and attractive. The beautiful orange and green flowers are unfortunately often borne too high to be fully appreciated. The tree is massive and substantial. It grows rapidly and soon forms a respectable specimen.

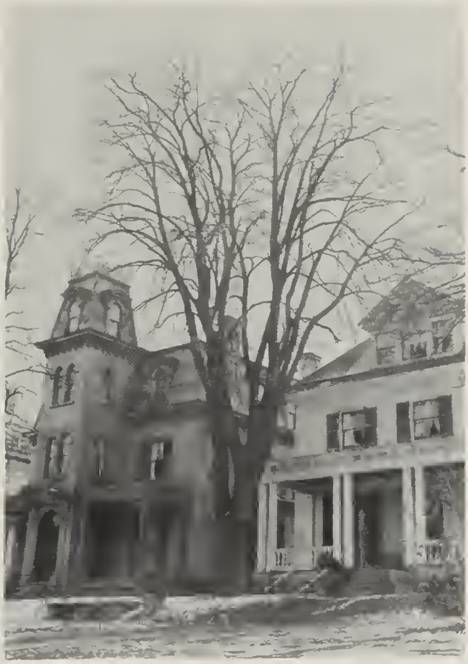
The species is intolerant of compacted soils, limiting its use as a street tree, and it cannot be recommended for small planting pockets in sidewalks. However, it would succeed along parkways or in similar situations that provide ample root space. Like its relatives the magnolias, the tulip tree should be transplanted in the spring.

Quercus rubra (Q. borealis)
Red oak

If left to grow naturally, a red oak will seldom assume anything resembling the vase shape of an American elm. However, if properly pruned it can give much the same effect in an avenue planting. In fact, it is one of the best large trees for avenue plantings in northern climates.

The red oak is a long-lived, moderately fast-growing tree, seldom exceeding a height of 75 feet in cultivation. If grown as a specimen tree in uncrowded situations, it branches relatively low to the ground from a massive, straight but short bole. The crown is dense and broad, often spreading as wide as it is tall. At maturity such a tree is magnificent. Although different in shape, it is comparable in scale to the American elm. If grown under more crowded conditions, the bole will grow taller without any management, but to insure an elmlike effect, the lower branches will have to be removed on a planned schedule for at least the first 15 years of growth.

Red oaks make excellent street trees. They are tolerant of poor, dry, compacted soils, salt and atmospheric pollution. The thick bark and strong wood are able to withstand the inevitable impact of vehicles. There is a particularly fine planting of this species along the Jamaicaway and the Arborway near the Arnold Arboretum. The black oak (*Quercus velutina*) is almost the equal of this species.



A specimen of the pendent silver linden (Tilia petiolaris) *that is exceptionally elmlike in form. Photograph by R. Horsey.*

Tilia petiolaris
Pendent silver linden

Most lindens have a tendency to branch low to the ground, so careful pruning is necessary while the trees are young to produce a specimen with a tall, straight bole. This species has a broad crown with somewhat pendent branches, and a mature specimen is majestic but still graceful.

An enormous, 75-foot-tall individual of this species, formerly at the edge of the *Aesculus* collection, was one of the most admired specimen trees in the Arnold Arboretum. Unfortunately, a serious, old cavity weakened the tree, and it was broken apart in a violent thunderstorm in 1981. Besides its form, the flowers and foliage of *T. petiolaris* are desirable ornamental characteristics. The blossoms are similar to others of this genus and are pleasantly fragrant. The foliage is outstanding, with leaves deep green above and covered with white hairs beneath. The slightest breeze causes them to rustle, producing a silvery effect. Unfortunately, the same white hairs collect dust and dirt, and the leaves may become somewhat unsightly on trees grown where there is a large amount of particulate matter in the air.

Ulmus parvifolia
Chinese elm

This is one of the smallest trees of those recommended here — it seldom grows more than 50 feet tall in cultivation in the Northeast. It is an exceptionally neat and graceful tree with a somewhat slender bole and a rounded to vase-shaped crown of ascending branches.

If a congener must replace the American elm, this is about the only one to consider. It will never assume the stature of its American relative, but it is highly resistant to Dutch elm disease. The foliage, glossy and with a fine texture, remains on the tree well into the fall, and at least in warmer climates some clones are semi-evergreen. The bark exfoliates in small patches, producing an ornamental pattern of grays, greens and browns.

The species has been more widely planted in recent years, and it shows promising tolerance of urban conditions. Chinese elms have been planted along streets of Philadelphia's Society Hill area. Here they have exhibited exceptional tolerance of repeated and severe damage to their trunks from automobiles and snow-removal equipment.

Zelkova serrata
Japanese zelkova

The Japanese zelkova is one of the trees being actively promoted as a substitute for the American elm. In fact, it was a rather rare tree in this country until Dutch elm disease became a serious problem. Although quite elmlike in basic form, it is not very elmlike in character. The bole is short and separates into numerous, rather small, stiffly ascending branches. In extreme cases, these branches are so numerous as to make the tree resemble an upturned broom. Judicious pruning, of course, can reduce the number of these branches.

The Japanese zelkova seldom grows to more than 60 feet in the northern United States, so the scale of the tree does not approximate that of the American elm. And it is only moderately resistant to Dutch elm disease. Two cultivars have been selected and are becoming widely planted: 'Village Green', for its straight trunk; and 'Parkview', for a better vase shape than the type. Both are tolerant of city conditions and make excellent street trees.

One disadvantage of this tree is its susceptibility to branch damage from ice and snow. New plantings along Commonwealth Avenue in Boston suffered significant structural damage during a recent early-winter snowstorm. This was in part due to the fact that the leaves had not yet fallen and, therefore, accumulated snow until the flux strength of the woody tissue was exceeded.

If you are familiar with the foregoing trees, you will know that all are different in stature than *Ulmus americana*. One characteristic that can make them more closely approximate the form of the American elm is a tall, straight, unbranched bole. Generally the trees discussed branch rather low to the ground, but where specialized maintenance can be supplied, the canopy can be "pushed" up.

Several techniques can be used to promote or force a higher branching system. The first technique involves annual pruning. As the tree

The Chinese elm (Ulmus parvifolia) *is one of the few species of its genus that is relatively resistant to the Dutch elm disease. Photograph by M. Dirr.*

grows, the lower limbs should be pruned off. As an example of "limbing up" pruning, we cite a specimen of turkey oak (*Quercus cerris*). This tree, grown *in situ* from an acorn, is 20 years of age and 35 feet tall. Each winter the owner of the tree removed the lower one quarter of its branches, pushing the bottom branch level ever higher. Today, the lowermost branch arises at 20 feet. While the owner wishes no additional branch clearage, the bottom branches could be pruned up to 25 feet with no damage to the tree. In pushing the branches up, two factors must be kept in mind. First, removal of the lower branches should be started when the tree is young, and continued annually thereafter, so the limbs do not become large in size, necessitating huge pruning cuts. Second, the side or secondary branches produce chemicals or food materials that contribute to increasing the diameter of the main trunk. If one forces the head of the tree up too rapidly, one creates the danger of a thin or weak stem. A thin stem may not adequately support the top growth, especially in the event of ice, snow, or wind storms.

The second method involves close spacing at planting time. The crowding and shading will cause the trees to become more open in the center and to grow taller as they reach for light. Some pruning might be employed to remove branches central to the mass, as well as twigs in undesirable locations.

The third means is to surround the tree with a rapid-growing but short-lived tall shrub, or small tree. For example, one could use a mass of *Elaeagnus angustifolia* or *Salix caprea* that would generate a mass of foliage quickly and provide a more immediate — but short-term — landscape effect. The shading from these smaller plants will stretch the tree up to overtop the ground. Once the tree is stretched, the nurse planting can be either removed or allowed to decline and disappear as part of a natural cycle.

Let us reiterate that no existing plant can duplicate the form of the American elm. However, the trees suggested above can achieve a similar effect in a variety of situations if planted and pruned properly.

Erratum — On page 248 of the November/December, 1981, issue of *Arnoldia*, the name of the donor for the arcto-tertiary garden should read Mr. Philip Hofer.

Sadness is the only term we can use to describe the sudden and untimely death of Carl Lobig, Editor of *Arnoldia.* In his memory the Staff and Friends of the Arnold Arboretum are planting a fine specimen of *Ulmus americana* at the Arnold Arboretum in Jamaica Plain.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We would like to thank Eileen Dunne, James Engelbrecht, and Joan Poser for their help in preparing this issue.

Front cover: A metasequoia at the Arnold Arboretum. The fernlike foliage and fluted trunk of this species makes it a handsome ornamental. Photograph by C. Lobig.

Inside front cover: The feeding habits of gypsy moth caterpillars. Caterpillars feeding on apple leaves (the bark on the lower part of the twig has been eaten by young caterpillars early in the season) (1), on a young growing shoot of white pine (2), and on a red oak leaf (3). From E. H. Forbush and C. H. Fernald, The Gypsy Moth *(Boston, 1896), Plate 40.*

Back cover: Ovulate cones of the metasequoia. Photograph by J. Kuser.

Spruces in the Arnold Arboretum

by Richard Warren

The members of the genus *Picea* (the spruces) grow exclusively in the North Temperate Zone and stretch around the world in the higher latitudes. In North America they grow above the Arctic Circle to latitude 70° north and extend south into Mexico. In favorable climates they reach heights of 70 meters. Among conifers this range is matched in extent only by the genera *Pinus* (pines) and *Juniperus* (junipers). Although relatively sensitive to air pollution and drought, spruces tolerate shade better than most other conifers. Some members of the genus have no peers in their ability to stand extreme cold.

The Arboretum's mission to grow all woody plants hardy in our climate has been well fulfilled in the case of the spruces. The representatives of the 21 species now growing on the grounds demonstrate many interesting features.

Description of the Genus

Picea belongs, under the gymnosperms, to the family Pinaceae, in which the plants are monoecious, with spirally arranged linear or needlelike leaves, two microsporangia on each microsporophyll, two ovules on each ovuliferous scale (to which the bract scale is not, or is only loosely, attached), and pollen grains with "wings." The other members of the family are *Abies* (the firs), *Cathaya* (a recently de-

Above: Arnold Arboretum pinetum in winter. The two tallest trees are Norway spruces. Photograph by R. Warren. Below: Range of spruces in the world. Shading indicates contiguous distribution, and dots show scattered occurrences. Map drawn by L. Meszoly after Schmidt-Vogt (1977).

scribed Chinese genus), *Cedrus* (the true cedars), *Keteleeria* (a Chinese genus resembling *Abies*), *Larix* (the larches), *Pinus* (the pines), *Pseudolarix* (the golden larch), *Pseudotsuga* (the Douglas firs), and *Tsuga* (the hemlocks).

The family Pinaceae is divided into two groups according to the arrangement of the leaves on the branchlets. In one the leaves grow in clusters or pseudowhorls from short side-shoots. This group includes *Larix*, *Pseudolarix*, *Cedrus*, and *Pinus*. In the other, which contains *Abies*, *Cathaya*, *Keteleeria*, *Picea*, *Pseudotsuga*, and *Tsuga*, the leaves grow individually from the long shoots. The spruces can be distinguished from other members of the second group by several characteristics:

Bark:	platelike, often flaking; frequently fissured on the lower stems of old trees.
Winter buds:	conical or ovoid (not round), with or without resin.
Shoots:	fissured and ridged, with the ridges being interrupted by woody projections (sterigmas or pulvini) that bear the leaves. These pegs are the most distinct diagnostic feature that separates *Picea* from the other genera. The branchlets of the genus *Tsuga* also have sterigmas, but their flat leaves are markedly different from those of *Picea*.
Leaves:	four sided (quadrangular in cross section) in most species, with white lines of stomata on all four sides.

Above: Sterigmas support the leaves on spruces (Picea abies, *left*) *but are absent on firs* (Abies alba, *right*). *Photograph by A. Coleman. Right: typical spruce bark, shown on* Picea montigena. *Photograph by R. Warren.*

The leaves of *Picea* ordinarily stay on the shoots for seven to ten years, but when branches are removed from the tree the leaves fall off within a few weeks, a feature that hampers the preparation of herbarium specimens and that is familiar to all who have used spruces as Christmas trees. The members of the genus *Tsuga* also lose their leaves, since they, too, bear their leaves on woody pegs.

The bright yellow or reddish color of the microsporangiate cones of many of the spruces makes a fine showing in the spring. The immature ovuliferous cones are often a handsome blue or purple. They stand erect at the end of the branches at the time of pollination, but turn downward on fertilization shortly thereafter and grow to maturity in the fall of the first year — unlike cones of *Pinus*, in which fertilization is delayed for a year after pollination in most species. The cones open and shed seeds while on the trees, then fall to the ground from weeks to years thereafter.

Spruce cones are cylindrical and taper, depending on the species, to a more or less rounded or pointed tip. The cone scales are thin, like those of haploxylon (soft) pines, and are imbricated or appressed, and regularly arranged.

The recognized number of species in the genus varies between 26 and 40, depending upon interpretation of specific and varietal limits. The Table lists 28 of the better-known species. It shows an interesting,

Twenty-eight common species of spruce.

Native Habitat	Area	Scientific Name of Species	Common Name	Present in Arnold Arboretum
North America	NW. U.S.A.	*brewerana*	Brewer's	+
	Mexico	*chihuahuana*	Chihuahua	0
	Rocky Mountains	*engelmannii*	Engelmann	+
	Transcontinental	*glauca*	White	+
	Transcontinental	*mariana*	Black	+
	Rocky Mountains	*pungens*	Colorado	+
	NE. North America	*rubens*	Red	+
	NW. North America	*sitchensis*	Sitka	0
Europe	Transcontinental	*abies*	Norway	+
	E. Europe	*omorika*	Serbian	+
Western, central, and southern Asia	Caucasus	*orientalis*	Oriental	+
	Central Asia	*schrenkiana*	Schrenk's	+
	Afghanistan, Nepal	*smithiana*	West Himalayan	0
	E. Himalayas	*spinulosa*	Sikkim	0
Eastern Asia	China	*asperata*	Chinese	+
	Japan	*alcoquiana*	Alcock's	+
	China	*brachytyla*	Sargent	0
	Sakhalin Is., Japan	*glehnii*	Sakhalin	+
	Japan, NE. Asia	*jezoensis*	Yezo	+
	Japan, Korea	*koyamai*	Koyama's	+
	China	*likiangensis*	Likiang	+
	Japan	*maximowiczii*	Maximowicz's	0
	China	*montigena*	Candelabra	+
	Formosa	*morrisonicola*	Mt. Morrison	0
	N. Europe, Asia	*obovata*	Siberian	+
	China	*purpurea*	Purple-cone	+
	Japan	*torano*	Tiger-tail	+
	China	*wilsonii*	Wilson's	+

A cone of Picea pungens, *showing papery and wrinkled cone scales with erose edges. This distinguishing feature is also shown by* P. engelmannii, P. jezoensis, *and* P. sitchensis. *Photograph by R. Warren.*

uneven geographic distribution, with half of the species growing in eastern Asia. In 1916 Charles Sargent, alluding to the recent exciting accomplishments of Ernest Wilson, stated that the Arnold Arboretum had received more spruce trees from western China during the preceding few years than had been known in the entire world 20 years earlier.

Using the above criteria, one can easily recognize and separate *Picea* from other genera of the Pinaceae. Distinguishing some of the species from each other, however, presents a problem. Helmut Schmidt-Vogt (1977, p. 12; author's translation) states: "The high variability of the morphological characteristics [of the spruces] makes the distinction between species difficult. This is especially true in the East Asian area, which has a propensity to produce manifold forms. . . . It is not possible to make an exact identification from the characteristics of single specimens in arboreta." Despite this statement, the following key is presented. It includes all of the species listed in the Table. Amplification of the descriptive material follows.

Key to the Commonly Recognized Species of Spruces

1. Leaves more flat than quadrangular in cross section, with stomata on lower surfaces only.
   2. Branchlets remarkably pendulous.
      3. Leaf-tips blunt. .... *Picea brewerana.*
      3. Leaf-tips pointed. .... *Picea spinulosa.*
   2. Branchlets not remarkably pendulous.
      4. Cone scales papery and wrinkled, the edges erose.
         5. Leaves often keeled. .... *Picea jezoensis.*
         5. Leaves entirely flat. .... *Picea sitchensis.*
      4. Cone scales not papery and wrinkled, the edges rounded.
         6. Leaf-tips mucronulate. .... *Picea omorika.*
         6. Leaf-tips acute. .... *Picea brachytyla.*

1. Leaves more quadrangular than flat in cross section, with stomata on all four sides.
   7. Branchlets remarkably pendulous. .... *Picea smithiana.*
   7. Branchlets not remarkably pendulous.
      8. Cone scales papery and wrinkled, the edges erose.
         9. Cones less than 6 cm long; branchlets slightly hairy. .. .. *Picea engelmannii.*
         9. Cones more than 6 cm long; branchlets glabrous. .... *Picea pungens.*
      8. Cone scales not papery and wrinkled, the edges rounded.
         10. Most leaves less than 1.5 cm long.
            11. Young shoots glabrous or only slightly hairy.
               12. Young shoots pale yellow or yellow-brown. .. .. *Picea glauca.*
               12. Young shoots reddish brown. .... *Picea maximowiczii.*
            11. Young shoots consistently hairy.
               13. Leaves of uniform length, shiny green, with rounded tips. .... *Picea orientalis.*
               13. Leaves of varying lengths on the same shoot, dull green, with truncate or acute tips.
                  14. Decurrent ridges on first- and second-year shoots rounded; cones falling after seeds have been shed. .... *Picea rubens.*
                  14. Decurrent ridges on first- and second-year shoots flat; cones remaining on branches long after seeds have been shed. .... *Picea mariana.*
         10. Most leaves more than 1.5 cm long.
            15. Most cones more than 10 cm long, the scales rhombic with truncate, emarginate tips. .. *Picea abies.*
            15. Cones 8 cm or less long, the scales not rhombic, with rounded tips.
               16. Foliage bluish to gray-green.
                  17. Leaves rigid; young shoots red-brown or yellow.
                     18. Leaves curved.
                        19. Leaves very sharp. .... *Picea asperata.*
                        19. Leaves blunt. .... *Picea montigena.*
                     18. Leaves straight.
                        20. Edges of cone scales erose. .... *Picea pungens.*
                        20. Edges of cone scales rounded. .... *Picea chihuahuana.*

17. Leaves not rigid; young shoots ashy-gray. .... *Picea wilsonii.*

16. Foliage green.
    21. Leaves at right angles to shoots, extremely rigid and sharp. .... *Picea torano.*
    21. Leaves at less than right angles to shoots, not extremely rigid and sharp.
        22. Outer bud scales elongated and acicular. .... *Picea glehnii.*
        22. Outer bud scales not elongated or acicular.
            23. Stomatic lines on leaves conspicuously whiter on one side than the other. ... *Picea alcoquiana.*
            23. Stomatic lines on leaves not conspicuously whiter on one side than the other.
                24. Young shoots hairy.
                    25. Young shoots pale gray. .... *Picea purpurea.*
                    25. Young shoots red-brown. .... *Picea obovata.*
                24. Young shoots glabrous.
                    26. Young shoots orange-brown. .... *Picea koyamai.*
                    26. Young shoots pale yellow-brown. .... *Picea schrenkiana.*

The Name

Anyone perusing the writings of the early botanists or inspecting early herbarium specimens expects to find that there have been major nomenclatural changes in almost any genus. Nowhere is this more evident than in the spruces. In addition to *Picea*, the genus has been known at various times as *Pinus*, *Peuce*, and, most frequently, *Abies*. Before the 1890's, when standardization of botanical nomenclature on the basis of priority and accurate description began to be emphasized, the matter was hotly debated. In these debates the thread of consistency was most frequently maintained by the common vernacular names. In English the spruces (present genus *Picea*) were referred to as spruce firs, and the firs (present genus *Abies*) as silver firs.

Linnaeus (1753) named the spruce fir *Pinus abies* and the silver fir *Pinus picea* despite the reverse use of the names by earlier writers. After Linnaeus confusion reigned. Some eminent botanists followed his names, and others the older ones. The protagonists in the debate often quoted the classics to support themselves. The faction supporting *Abies* as the correct name for the spruce fir cited Pliny, who said that in his "Abies" the fruit hung downward. Therefore, they said, it could not be the silver fir. The *Picea* faction quoted Virgil, who wrote in the *Aeneid* that the ribs of the Trojan horse were made of *Abies*. This, they claimed, must refer to the silver fir, since that is the only single-needled conifer native to Troy, and no spruces grow there. Sargent (1899, p. 26) summed up the modern opinion: ". . . in the United States and in Continental Europe the Spruces are almost habitually called Picea and the Firs Abies. According to the rules of botanical nomenclature this use is certainly correct without reference to the classical meaning of the two words, or to Linnaeus's use of Picea and Abies as specific names for his genus Pinus, because Picea is the oldest name under which the Spruce trees have been generically distinguished."

According to the *Oxford English Dictionary*, the English word "spruce" comes from the word "Prussia." *Picea abies* is as prevalent there and in neighboring areas of northern Europe as it is in Norway, and was thus perhaps more accessible to English-speaking travelers of the early days. The other meaning of "spruce" — neat in personal appearance — has no relation to the tree, but apparently arises from the one-time elegant fashion of wearing jerkins of Spruce (Prussian) leather.

The Arnold Arboretum's Plants

Picea abies (L.) Karsten — Norway spruce

Introduced into North America from Europe late in the 18th century, this tree grows faster in the New England climate than our native spruces. It can reach a height of 40 meters. If it is in a freestanding situation, it keeps its lower branches well. Those of older trees often layer, put down their own roots, and form a palisade of new young plants that continue to grow around the parent tree after it has died. John Loudon (1838, p. 2295) called it "the loftiest of European trees." He praised it as excellent for sheltering other plants and for protecting wildlife against the weather; a "good nurse," the expression then was.

Charles Sargent (1897, p. 482), however, showed little enthusiasm for the tree. He stated that, although it grows rapidly for 30 or 40 years, it then begins to fail at the top: "vigorous Norway spruces more than 50 years old are uncommon in this country." He termed its popularity "a misfortune," and this point of view has prevailed in the literature since. Admittedly, planting of Norway spruce may have been overdone, but many trees over 100 years of age are flourishing today. Its pyramidal, straight-growing habit and its swooping branches, adorned in most forms of the tree with pendulous branchlets (which have given rise to the German term "Kammfichte," or comb spruce), are a pleasant sight in most northeastern towns. Its profuse elongated cones with distinctive rhomboid and slightly emar-

Picea Abies. Left: Typical cone, showing scales with truncate-emarginate tips. Photograph by R. Warren. Above right: A mature plant in the Hunnewell Pinetum, Wellesley, Massachusetts, with layered branches around it. Arnold Arboretum photograph. Below right: The same tree thirty years later after the main stem has declined and been removed. The layered branches are represented by a rosette of independent plants. Photograph by R. Warren.

ginate cone scales often take on a handsome purple color in the spring and later in the year form a carpet under the mature trees. Its minimum seed-bearing age is 30 to 50 years.

Tradition and availability have led Britons and Europeans to favor this spruce for Christmas trees. In North America other needle evergreens have provided competition. To many people, the spruce's habit of dropping its needles after the tree has been cut is a disadvantage.

Long ago, people used to crush the leaves and twigs of spruces to produce an essence for making spruce beer. This was combined with sugar, molasses, treacle or honey, and yeast, allowed to ferment, and then bottled. The resulting potation was consumed for pleasure and was also used as an antiscorbutic for long sea voyages. The taste was both aromatic and medicinal. American spruces can be used in the same way as Norway spruces for this purpose, for those so inclined.

Because the wood of *Picea abies* is light, strong, and straight grained and takes a good finish, it is excellent for carpentry and construction. Its planks, as well as those of pine and fir, are referred to as "deal" (those of *P. abies* are known as "white deal").

At least 140 horticultural varieties of *Picea abies* have been identified. They are distinguished by varying habits of growth and, to some extent, by the shape, angle, and rigidity of the leaves. Most can still be recognized as *P. abies*, however, by the typical red-brown shoots, the dark green foliage, and the familiar slightly resinous buds.

The Arboretum has 25 plants of typical *Picea abies*. Two are just 100 years old, and 28.2 and 29.7 meters tall; they form the showpieces of the pinetum as viewed from the southwest. They, together with the 29-meter *Acer saccharinum* on Meadow Road, are the tallest trees in the Arboretum. Eleven other *P. abies* of accession number 2306 are of unknown origin or age but are well-grown trees between 19.5 and 28.2 meters in height. Two forms, f. *conica* and f. *cupressina*, are represented by plants of 100 and 66 years, respectively, and measure 19.5 and 22.5 meters. Together with many other cultivars, these plants are important and distinguished constituents of the pinetum.

Picea alcoquiana (J. G. Veitch ex Lindley) Carrière Alcock's spruce

This tree was discovered in 1861 by John Veitch while he was climbing Mt. Fuji in company with Rutherford Alcock, British Minister to Tokyo. In its native habitat it grows sparsely and at high elevations. It is a tree with delicate leaves that point strongly forward on the upper aspect of the shoots and are spreading and less forward pointing below. The stomatic lines are more prominent than in most other quadrangular-leaved spruces and are brighter on the lower surface of the leaves than on the upper, thus giving rise to the name *Picea bicolor* (Maxim.) Mayr, under which the species has recently been known.

The cones are medium sized (5–10 cm), with the tips of the scales slightly wavy or serrulate. In the Arboretum trees the scale tips have a

A cone from a Picea alcoquiana *tree in the Arnold Arboretum. The tips of the cone scales roll outward. Photograph by R. Warren.*

tendency to roll outward. This character reaches full expression in the variety *reflexa*, which is not included in the Arboretum's collection.

Picea alcoquiana is not a rapid grower, and its main ornamental feature is its interesting two-toned leaves. It is rare in cultivation.

Six plants grow in the pinetum, all of them over 60 years of age. Two were received from Veitch's Nursery in England and three from the Hunnewell Pinetum in Wellesley, Massachusetts. They are between 10.8 and 16.8 meters tall.

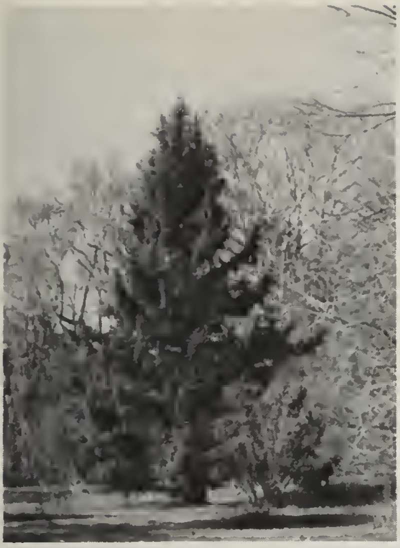
Picea asperata Masters Chinese spruce

Ernest Wilson brought the seed of *Picea asperata* back from China in 1911. Its role in that country has been compared with that of *Picea abies* in Europe: it covers a wide area, and its foliage varies in character — to some extent depending on the climate. It is a stronger grower there than most other native Chinese spruces.

Its glaucous, light gray-green foliage is striking when seen from a distance and has given rise to a Chinese vernacular name that means "cloud spruce." The leaves are stiffer than those of Norway spruce; they spread all around the reddish shoot and sweep upward on the branchlets. Their tips are sharp. This feature, combined with the stiffness, makes the foliage very prickly and probably occasioned the tree's common name, dragon spruce. The winter bud is large and conical with a swollen base.

Wilson recognized three varieties: var. *heterolepis* Rehder & Wilson) Cheng, with split cone scales; var. *notabilis* Rehder & Wilson, with narrow cone scales; and var. *ponderosa* Rehder & Wilson, with large cones. *Picea aurantiaca* Masters, introduced from western China in 1908, *P. meyeri* Rehder & Wilson, introduced from northern China in 1910, and *P. retroflexa* Masters, introduced from western China in 1911, are closely related species, showing slight differences in the color or hairiness of the branchlets and in the shape of the leaves or the cone scales.

Picea asperata grows slowly here. This quality, its gray-green foliage, and its informal habit of growth have a charm or, at least, an




Left: Picea asperata *var.* ponderosa *growing on the north side of Bussey Hill in the Arnold Arboretum. Photograph by R. Warren. Right:* P. brewerana *growing in Dublin, Ireland, in 1952. Arnold Arboretum photograph.*

interest that should lead to its wider use as an ornamental. It is commonly found in botanic gardens and arboreta but is seldom offered commercially.

Forty plants, including representatives of the above-mentioned varieties and related species except for *Picea retroflexa*, are growing at the Arnold Arboretum. The tallest is 13.5 meters. They are located in four areas: the pinetum, the south side of Bussey Hill near South Street, Peters' Hill, and the knoll west of the Hunnewell Building.

Picea brewerana Watson — Brewer's spruce

The home of this spruce is the Siskiyou Mountains of southern Oregon and northern California. Probably discovered by Prof. William H. Brewer in 1863, it was first brought into cultivation on the West Coast, whence Sargent procured it for the Arnold Arboretum in the 1880's. Kew Gardens received a plant from him in 1897 that is still growing there; in December, 1981, it was 12.8 meters tall.

It is the slowest growing of the spruces. In the 80 years of their cultivation, none is known to have reached 13 meters in height. Even in their native habitat, trees over 22 meters are rare.

Picea brewerana is one of the three spruces (not including *P. abies*, in which the characteristic is not so extreme) that show outstanding pendulous branchlets. The other two are *P. smithiana* and *P. spinulosa*, from the Himalayan region, neither of which is hardy in our area.

Normally the crown is pointed. The branches sweep upward at the top but point downward in the lower areas. The dangling, hairy branchlets can be more than a meter long. The leaves arise all around the shoot, point forward, and curve away from it. They are up to 3.5 cm in length, flattened, and blunt tipped.

Charles Sargent (1897, p. 482) said, "a few small grafted plants in the Arnold Arboretum are probably the only representatives of this interesting tree in the eastern states." We have no record of the fate of these plants. Today, however, one plant — obviously a tree of some age but only 2.5 meters tall — is growing in the Peters' Hill area. Its record is lost, and it was only recently that Dr. Richard Weaver recognized it as an example of *Picea brewerana*. The branchlets are pendulous, but the stunted habit prevents their proper display. The flattened leaves are, however, diagnostic.

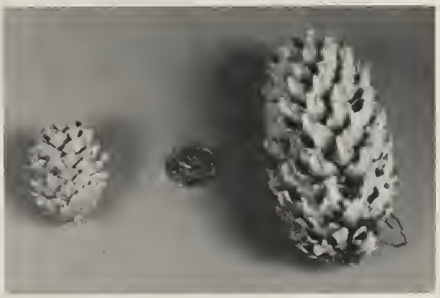
Picea engelmannii (Parry) Engelmann — Engelmann spruce
and
Picea pungens Engelmann — Colorado spruce

The similar appearance of these two handsome spruces, their overlapping habitats in the Rocky Mountains, and their almost simultaneous discovery make it appropriate to discuss them together. Charles Parry found them near Pike's Peak in 1862. Engelmann spruce covers a wider area than Colorado spruce, extending into Canada and to the Mexican border. It grows at a higher altitude. Both have blue foliage. In the case of Engelmann spruce, bluish foliage is relatively constant, whereas in Colorado spruce the leaves of different specimens vary from vivid blue to drab gray-green.

The cones of both are light yellow, and the papery scales have erose tips. Differences do exist, however. Engelmann spruce, when compared to Colorado spruce, has a broader crown (viewed from a distance), smaller cones, and usually hairy (rather than glabrous) shoots. Its leaves are more flexible and less pointed, and the branches are less stiffly horizontal. Often, in fact, Engelmann spruce has been considered allied to *Picea glauca*.

The Colorado spruce is a favorite in landscaping. (It is the State tree of Colorado). Its many cultivated varieties providing different shades of blue are seen throughout North America and Europe on large and small estates. Many agree that their planting has been overdone, and the trees have often been placed too close to houses. Their symmetrical horizontal branching and showy blue color make them vulnerable to vandalism during the Christmas season. Engelmann spruce is considered by many to be an equally handsome tree. It deserves more consideration in decorative planting than it now receives.

Cultivars of *Picea engelmannii* are not common, whereas those of *P. pungens* are many and familiar.



Above: Plants in the Arnold Arboretum pinetum. The trees with narrow crowns are Picea pungens, *and those with broad crowns are* P. engelmannii. *Photograph by R. Warren. Below left: Shoots of* P. pungens *(left) are smooth, while those of* P. engelmannii *(right) are hairy. Photograph by A. Coleman. Below right: Cones of* P. engelmannii *(left) and* P. pungens *(right). Photograph by R. Warren.*

Left: Picea glauca *in the Arnold Arboretum. Right: Sixty-year-old plants of* P. glauca *f.* conica *growing in the old dwarf conifer area of the Arboretum. Photographs by R. Warren.*

The Arboretum's collection contains nine plants of *Picea engelmannii*, all over 50 years of age. Four of these — among the finest trees in the pinetum — are over 100 years old and reach a height of 19 meters. Of the many specimens of *P. pungens* in the Arboretum, 14 are over 50 years old, and 5 over 100. The tallest is 22 meters.

Picea glauca (Moench) Voss white spruce

Picea glauca, together with *P. rubens*, the red spruce, and *P. mariana*, the black spruce, are the most abundant conifers of the northern part of North America. The southern boundary of the range of the white spruce extends from western Massachusetts to western Montana, the northern from latitude 60° N in Labrador to 70° N in the Mackenzie District of northwestern Canada. Its profile in the wild is broader than that of the spirelike black spruce, and the foliage is denser. The color, true to the common name, is lighter than that of the black spruce, and it can show either a bluish or a greenish cast. Its yellow-brown, glabrous branchlets distinguish *P. glauca* from the other two spruces, which are customarily reddish and hairy.

The crushed foliage of *Picea glauca* exudes a musky odor that has caused woodsmen to name it the cat or skunk spruce. Its yellow cones are of a distinctive teardrop shape and are up to 7–8 cm in length; they do not appear until the plants are 25 years of age, and they fall at maturity. The black spruce's smaller cones appear at a younger age and remain on the tree for some years after shedding their seeds.

From the lumberman's viewpoint, *Picea glauca* is the most important constituent of our great northern forests. Its long-fibered wood is excellent for paper pulp as well as for construction, but the species

Picea glehnii *growing on Peters' Hill. Photograph by R. Warren.*

cannot compete in speed of growth with the West Coast spruces.

Its unremarkable appearance, its odor, and perhaps its familiarity make it less popular ornamentally than the Norway spruce. The Arboretum grows four *Picea glauca* trees at the present time. The oldest of known age is 85 years; its height 14.4 meters. Another, of unknown age, is 15 meters tall.

Picea glauca has given rise to a few cultivated varieties. A familiar one, forma *conica* Rehder, must be mentioned. In 1904 Alfred Rehder and John Jack, while awaiting a train that was behind schedule near Lake Laggan, Alberta, took a stroll and found some dwarf spruces resembling witches' brooms, which they sent back to the Arnold Arboretum. This was the origin in cultivation of the familiar slow-growing, conical plant that has been a conspicuous addition to ornamental planting, particularly in rock gardens. It is sold in nurseries as dwarf Alberta spruce. As an ornamental it has few disadvantages, although if it suffers winter burn or some other disfiguring accident, a long-standing blemish afflicts its otherwise tidy appearance. In the old dwarf conifer area at the Arboretum, there are several plants that are 60 years of age. Although these are obviously now oversize for a rock garden, they are interesting and decorative items.

About two dozen other varieties and cultivars of *Picea glauca* are recorded in the literature.

Picea glehnii (Fr. Schmidt) Masters — Sakhalin spruce

This tree is native to Sakhalin Island in Russia and to the nearby Japanese island of Hokkaido. It was introduced to Britain in 1877 by Maries for the Veitch Nurseries in England. Its size in its native habitat is moderate, reaching to 30 meters. It is similar to the red spruce (*Picea rubens*). The scales of the bark are somewhat reddish, and the branchlets, buds, and cones are reddish brown. The branch-

Picea koyamai. *Left: One of the group growing on the slope near the Hunnewell Building, Arnold Arboretum. Right: Cones. Photographs by R. Warren.*

lets are hairy, particularly in the furrows. The outer scales of the buds have curious needlelike projections extending the length of the bud, a feature seen in three other spruces, *P. mariana*, *P. omorika*, and *P. rubens*. The leaves are slender, short, straight, and stiff; they are arranged in a pectinate fashion beneath the branchlets, pointing forward to cover the branchlets above.

Although *Picea glehnii* is not well known by the general public, it is handsome and has an exotic attraction that has given it a place in many collections.

The Arnold Arboretum has 12 specimens of *Picea glehnii*, all grown from seeds received in 1894 from the Government Forestry School at Tokyo. The trees stand in two groups: one of seven trees located in the pinetum, the other of five on Peters' Hill. The tallest have now reached 19 meters in height.

Picea koyamai Shirasawa — Koyama's spruce

Picea koyamai has a restricted distribution in central Japan. Mitsuo Koyama discovered it on Mt. Yatsuga-dake in 1909 and guided Ernest Wilson to the area in 1914.[1] Wilson sent the seeds to the Arnold Arboretum, which passed them on to other botanic gardens. It is a handsome spruce with dark foliage, bark with large rectangular plates, and sturdy, spreading branches that turn conspicuously up-

[1] I am grateful to Dr. Tatemi Shimizu, of Shinsu University, Matsumoto, Japan (located near the area on Mt. Yatsuga-dake where *Picea koyamai* grows), who visited the Arnold Arboretum in 1980. He informed us that two separate stands grow there, one of which Wilson apparently did not know. In 1958 a typhoon flattened the stand from which our specimens come, leaving the other intact. New growth is taking place well, however, in the grove that Wilson visited.

ward at the ends. The shoots are pale orange, glabrous on the leading branches, and often hairy on the side branches. The buds are large, conical, and resinous. The leaves are stiff, pectinate below, lying forward and curved upward above. The cones are brown when mature, moderately tapered, and on some plants distinctly barrel shaped, with smooth, rounded scale edges.

Similar trees, but with more delicate and straighter needles, have subsequently been found in Korea. There is considerable disagreement as to whether they are variants of *Picea koyamai* or belong to a separate species, *P. koraiensis* Nakai.[2]

Picea koyamai, and occasionally some of its allies, are seen in most pineta, but not in small collections. Its unique dark, sturdy appearance should recommend it for wider use. No cultivars are reported.

The Arnold Arboretum's collection now contains 15 specimens of *Picea koyamai*, 11 dating from the introductions by Wilson in 1915, and four others from the early 1920's. The tallest is 17.4 meters. There are also three younger plants grown from seed received in 1960 from Minnesota. Because their leaves are narrower and straighter than those of other specimens, and because the plants came from near the Yalu River in North Korea, they are probably referable to *P. koraiensis*, if indeed this is a distinct species.

Picea likiangensis (Franchet) Pritzel — Likiang spruce
and
Picea purpurea Masters — purple-cone spruce

These two spruces go together here because many botanists consider the latter to be a variety of the former. *Picea likiangensis* grows in western China and Tibet. Discovered by Delavay in 1884, it was introduced to Veitch's Nursery by Wilson in 1904. *Picea purpurea* is from an area of western China somewhat north of the locality for the type he introduced in 1910.

More than any other species of the genus, *Picea likiangensis* typifies the identity problems of the Chinese spruces. From crossbreeding trials Jonathan Wright (1955) considered it to be a group rather than a single species. To quote William Bean (1976, p. 188): "even from a single seed collection *P. likiangensis* varies considerably in the colour and degree of hairiness of the shoots, colour of leaves, etc." Any description, therefore, must be couched in general terms. Its leaves are bicolored as in *P. alcoquiana*, and its shoots are usually light yellow or whitish gold, and hairy. The sterigmas lean forward, curving upward and back at the tips. The young cones are bright red. The scales of the mature cones are rhomboid, narrowed, and usually erose at the tips.

[2] Reports have appeared on three varieties of *Picea koraiensis: intercedens, pungsanensis,* and *tonaiensis.* Some observers contend that all of these are transitional forms between *P. koyamai* and *P. obovata,* a relative of the Norway spruce that extends into northeastern Asia.

Picea purpurea, often termed *P. likiangensis* var. *purpurea* (Masters) Dall. & A. B. Jackson, differs from *P. likiangensis* only in having shorter leaves and brighter, more purple cones.

In its living collections the Arboretum has only one specimen of *Picea likiangensis*, dating from 1965. It has lost its upper half and is presently an ungainly, stunted plant 2 meters tall. Of the five specimens of *P. purpurea*, four are from seeds that Wilson brought here in 1911. The tallest is 13.5 meters. They are all growing in congested situations and have not achieved their potential as specimen trees. The fifth tree, received from H. H. Hunnewell in 1922, is growing in a less crowded section and is 11 meters tall.

Picea mariana (Miller) Britton, Sterns, & Poggenburg black spruce and

Picea rubens Sargent red spruce

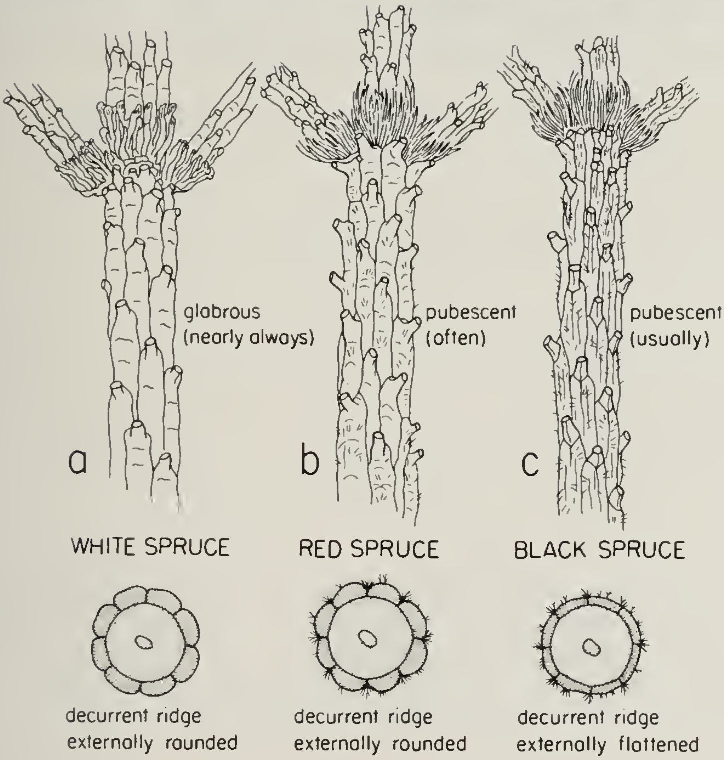
These two plants are similar in appearance. The habitat of the black spruce approximates that of the white: Canada, from the Atlantic coast in the east but stopping short of the Pacific coast in the west, extending southward into the northern United States. The red spruce is limited to northern New York and New England, Nova Scotia, New Brunswick, and the St. Lawrence Valley, extending down the Alleghenies to North Carolina. Both species have reddish scaly bark and reach a maximum height of 24 meters. The black spruce ranges farther north than does the red and often grows in boggy places. When seen from a distance, its foliage is dark green, while that of the red spruce is faintly auburn. The leaves of both are short — hardly more than 1.4 cm. On the black spruce they are straight and show blue-white below, whereas on the red spruce they are lighter green, with the lateral ones incurved.

The branchlets of both spruces are reddish brown and hairy. The ridges on them that lead to the sterigmas have flattened crests in the black spruce, and rounded crests in both the white and red spruces. On black spruce branchlets, particularly those on which newest growth has just been completed, these crests look like a long row of coffins. In the older shoots later growth in diameter tends to flatten out the rounded crests of the ridges.

The outer scales of the buds in both these plants have needlelike tips similar to those of *Picea glehnii* and *P. omorika*. The cones of the two species are similar, but those of the black spruce are shorter, appear when the plants are younger, and conspicuously cling to the branches after they have shed their seeds.

The profile of the black spruce is more spirelike and neatly symmetrical than that of the red, except in the far north, where climatic conditions reduce the black spruce to a shrubby habit and the red spruce does not grow.

The wood of both *Picea mariana* and *P. rubens*, as well as that of *P. glauca*, is used for making paper pulp. In *P. mariana* the wood is



Above: Picea mariana *(left) and* P. rubens *(right) in the Arnold Arboretum. Photographs by R. Warren. Below: Branchlets of* P. glauca, P. rubens, *and* P. mariana *(after Gordon, 1952, with permission).*

strong and useful for building. The slow growth of these trees, however, renders them no longer economical for this use.

A few cultivars are known from each species. Those of *Picea mariana* — 'Beissneri', 'Doumetii', and 'Ericoides' — are more familiar, having a compactness and a light, bicolored flecking to the leaves that are especially attractive. They are more desirable for ornamentals than the species itself.

One 50-year-old plant of *Picea mariana* is growing as a free-standing specimen slightly separated from, and to the northeast of, the pinetum's spruce collection, not far from Bussey Brook. It was acquired in 1922 from Jasper Park, Alberta, Canada, via J. G. Jack. It is a fine, sturdy specimen 11.4 meters tall, but it does not show the shapely conical top characteristic of these trees in the wild. Three other young (1969) plants are growing at the Case Estates in Weston. The Arboretum's specimens of *P. rubens* consist of eight plants received in 1895 from Bar Harbor, Maine. They are healthy trees 11 to 18 meters tall.

Picea montigena Masters candelabra spruce

Introduced in 1904 by Ernest Wilson for Veitch's Nursery, *Picea montigena* grows in its native habitat of western Szechuan, China, at altitudes of 3000–4000 meters to heights of about 30 meters. Most accounts of this species associate it with *P. likiangensis* — an unhelpful comparison, considering the variability of the latter. Alan Mitchell (1972) stated that the specimens available to him are closer to *P. asperata:* the cones are alike; the leaves are similarly stiff, pectinate below, and upswept from the sides; and the buds are large and resinous. The bark, as in *P. asperata* and *P. koyamai,* flakes in large plates. The leaves are dark blue-green, not gray-green as in *P. asperata,* and the tips are not so sharp; the shoots are more hairy. It resembles *P. asperata* in habit.

Maxwell Masters, remarking in 1906 on the plants just introduced into Britain, noted that the scales of the young cones turn downward, only to return to normal position before maturity. I have recently observed this phenomenon on plants in the Arnold Arboretum: it is striking at the time of pollination — an exaggeration of the downward curving seen in the cone-scale tips of all spruces during this period.

Eight specimens are growing in the Arboretum, all from seed brought by Wilson in 1911. The tallest has reached 12.3 meters after 70 years. They closely resemble *Picea asperata*, but they do not have the grayish cast to the foliage and the leaves are less prickly.

Picea obovata Ledebour Siberian spruce

Picea obovata is commonly considered to be a close relative of *P. abies* that extends into Asia; many think that it is a variety of that species. Helmut Schmidt-Vogt, a recent authority, even denies it varietal status. The slower growth, the shorter, more slender leaves, the

Picea montigena *(left) and* P. omorika *(right) in the Arnold Arboretum. Photographs by R. Warren.*

paler and more hairy branchlets, the shorter cones, and the more rounded edges to the cone scales separate it from typical *P. abies.*

Picea obovata is seldom seen in nurseries. No horticultural forms are recorded.

In the Arboretum are three plants labeled *Picea obovata,* the oldest dating from 1904 and now 16.5 meters tall. In addition, there are two examples of *P. obovata* var. *coerulea* Tigerstedt and one of var. *fennica* (Regel) Henry (Finnish spruce). The latter plant was acquired in 1901 and is 20 meters tall, a vigorous and handsome specimen. In all these plants the foliage and cones show the differences mentioned that distinguish *P. obovata* from *P. abies.*

Picea omorika (Pančić) Purkyně Serbian spruce

This tree, from a restricted area in southwestern Yugoslavia, was not introduced into cultivation in western Europe until 1881. With its characteristic narrowly columnar habit, the pendulous branches turning upward at the tips, it is easily recognized at a distance. In its native habitat it reaches 30 meters in height, a dimension that the oldest specimens in cultivation in Britain have now attained after 90 years.

The upper leaves of *Picea omorika* may lie forward along the shoot in a broadly imbricated arrangement, curving gently upward at the ends, the lower ones spreading laterally. The leaves are flat, with the upper surface shiny, slightly convex transversely, and without stomata, and the lower surface with two white stomatic bands. The


Left: Picea orientalis *in the Arnold Arboretum. Photograph by R. Warren. Right: The short, regularly arranged leaves of equal length of* P. orientalis *(right) compared with the long, flat leaves of* P. omorika *(left). Photograph by A. Coleman.*

leaf tip appears blunt, somewhat like that of *Picea brewerana*, but close inspection often reveals a tiny sharp mucro prickly to the touch.

Picea omorika is hardy here and is tolerant of a variety of soils. Its buds break late in the season, thus rendering it less vulnerable than others to damage from late frosts. It has been recommended as a competitor to *P. abies* for forest plantings in Britain. It has become justifiably popular in our area as an ornamental and is available in nurseries.

Cultivars of *Picea omorika* are few but interesting. The compact, globular growth of *P. omorika* 'Nana' is very different from the slender habit of the type plant, and its bicolored green and white leaves make it a popular ornamental.

The Arnold Arboretum first received *Picea omorika* in 1881 as seed from Germany. The trees grown from these seeds no longer survive, but in 1887 they provided scions from which our present mature plants grew. There are now 16 trees, including five dating from that time. The tallest are 18 meters. Although not as tall as our *P. abies* of the same age, they compete well with them as specimen trees.

Picea orientalis (L.) Link oriental spruce

Scattered descriptions of this tree, whose native habitat is the Caucasus, date from as far back as 1717. It was probably introduced into cultivation in western Europe around 1840 and presumably came to America not long thereafter. In its native habitat it can reach heights of 60 meters, and in cultivation in Britain it has grown to over 30 meters.

Alan Mitchell (1972, p. 25) has pointed out that "crowns of older trees become very dense indeed, but around the apex remain open. Slender straight young shoots project, slightly ascending, from the

Left: Rigid, sicklelike leaves of Picea torano. *Photograph by R. Warren. Right: buds of* P. torano *(lower left; large and smooth),* P. abies *(above), and* P. mariana *(lower right; note needlelike tips to the bud scales). Photograph by A. Coleman.*

general line of the crown in a distinctly spiky way" — a useful thing to remember when viewing the tree from a distance. The leaves are among the shortest in any spruce, and the length varies little throughout the tree. They point forward in regular rows, giving an attractive, tidy appearance. They are glossy green and blunt tipped. The shoots are pale yellow and hairy, and the cones are 6–10 cm long, tapered, slightly curved, and gray-brown. The tips of the cone scales are rounded and entire.

Picea orientalis is present in most botanical gardens and some nurseries. Its dense habit and textured foliage make it the favorite spruce of many conifer enthusiasts. Although it is not the hardiest spruce in our area, it should increase in popularity.

Several cultivated forms of *Picea orientalis* exist. The dwarf ones, particularly 'Aurea', are beautiful additions to a rock garden.

The Arboretum's eight specimens include five grown from seed acquired in 1873 from the St. Petersburg Botanical Garden, and one other collected in the wild in 1903 by Charles Sargent. These are magnificent trees reaching 21 meters in height.

Picea torano E. Koehne — tigertail spruce

This Japanese native was introduced to the West (England) by J. G. Veitch in 1891. In Japan it grows to 90 meters or more. It is a pyramidal tree, dark green in color, and of dense habit. Its most outstanding characteristic is its curved, very rigid, sharp-pointed leaves, which make it stand out from all other spruces. This feature gives rise to the name tigertail, although presumably this refers not to the sharpness of the bristles on the tail but to the scratching one would get from grabbing it. The leaves and the surface of the branchlets are glossy smooth, a feature perhaps responsible for the other name by which it is known, *Picea polita* (Sieb. & Zucc.) Carr. ("polita" is Latin for "polished"). The sterigmas are extraordinarily thick and sturdy to match the leaves they bear.

Picea torano is not readily available in nurseries, a situation that I feel should be remedied. It is hardy. Its distinctive foliage and vigorous habit make it a source of curiosity and admiration wherever it is grown.

Despite its large size in its native habitat, it is a slow grower in cultivation. Although some of the trees planted in England are 90 years old, the tallest ones are under 22 meters. This deliberate growth can be an advantage on a limited estate.

The Arboretum's collection contains two specimens received in 1895 from Veitch's Nurseries. They have reached heights of 18 meters.

Picea schrenkiana Fischer & Meyer Schrenk's spruce

This spruce comes from Central Asia, crossing the border between the southern USSR and Sinkiang Province, China, where it grows at altitudes of 1400–3000 meters. It was discovered by A. G. Schrenk in 1840 and was introduced into cultivation in western Europe in 1878. Although it was first confused with *Picea smithiana* (Wallich) Boiss., West Himalayan spruce, and apparently still is in some herbaria, it is quite distinct from it. *Picea smithiana,* coming from considerably farther south, has longer leaves and cones and more pendulous branchlets. *Picea schrenkiana* has also been associated with *P. obovata*, a Siberian species that extends into the northern part of its range. As with other spruces, there are variations in the habit and foliage of Shrenck's spruce that have stimulated attempts to recognize more than one species. The only one that seems possibly valid at the present time is *P. tianschanica* Rupr. From a southerly range contiguous with that of *P. schrenkiana*, it is a smaller tree with hairy, terra cotta–colored branchlets. The buds are barrel shaped and of a cinnamon color, and the cones are almost twice as long as those of *P. schrenkiana.*

Picea schrenkiana grows to 50–60 meters in its native habitat, but (at least in England) it has reached only one-third that height in cultivation. The bark is dark gray, and the buds are golden brown, 4.0 to 6.8 mm long, and nonresinous. The shoots, which may or may not be hairy, are cream colored. The green leaves point forward, covering the shoot above and scarcely parted below. They are quadrangular in cross section, 15–35 mm long, and with two to four lines of stomata on all four sides. The cones are 6–11 cm long, with the scales coffee brown, their edges rounded and wavy.

This species is not known to be available in nurseries. Because of its resemblance to the Himalayan spruces (*Picea smithiana* and *P. spinulosa*), it might be considered for cultivation. No cultivated varieties of *Picea schrenkiana* are known.

The Arboretum's only living specimen at present is a plant received from St. Petersburg, Russia, in 1903. Eleven meters tall, it is growing in a shaded situation in the pinetum and has lost the lower half of its foliage. No cones are available, but the vegetative characteristics of

Picea wilsonii *growing on Peters' Hill, Arnold Arboretum. Photograph by R. Warren.*

the tree conform to its classic description and to our herbarium specimens.

Picea wilsonii Masters Wilson's spruce

Another East Asian spruce, this tree was collected first by Henry in 1888 and was introduced by Wilson to Veitch's Nursery in England in 1901. It is widespread in the mountains of northwestern Szechuan and Hupeh, extending into Kansu and Shansi. It grows there to a height of 25 meters.

It is a handsome, pyramidal tree with branches that tend to grow out to the same length at all levels of the tree, resulting in a broad crown. The most distinctive feature of the tree is the ashen-yellow color of the glabrous branchlets, not only on the new growth, but lasting for the next three or four years. The sterigmas are noticeably small to support the slender, dark green leaves, which point forward above the branchlets, laterally below, and show faint lines of stomata on all sides. The buds of *Picea wilsonii* are dark and shiny chestnut in color, producing a marked contrast with the pale branchlets. The nondistinctive cones are 4–6 cm long; the scales have rounded edges.

Because of the gray color of its shoots, *Picea wilsonii* is relatively easy to distinguish from other East Asian spruces. For that reason, in addition to its pleasing habit of growth, it should be more widely known and seen. It is as yet rare in cultivation.

The Arboretum's collection contains 17 trees, all accessioned between 1908 and 1912. The tallest is 15.3 meters.

Comment

Of the 28 species of *Picea* listed in the Table, there are seven that the Arboretum does not grow as established trees. Most have been tried unsuccessfully and are continuing to be tested as material comes in from different areas of the world. Named hybrids to be found on the grounds are: *Picea* × *hurstii* De Hurst (*P. engelmannii* × *P. pungens*), *Picea* × *mariorika* Boom (*P. mariana* × *omorika*), and *Picea* × *notha* Rehder (*P. glehnii* × *P. jezoensis* var. *hodoensis*), as well as several formula hybrids.

With rare exceptions this account has not dealt with the horticultural forms of the various species. Of the 283 of these listed in Den Ouden and Boom's *Manual of Cultivated Conifers*, our inventory includes 120, many of which are represented by several specimens. Forty-five (or more than one-third) of these are cultivars, varieties, or forms of *Picea abies*. The next most highly represented species is *P. pungens* with 23 subspecific taxa. Each is worth close attention and separate study.

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Metasequoia Keeps on Growing

by JOHN KUSER[1]

It has been 34 years since the Arnold Arboretum introduced the dawn redwood, *Metasequoia glyptostroboides* Hu & Cheng, into the Western world, and 14 years since *Arnoldia* published a list of 50 of the tallest specimens (Wyman, 1968).

In September, 1981, I mailed a questionnaire to those responsible for the 50 specimens, and in addition I sent copies to 45 state universities, 45 state forestry commissions, 25 botanical gardens, and 24 institutions or individuals whose names were furnished by other respondents. The questionnaire requested data on size and age of specimens, site, elevation, mean January and July temperatures, mean annual precipitation, length of frost-free growing season, production of female and male cones or catkins, seedlings, attempts at hybridization, and incidence of disease or insect attack. In return, I received 80 questionnaire returns, 25 letters with more detailed information, and several good photographs.

The news is that metasequoias have continued to grow rapidly, and that those resulting from the Arboretum's original introduction have become sexually mature. The tallest one in November, 1981, was a 104-footer[2] growing near James Blair Hall at the College of William

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[2] Measured by Blume-Leiss rangefinder altimeter.

Metasequoia glyptostroboides *at the Arnold Arboretum in summer (left) and winter (right; photograph by E. Gray).*

and Mary, Williamsburg, Virginia (see Table). This tree was 67 feet high in 1967 (Wyman, 1970), and 92 feet when I measured it in January, 1976. It has grown an average of two feet a year since then, an impressive annual increment for a large tree.

The geographic area in the United States where *Metasequoia* grows best lies along the boundary zone between two of the floristic provinces (the Eastern Deciduous Forest and the Coastal Plain) proposed by Gleason and Cronquist (1964). Along a belt from northern Alabama and Georgia to southern New England, many metasequoias have attained heights of 75 feet or more and circumferences of 10 feet. Climatically, this broad area is characterized by a growing season of 160 to 220 days, annual rainfall of 40 to 55 inches, and warm, humid summers with mean July temperatures ranging from 70° to 80°F. Mean January temperatures vary from 23°F at Northampton, Massachusetts, to 43°F at Auburn, Alabama. West of the Appalachians, where temperature extremes are wider and dry spells more pronounced, *Metasequoia* has also thrived, but to a lesser degree. In the mild climate of the Pacific coast west of the Rocky Mountains, it has prospered on sites where moisture is available through the summer. Many have grown well in western and southern Europe along a belt from the British Isles to the Georgian S.S.R. An excellent account of its growth in Britain has been published (Mitchell, 1977). It is favored in the Ruhr district of Germany because of its resistance to air pollution (Petsch, 1978) and is one of the four main species involved in urban forestry in its native China (National Academy of Sciences, 1975).

In site preference, *Metasequoia* seems to be living up to its Chinese name of "shui-san" (water fir). The big trees at Locust Valley, New York, and Auburn, Alabama, are both near ditches, and the Williamsburg, Virginia, trees grow on a stream terrace about 12 feet above water level and 75 feet back from the edge of the ravine. In New

Height, circumference, and crown spread of the 50 largest metasequoias

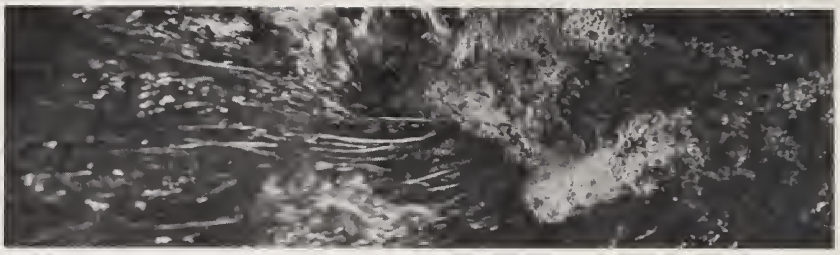
Location	Date Planted	Height	Circumference at 4½′	Crown Spread	Points†
Bailey Arboretum, Locust Valley, New York	1949	79′	12′10″	40′	243
College of William and Mary, Williamsburg, Virginia	1949	104′	9′ 6″	45′	229
Auburn University, Auburn, Alabama	1952	90′	10′ 3″	51′	226
Princeton University, Princeton, New Jersey	1949	85′	10′ 6″	40′	221
Winterthur Gardens, Winterthur, Delaware	1949	78′	10′ 9″	40′	217
Willowwood Arboretum, Gladstone, New Jersey	1950	82′	10′ 0″	42′	212
Smith College Botanical Garden, Northampton, Massachusetts	1949	72′	10′ 0″	42′	202
Morris Arboretum, Philadelphia, Pennsylvania	1953	70′	8′ 9″	40′	185
Oregon State University, Corvallis, Oregon	1949	76′	8′ 5″	31′	185
Longwood Gardens, Kennett Square, Pennsylvania	1949	70′	8′ 8″	36′	183
University of California Botanical Garden, Berkeley, California	1949	90′	7′ 1″	24′	181
Biltmore House, Asheville, North Carolina	1950	81′	7′ 6″	30′	179
Peter Finnerty, Princeton, New Jersey	1949	83′	7′ 1″	36′	177
Marquand Park, Princeton, New Jersey	1949	71′	8′ 0″	30′	175
Carleton Goff, Barrington, Rhode Island	1949	76′	7′ 3″	39′	173
Alexander St., Princeton, New Jersey	1949	72′	7′ 8″	36′	173
Duke University Gardens, Durham, North Carolina	1949	66′	8′ 0″	38′	172
Arnold Arboretum, Jamaica Plain, Massachusetts	1949	70′	7′10″	24′	170
Broadmead, Princeton, New Jersey	1949	98′	5′ 6″	24′	170
Peavy Arboretum, Corvallis, Oregon	1949	67′	7′ 8″	40′	160
University Botanic Garden, Cambridge, England	1949	75′	7′ 1″	27′	167
UCLA Botanical Garden, Los Angeles, California	1948	94′	5′ 6″	22′	165
J. J. Willaman, Plymouth Meeting, Pennsylvania	ca. 1950	83′	6′ 4″	24′	165
Forest Research Institute, Rotorua, New Zealand	1950	51′	8′ 2″	38′	158
Samuel Humes, Lawrenceville, New Jersey	ca. 1950	73′	6′ 4″	24′	155
Los Angeles State and County Arboretum, Los Angeles, California	1948	85′	4′ 9″	12′	145

reported in the 1981/82 survey.*

Location	Date Planted	Height	Circumference at 4½′	Crown Spread	Points†
Missouri Botanical Garden, St. Louis, Missouri	1950	65′	5′ 9″	28′	145
Dawes Arboretum, Newark, Ohio	1950	58′	6′ 7″	10′	140
National Arboretum, Washington, D. C.	ca. 1949	53′	6′ 8″	25′	139
University of Washington Arboretum, Seattle, Washington	1954	71′	5′ 2″	18′	138
Scott Horticultural Foundation, Swarthmore, Pennsylvania	1949	60′	5′11″	22′	137
Brooklyn Botanic Garden, Brooklyn, New York	1954	67′	5′ 2″	24′	135
Rutgers University, New Brunswick, New Jersey	ca. 1950	70′	4′ 9″	24′	133
Secrest Arboretum, Wooster, Ohio	1949	69′	4′ 8″	15′	129
Mount Auburn Cemetery, Cambridge, Massachusetts	?	62′	5′ 0″	23′	128
Hoyt Arboretum, Portland, Oregon	1964	56′	5′ 4″	24′	126
North Carolina State University, Raleigh, North Carolina	?	51′	5′ 9″	22′	125
Callaway Gardens, Pine Mountain, Georgia	1961	70′	4′ 0″	25′	124
Mrs. R. P. Nash, S. Euclid, Ohio	ca. 1954	70′	4′ 0″	25′	124
Royal Horticultural Society Garden, Wisley, England	1948	70′	3′ 6″	30′	119
Bernheim Forest Arboretum, Clermont, Kentucky	1964	55′	4′ 9″	20′	117
Ayrault House, Newport, Rhode Island	ca. 1949	61′	3′ 7″	28′	111
Beacon Hill Park, Victoria, B.C., Canada	ca. 1949	52′	4′ 2″	20′	107
University of Connecticut, Storrs, Connecticut	1963	69′	2′ 6″	24′	105
Strybing Arboretum, San Francisco, California	?	34′	5′ 3″	27′	104
University of Georgia, Athens, Georgia	1964	45′	4′ 2″	25′	101
Clemson University, Clemson, South Carolina	1963	49′	3′ 9″	24′	100
Vancouver Parks, Vancouver, B.C., Canada	?	35′	4′7″	26′	96
Cave Hill Cemetery, Louisville, Kentucky	1967	40′	4′ 3″	21′	96
Menninger Foundation Arboretum, Topeka, Kansas	1962	42′	4′ 2″	12′	95

* Data are reported for only one tree per location.

† I have used the ranking system followed in "National Register of Big Trees" (American Forestry Association, 1982): one point for each foot of height, one point for each inch of circumference, and one-quarter point for each foot of crown spread.



Metasequoia *roots floating in a stream at Princeton, New Jersey. Photograph by J. Kuser.*

Jersey the Broadmead grove in Princeton extends along both sides of a brook in which mats of the trees' white roots can be seen pointing downstream in the current, and the Willowwood Arboretum tree is on a bottomland site near a stream. The tree at the University of California at Los Angeles grows next to a pool in an artificial recirculating stream. Until it was moved to the streamside site in 1960, this tree was one of the smaller ones in its grove; since then it has outgrown the others. Metasequoia resembles hemlock, however, in that although it grows best on moist sites, it requires good drainage.

A flurry of anxiety followed the report of branch dieback and trunk cankers on several metasequoias at the National Arboretum in Washington, D.C. (Stipes *et al.*, 1971). The disease was caused by the imperfect (*Dothiorella*) stage of *Botryosphaeria dothidea* (formerly known as *B. ribis*), the common apple white-rot fungus. A clone of *Metasequoia* resistant to the fungus was selected and propagated (Santamour, 1977). However, the disease seems not to have been of much general importance, since only one of 80 questionnaire respondents answered affirmatively to the question asking whether any diseases had been observed. The *Dothiorella* syndrome on *Metasequoia* remains confined to the metropolitan Washington area (Santamour, pers. comm.). A similar syndrome exists on *Sequoia* and *Sequoiadendron* planted outside their native ranges (Santamour, 1977), and in the latter it appears to be associated with humid and maritime climates (Libby, 1981).

Three respondents cited insect pests — Japanese beetles, stink bugs, thrips, and an unidentified leaf-eater — attacking their metasequoias. In China larvae of two species of moths cut seedlings and drag them into underground burrows, a bagworm (*Cryptothelia minuscula*) feeds on the leaves, and larvae of two longhorned beetles (*Anoplophora chinensis* and *A. glabripennis*) tunnel in the wood; another beetle (*Holotrichia diomphalia*) feeds on the leaves in its adult stage, while its grubs feed on the roots. The Chinese regard these pests as minor, however, and favor *Metasequoia* because in comparison to other trees it is little bothered by insect pests or fungus diseases (Liu *et al.*, 1978).

The fact that *Metasequoia* is related to *Sequoia* and *Taxodium* originally raised hopes that it would produce valuable, decay-resistant

The fluted trunk of "Bailey 1," Locust Valley, New York. Photograph by J. Kuser.

lumber. It apparently does so in China, where trees felled but not used remain sound for many years, their wood gradually darkening with age. It is used there for exterior construction, footbridges, boat-building, furniture, agricultural tools, and paper pulp. Farmhouses built of its wood have remained in near-perfect condition, providing shelter for as many as seven generations of inhabitants (Liu *et al.*, 1978). Extracts from its heartwood contain six different phenolic compounds (Enoki *et al.*, 1977). However, the U. S. Forest Products Laboratory found wood from trees grown in the National Arboretum to have only two-thirds the hardness, crushing strength, and static bending strength of second-growth redwood (United States Department of Agriculture, 1967). This does not necessarily preclude commercial use of dawn redwood for some less strength-demanding applications such as siding, shakes, air-conditioning cooling-tower slats, and outdoor garden novelties. It is also possible that the wood tested by the Forest Products Laboratory lacked strength because the samples were taken from young, fast-growing trees. Weak wood has similarly been produced by young, fast-growing coast redwood (*Sequoia sempervirens*) trees in New Zealand. When wood from a 21-year-old plantation of that species was tested there, its air-dry density was only 19 pounds per cubic foot. Rate of growth averaged two rings per inch, and the main strength values were about one-sixth those of American-grown redwood, which has ten rings per inch (Weston, 1971).

In the Soviet Union, comparison of *Metasequoia* wood with that of other softwoods grown in the U.S.S.R. indicated that mature wood should have physical and mechanical properties superior to those of *Sequoiadendron* and not inferior to those of *Pinus sylvestris* (Jaroslavcev and Visnjakova, 1965).

Notwithstanding its failure thus far to equal its kin in strength, the newcomer is well on its way to becoming a popular amenity tree. Its fernlike, light green foliage, russet fall color, and fluted trunk make it

Ovulate cone (left), microsporangiate strobilus, and branchlet (right) of Metasequoia glyptostroboides. *Photographs by J. Kuser.*

a handsome ornamental. In Maplewood, New Jersey, it has gained favor as a street tree; pruned up to standard height in the nursery, Maplewood's metasequoias have not developed the flaring bases characteristic of open-grown trees, and they have withstood severe root pruning with no apparent harm (Walter, pers. comm.). About 10,000 young cutting-grown metasequoias in containers are sold yearly and the number has been rising (Henkel, pers. comm.).

During their first 20 years, some trees grown in the United States began to bear ovulate cones, but there were few or no microsporangiate strobili and hence hardly any fertile seed. Now most of the larger specimens bear three- to six-inch catkins of microsporangiate strobili like those of *Taxodium*. These appear in August and remain through the winter, giving trees with a heavy crop a tasseled look until pollen is shed in early spring. Seedlings have been raised from trees in Alabama, Virginia, Delaware, New Jersey, Massachusetts, and Rhode Island.

Little is known, however, about whether inbreeding depression exists within the species. Tests are underway at Rutgers University to compare seed and seedling characteristics of isolated (presumably self-pollinating) trees and trees in mixed-clone groves where cross-pollination is likely.

To our knowledge, nobody has succeeded in hybridizing *Metasequoia* with any related trees. Stebbins (1948) postulated that *Sequoia*, an unusual hexaploid in the otherwise diploid Taxodiaceae, is an autoalloploid derivative of a late Mesozoic or Tertiary hybrid

Seeds (left) and seedling (right) of Metasequoia glyptostroboides. *Photographs by J. Kuser.*

between *Metasequoia* and some extinct taxodiad. This hypothesis is strengthened by Saylor's (Saylor and Simons, 1970; Saylor, pers. comm.) karyotypic profile of *Sequoia* as having two sets of chromosomes resembling those of *Metasequoia* and one set unlike them. Crosses of *Metasequoia* × *Sequoia* (both ways) and *Metasequoia* × *Sequoiadendron*, however, have not succeeded (Krugman, pers. comm.; Chambers, pers. comm.). However, the possibilities are far from exhausted, and someone may yet resynthesize *Sequoia* or produce new and useful hybrids.

This exotic species may still have limited appeal in the United States at this time, but its popularity as an amenity tree appears likely to keep on growing. With the world's escalating demands for wood products, this ancient but very much alive Asian relict may even find a place in the wood industry of the Western Hemisphere.

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Ultraviolet Patterns in Flowers, or Flowers as Viewed by Insects

Richard B. Primack[1]

Insects see the world very differently than humans do. Their eyes are sensitive to energy from sunlight in frequencies somewhat different than ours are (Silberglied, 1979). We can see light in the energy spectrum from red through orange, yellow, green, blue, indigo, and violet, but we cannot normally detect short-wavelength ultraviolet light because our eyes have shielding pigments. Ultraviolet light is electromagnetic energy between 40 and 400 nanometers in wavelength. This so-called "black light" is commonly used to cause visible fluorescent patterns in "psychedelic" posters and other objects containing special pigments. The visual perception of insects generally overlaps with our own, except that insects cannot see red light and can see ultraviolet light. The ability of insects to communicate in ultraviolet light has been investigated by the late Robert Silberglied, of the Museum of Comparative Zoology, Harvard University. This discussion draws on his research.

How do we know that insects can see ultraviolet light? In a simple experiment peformed in the late 19th century, Sir John Lubbock exposed an ant colony to different parts of the visual spectrum (a "rainbow") that had been separated by passing light through a prism. Ants

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will normally carry their larvae and pupae away from any light source. Lubbock found that the ants did not leave the area exposed to red light but did leave the other lighted areas, as well as the area beyond the violet that appeared unlighted to a human observer. The presence of ultraviolet light in this apparently unlighted area was demonstrated using fluorescent pigments. This experiment revealed that ants cannot perceive red but can see the other colors including ultraviolet.

Two indirect pieces of evidence also suggest that insects can see ultraviolet light. First, receptors sensitive to ultraviolet light have been found in the eyes of most insects that have been studied. Also, many insects and the flowers that they visit have ultraviolet patterns that are not apparent to the unaided human observer. By means of special photographic techniques, these patterns can be studied to give insights into the world as perceived by an insect. Such techniques generally involve placing a special filter that transmits only ultraviolet light over the lens of the camera. The resulting photographs often reveal hidden bars, spots, and stripes on the bodies and wings of such visually acute flying insects as butterflies and dragonflies. By producing conspicuous patterns in the ultraviolet spectrum, these insects presumably communicate among themselves but are still not conspicuous to birds, which hunt insects by means of the visual spectrum only.

Biologists working with ultraviolet patterns in the flowers of temperate species have shown that the flowers of about 33 percent of all species strongly reflect ultraviolet light (Guldberg and Atsatt, 1975). This ultraviolet reflectance is most often found in large flowers but is not related to whether the flowers show bilateral or radial symmetry. Yellow or violet flowers show a greater tendency to reflect ultraviolet light than do flowers of other visible colors.

About seven percent of all flowers show floral patterns in ultraviolet light that are not evident in visible light. For example, in the black-eyed Susan (*Rudbeckia hirta*) there is an ultraviolet-absorbing region caused by the presence of flavonols, a class of chemical pigments (Thompson *et al.*, 1972). Flavonol-containing flowers are usually yellow in the visible spectrum, a tendency perhaps due to the fact that many flavonol pigments found in petals both absorb ultraviolet light and reflect yellow light.

The petals of many flowers have spots or streaks of color in the visual spectrum. These markings are called "nectar guides" or "honey guides" by botanists and are considered to be important in aiding pollinating insects to orient themselves on the flowers for feeding and pollen transfer. They are frequently found at the base of the petals or around the nectaries. In many species the flowers appear to be uniformly colored in the visual spectrum but show dramatic patterns of nectar guides in ultraviolet light. For example, in the marsh marigold (*Caltha palustris*), which is visited in the spring by small bees, the flowers are uniformly bright yellow in the visual spectrum. When the flowers are viewed in ultraviolet light, however, the outer third of each

Above: Caltha palustris. *The flowers are uniformly yellow in visible light (left), but the base of the petals and the stamens and pistils are dark in ultraviolet light (right). Below:* Geum macrophyllum. *The flowers are uniformly reflective in visible light (left), but have a dark spot at the base of each petal in ultraviolet light (right). Photographs by R. Primack.*

petal is highly reflective of ultraviolet light while the inner portion of the petals and the stamens and carpels strongly absorb it. This creates a bull's-eye effect, which presumably aids the insect to land in the center of the flower. In the mountain avens (*Geum macrophyllum*), which is visited by flies, the flowers are uniformly yellow except for brown veins at the base of the petals. In ultraviolet light the outer two-thirds of each petal is highly reflective, while the inner third is absorbing. In the cinquefoil (*Potentilla norvegica*) the base of each petal has a strongly absorbing spot in ultraviolet light that is not present in visible light. These marks presumably help insects to locate the center of the flower, where nectar and pollen are produced.

Also common is a floral pattern in which all or part of one petal absorbs more ultraviolet light than the others. For example, in two species of *Rhododendron*, *R. luteum* and *R. calendulaceum*, which are probably pollinated by butterflies, the petals are more or less uniformly colored, either yellow or orange. In ultraviolet light the

Above: Rhododendron calendulaceum. *The flowers are uniformly colored in visible light (left), but the upper petal is strongly absorbing in ultraviolet light (right). Below:* Rhododendron catawbiense. *The flowers have many small green spots on the upper petal in visible light (left), but this region appears uniformly dark in ultraviolet light (right). Photographs by R. Primack.*

upper petal in both species has a large light-absorbing region that contrasts with the rest of the corolla. These spots probably serve to highlight the location of individual flowers within the inflorescence. Also, in the upper petal of the pink-flowered *R. obtusum*, a large strongly absorbing region is clearly evident in ultraviolet light but is indistinct in visible light. In *R. maximum*, a species with large pink or white flowers, small, dark green pigment spots are present on the upper part of the corolla in visible light. In ultraviolet light, however, these individual spots are not evident, but a large, indistinct area of ultraviolet absorbance is present on the upper petal.

The overall contrast in floral patterns is usually similar in visual and ultraviolet lights. However, in a few species these patterns are dramatically reversed. For example, the yarrow (*Achillea millefolium*) and *Fothergilla major* produce bright, white, terminal inflorescences, which appear almost uniformly dark in ultraviolet light. Another example is the inflorescence of the flowering dogwood,

Achillea millefolium. *The flowers are very bright in visible light (left) but dark in ultraviolet light (right). Photographs by R. Primack.*

Cornus florida, which appears to be one large four-petaled flower but is really composed of four bracts surrounding many small flowers. In both this species and the Korean dogwood (*Cornus kousa*) the bracts appear white and the small central flowers are yellowish green in visible light. However, in ultraviolet light the pattern is reversed: the central flowers appear highly reflective and the large bracts dark. Many of the early-blooming ericaceous shrubs that have uniformly white flowers in the visual spectrum have more complicated patterns in the ultraviolet. In ultraviolet light the flowers of mountain andromeda (*Pieris floribunda*) are generally dark except for distinct spots at the base of the corolla and, to a lesser extent, the sepals.

The stamens may strongly contrast with the rest of the flower in ultraviolet light, even when they are not very different in visible light. Stamens that are light colored and not contrasting in visible light may absorb ultraviolet light strongly, thereby contrasting with a reflecting corolla. This is true for Tatarian honeysuckle (*Lonicera tatarica*). Such patterns may be important in plant species in which the pollen is an important food source for pollinators. The opposite effect is shown by the flowers of the toothwort (*Dentaria diphylla*), which have white petals and yellow stamens in visible light. In ultraviolet light, the flower is generally not reflective, but the anthers are highly reflective and can thus be readily located by such pollinators as small bees. In the stamens of *Aesculus arguta*, the filaments are white on the top and dark on the bottom in visible light, but uniformly dark in ultraviolet light.

Many plant species produce hairs at various places in their flowers. Besides serving as useful taxonomic characters for botanists to distin-

Lonicera tatarica. *The flowers are uniformly light colored in visible light (left), but the anthers are dark in ultraviolet light (right). Photographs by R. Primack.*

guish between species, these hairs are usually considered to be important both in preventing small, unwanted insects from entering the flowers to steal nectar and in regulating the temperature and the water loss of the flower. These hairs do not typically show large differences in color from the floral parts on which they occur. In ultraviolet light, however, they are often highly reflective, in contrast to the rest of the flower, in species such as *Caragana arborescens*, *Aesculus arguta*, and *Rhododendron nudiflorum*. Perhaps the hairs serve as beacons, helping the insect to orient on the flower.

Methods of Ultraviolet Photography

There are several ways of examining flowers (or insects) in ultraviolet light. Using a modified camera is relatively inexpensive; this gives high-quality photographs and is probably the best option for most people.

Equipment

The basic piece of equipment is a good-quality camera with a close-up (macro) lens and flash. The ultraviolet pictures shown here were taken with a Canon AE-1 with a 100-mm macro lens, and a Canon 199A Speedlite. Since glass absorbs ultraviolet light, close-up rings and lens filters probably should not be used. Not all flash attachments are suitable for this work since some do not put out sufficient ultraviolet light. In addition, some lenses may not transmit enough ultraviolet light. Testing a combination of equipment is the only way to determine its suitability for ultraviolet work.

One specialized piece of equipment that must be obtained through a camera shop is a Kodak Wrattan 18A filter (about $30). This filter is a two-inch square of glass that transmits only ultraviolet light. It should be glued onto a threaded ring (such as from a skylight filter or a close-up ring from which the glass has been removed), with black tape used to hold the filter onto the ring and to prevent light from passing between the lens and the ring. The filter can then be easily screwed on or off the front of the camera lens.

Use Kodak Tri-X film, which should be shot at ASA 800 and pushed during developing to ASA 800.

Calibrating Your Camera

The following is my simple calibration technique, a combination of practicality and the more theoretical approach of Silberglied (1976). Choose a subject that might have an ultraviolet pattern — a large yellow buttercup flower, a composite head like a dandelion, or a pierid butterfly. Lacking these, use any brightly colored, large, flat flower. Remove the ultraviolet filter from the camera. Using a tripod, compose the picture you want and focus on the subject. Fasten the ultraviolet filter over the lens. Place the flash as close to the subject as possible, using either a tilt flash or an extension cord. Set the shutter speed to the speed used with the flash (1/60 second for most cameras). Now, shoot a sequence of pictures at a complete range of f-stops. When you have developed the film, you will see the best range of aperture sizes for all subsequent shots. For the Canon AE-1 the best apertures are f8 and f5.6. During the calibration procedure and subsequent sessions, you should keep a record of your pictures so that you can continue to refine your technique.

For some cameras, the pictures — particularly the close-ups — may not be in perfect focus, since ultraviolet light has a slightly different focal distance than visible light. In addition, the depth of field is usually so small that even slight movements of the subject can put the picture out of focus. Consequently, the camera might have to be focused somewhat forward or backward from the correct focus in the visual spectrum. Learning the appropriate focus for your camera comes with experience. My technique is to shoot several pictures at slightly differing focal distances.

Shooting Pictures

Once the camera has been calibrated for ultraviolet photography, taking the pictures is a straightforward process. It is a good idea to take several shots of each subject, since breezes can easily cause the flowers to come out of focus. Flowers must be perfectly dry for ultraviolet photography, otherwise droplets reflect the flash as points of light.

Black-and-white pictures of the flower in the visible spectrum can be shot at the same time on the same roll of film by removing the filter from the lens. The pictures may need to be underexposed by about one or two f-stops, however, since the film will be developed at ASA 800 rather than ASA 400. For my own work, I carry two cameras. The first camera is loaded with Tri-X film and is used for the ultraviolet and black-and-white work. My second camera contains color slide film, for obtaining a color record of the flower.

The most common method of taking ultraviolet pictures of flowers — using a powerful flash — is effective for revealing the contrasts in ultraviolet reflection within a flower or inflorescence. However, it has the associated disadvantage of usually making the background appear dark. This is due to the rapid decrease in light intensity with increase in distance from the flash. Since flowers that absorb ultraviolet light do not contrast well with this dark background, the most interesting flowers in ultraviolet photographs are ones that are strongly reflective. Several natural backgrounds, including sand, sky, and hairy or otherwise reflective leaves, do reflect ultraviolet light, and many ultraviolet-absorbing flowers may be conspicuous against these backgrounds (Frohlich, 1976). Consequently, if it is desirable to show the natural background of the flowers, on sunny, windless days pictures can be taken without a flash using longer exposure times. Of course, this technique is more difficult.

Video-Viewing

Another way to view ultraviolet flower patterns is to use a video camera that has a quartz or other lens capable of transmitting ultraviolet light (Eisner *et al.*, 1969). If a Wrattan 18A filter is placed over the lens, the video camera receives only ultraviolet images, which can be viewed directly or displayed on a monitor.

Despite the complexities described here, the basic techniques of ultraviolet photography are easily mastered. The challenge of obtaining well-composed and perfectly focused pictures under field conditions provides continuing enjoyment. Looking at the world of insects and flowers through special ultraviolet eyes opens a new aesthetic dimension to someone who enjoys natural beauty.

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What Do You Do for Your Tree after It Has Been Defoliated by Gypsy Moths?

by FRANCIS W. HOLMES[1]

Defoliation by the gypsy moth is simply another source of stress to be added to any others a tree has undergone previously or may undergo later. Other causes of tree stress include prolonged drought, unsuitable soil (e.g., clay or sand), change in the water table or grade, disease of or injury to the root system, soil compaction, construction of a paved surface over the roots, improper (too deep) transplanting, earth fill, injury from salt or weedkiller, flooding of the soil with water or gas, and leaf damage due to prolonged exposure to warm, dry winds, infection with foliar disease organisms, chewing by other leaf-feeding insects, and sucking by mites and aphids.

Since many aspects of civilization cause stress in trees, trees in ornamental, yard, park, and street environments are often under greater stress — and thus in poorer health — than those in forests and woodlots. Trees of the same species and with similar outward appearances may be in quite different health conditions because of the unique combinations and degrees of these numerous stresses, and because of differences in where they are growing. Some can endure much more stress than others.

Sometimes symptoms of this stress are very conspicuous. They include excessive seed set, early autumn coloration of the foliage,

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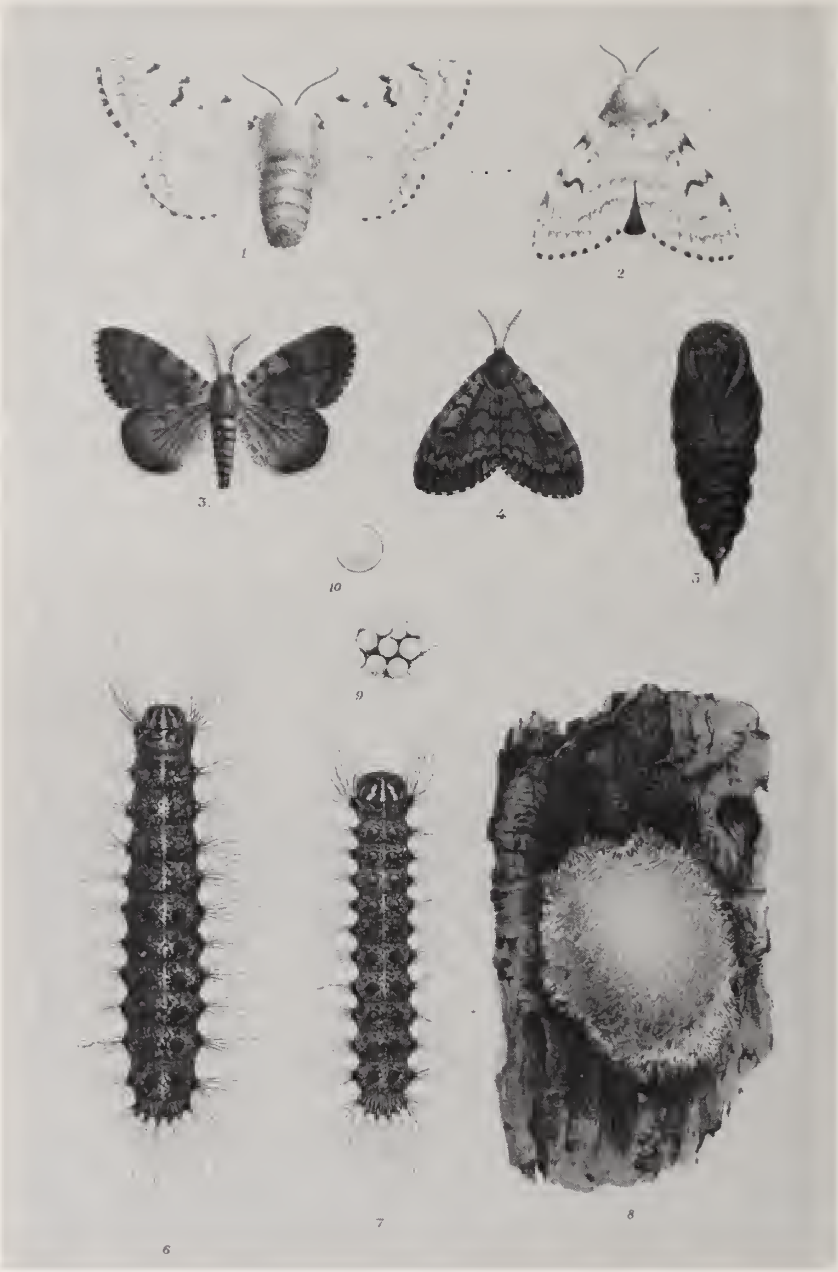

The gypsy moth: a female with wings spread (1) and wings folded (2); a male with wings spread (3) and wings folded (4); a pupa (5); caterpillars (6, 7); a cluster of eggs on bark (8); several eggs, enlarged (9); and a single egg, greatly enlarged (10). From E. H. Forbush and C. H. Fernald, The Gypsy Moth *(Boston, 1896), Plate 1.*

Trees in Arlington, Massachusetts, defoliated by gypsy moth caterpillars. Photograph taken July 9, 1891. From E. H. Forbush and C. H. Fernald, The Gypsy Moth *(Boston, 1896), Plate 10.*

early leaf fall (abscission), and fewer, smaller leaves in the spring. Other related symptoms include the presence of dead areas at the tips of evergreen needles, or "scorch" — dead areas at the outer margins and between the veins of broader leaves, leaving green only in stripes along the veins. Further stress leads to dieback of the top branches (called "stag-heading") and, eventually, to the death of the tree.

Stress increases a tree's susceptibility to attack by certain weaker (secondary) diseases and pests, like the shoe-string rootrot disease, the *Cytospora* canker disease, the two-lined chestnut borer, and various bark beetles. Most of these agents, and the organisms they may bring with them (especially the blue-stain fungi, brought to conifers by the bark beetles *Ips* and *Dendroctonus*), can ultimately kill a tree. Tree deaths ascribed to a secondary organism may have been triggered by a primary stress such as the gypsy moth.

When the gypsy moth defoliates a tree that is already under considerable stress from other causes, the tree may die relatively promptly. However, when the gypsy moth attacks an otherwise vigorous tree, the tree may or may not then be attacked by secondary organisms before it has a chance to recover its vigor during the following several growing seasons. Much depends upon whether the secondary pathogens or pests are in the vicinity at the right time. This uncertainty accounts for much of the variation in tree mortality that has confused some observers.

One effect of defoliation is a substantial decrease in the amount of food reserves stored in the tree. These reserves — ordinarily stored as starch in the roots of broad-leaved deciduous trees and to a certain extent in those of evergreen conifers as well — maintain the tree's life processes during winter dormancy and times of defoliation, when little or no food is produced. They also provide the energy and substance necessary when a new set of leaves is being put out, whether in early spring or at a less usual time.

In conifers considerable additional food reserves are stored in the older foliage, so defoliation not only deprives a conifer of its current food source but also removes significant amounts of its food reserves. In addition, conifers rarely refoliate in response to a complete defoliation. A single defoliation often proves fatal for a conifer, while hardwoods frequently live on after a first or even a second defoliation.

The fact that a hardwood tree clothes itself in a second set of foliage late in the growing season after gypsy moth defoliation ought not be a cause for rejoicing, however. Dr. Philip Wargo, of the U.S. Forest Service's Northeastern Forest Experiment Station in Hamden, Connecticut, has found data that confirm earlier suspicions: a tree commonly uses more of its food reserves to build a second set of leaves than it replaces through photosynthesis during the late summer and early fall.

The following spring such trees have even smaller leaves, and because the twig growth pushed out in the previous late summer did not harden off, it has often been killed by the winter cold. It would have been far better if enough leaf surface — no matter how ragged in

Men inspecting the Dexter elm in Malden, Massachusetts, for gypsy moth eggs. After intensive efforts to clear this tree of eggs and caterpillars in 1891 and 1892, it was free from them in 1893. From E. H. Forbush and C. H. Fernald, The Gypsy Moth *(Boston, 1896), Plate 36.*

appearance — had remained to prevent triggering the trees into putting forth the extra leaves.

What should you do, then, with a tree that has been weakened by defoliation from the gypsy moth? Do nothing different than you would do to help a tree weakened by anything else.

First, remove all present causes of stress. If the defoliation continued last year without any action on your part, that *cause* of stress is now gone — the gypsy moths left the tree last summer, when they had either completely removed the leaves from the tree or reached the end of their larval growth period and changed into adults. The *stress*, of course, continued after the insect-feeding injury had been completed.

You then need to protect the tree from all stress for several years. The most obvious stress to prevent in 1982 is another defoliation by the gypsy moth. Even if the 1982 defoliation occurs in a smaller total area than that of 1981, the effects will be more severe — many of the trees will be weaker due to last year's defoliation.

Trees that were defoliated last year should receive high priority for protection and should be treated like sick trees. You will need to decide which trees to treat for control of these caterpillars and which ones not to treat. You must also decide how important it is for the treated trees to survive — this will determine the material to use in the treatment.

In the case of broad-leaved deciduous trees that were not defoliated last year, are not under any severe stress from other causes, *and* are not of any historical or personal significance, partial defoliation can be accepted — provided that enough leaves remain to prevent the tree from squandering its remaining food reserves in a second set of 1982 leaves. Even if these trees lose all their leaves and refoliate, chances are that they will survive one such defoliation.

A description of the gypsy moth and its life history, together with a list of the insecticides — both chemical and biological — used against this insect and a discussion of other measures taken in its control, are in the circular *Gypsy Moth.*[2]

The second step is feeding. Don't feed the tree immediately after defoliation! Feeding from approximately mid-June through September may force a flush of new growth that will be killed by the first frosts because it has not had time to go dormant and harden off. Fertilizer applications are ordinarily made to trees either in late fall or in spring after the ground thaws (i.e., from mid-October through May).

While compost and well-rotted manure are good fertilizers, commercial dry fertilizers are usually more readily obtainable and can be used under most circumstances. Those relatively high in nitrogen, such as are used for lawns, are considered best for most trees, although an ordinary garden fertilizer will do as a substitute. The important point is to use a complete mix that includes nitrogen, phosphorus,

[2] All publications mentioned in this paper are available from Massachusetts County Extension offices or from the Shade Tree Laboratories. They have also been sent to every public and high school library in Massachusetts and to every municipal Tree Warden in the state.

Injection of fertilizer into the ground. Photograph courtesy of Frost and Higgins.

and potassium. With members of the rose family — for example, apple, pear, crabapple, and mountain ash — avoid high-nitrogen fertilizers because they make the tree more susceptible to the fireblight disease. Water-soluble or liquid fertilizers generally come in higher concentrations and can be applied with an injector attached to the garden hose. The beneficial effects of liquid fertilizers (dark green foliage) appear sooner, but those of dry fertilizers last longer.

To determine the amount of fertilizer to use, measure the diameter of the tree trunk four feet above the ground. Per diameter inch, use two to four pounds of fertilizer for trees with trunks six inches or more in diameter, and one to two pounds for smaller trees; for needle-type evergreens use the lower number of pounds. With water-soluble or liquid fertilizers follow the directions on the package.

Application is made through one-inch (or slightly larger) holes punched or drilled in the soil over the root system. A crowbar or a hollow tube may be used to make the holes, which should be 12 to 18 inches deep and about two feet apart, arranged in concentric circles starting one foot or more from the trunk and extending out at least as far as the spread of the branches. With larger trees, start farther from the trunk to avoid wounding the large roots.

Distribute the fertilizer equally among the holes, using a funnel (or a small can with the top edge bent to form a pouring spout) to prevent spilling fertilizer on the lawn and burning the grass. After you have put the fertilizer in, you may either fill the holes with topsoil or leave them open. Open holes will help air and water reach the roots; this effect is especially needed if the soil is hardened or packed down. Rain and soil moisture will distribute the fertilizer among the feeding roots.

You can use water-soluble or liquid fertilizers by inserting the injector at regular intervals as stated above and applying the fertilizer by water pressure. This method is easier than using dry fertilizer, if you have the necessary equipment. The water used to carry the fertilizer

Apple trees in Swampscott, Massachusetts. The above photograph was taken August 15, 1891, after the trees had been defoliated by gypsy moth caterpillars. The photograph on the opposite page shows the same trees in July, 1892, after the moths had been cleared from the area by agents from the Board of Agriculture. From E. H. Forbush and C. H. Fernald, The Gypsy Moth *(Boston, 1896), Plates 37 and 38.*

into the soil will help distribute the fertilizer and make it readily available to the plant.

How often you should fertilize a tree depends on the type of tree and how it responds to treatment. Generally it is safe to fertilize every two

or three years. Fertilizer should not be used at the time of transplanting; instead, plantings should be made in a good-quality topsoil containing plenty of organic matter. After the tree has grown in this soil for two or three years, it may be included in the program of fertilizer applications described above. Consult the publication entitled *Fertilizing Trees and Shrubs* for further details.

The third step in helping a tree to regain vigor after defoliation by the gypsy moth is watering. Natural rainfall may be quite adequate, depending on the season. When it is not sufficient, a mere sprinkling is of no value: enough water must be placed in the soil surface to penetrate down to the roots in the upper foot of soil. If trees receive only a little water too often, they tend to develop their roots too near the soil surface. Such roots are more likely to be injured during a drought. If the foliage is sprinkled during the watering process, leaf diseases may develop and may further reduce the tree's vigor (a drawback to the frequent use of lawn sprinklers to water trees). On the other hand, unnecessary watering during a wet season can itself be a cause of weakening and stress, since the roots may drown. Roots need oxygen, which filters down to them through the interstices between the soil particles, and they need to get rid of carbon dioxide, which diffuses up to the ambient air.

You should therefore water about once a week, and only during dry periods. To be soaked to a depth of two feet, a fine sandy loam soil dry enough to cause plants to wilt requires one gallon of water per square foot of surface over the roots. The roots usually extend beyond the limits of branch spread and may pervade the entire lawn. (In areas with heavy clay or poor drainage, be careful not to drown the roots by waterlogging the soil.)

It is likely that no one has the patience to stand on the lawn with hose in hand long enough to put down as much as one gallon of water per square foot. This amount is equivalent to a layer of water more than one and a half inches deep over the entire area. The way to soak the soil, then, is to lay the hose on the ground, with the water running slowly enough not to run away over the surface of the soil. Two soaker hoses, joined with a siamese coupling, will provide for slower seepage and therefore less puddling. Move the hoses from time to time.

Unfortunately, the time when trees need water most is also the time when such use of water may be locally banned because of shortages. In that case, the only way to provide artificial watering may be to haul or pump water from a pond or stream where you have water rights; this is practical only for small trees. Consult the publication entitled *Watering Shade Trees* for more information.

Emphasis should be given to the fact that feeding and watering help to increase the vigor of a tree, but they do not protect it against future feeding by gypsy moth caterpillars. Defoliation, or spraying to protect from defoliation, during one season gives no protection for another year. So far as pest control is concerned, the 1982 season is "a new ball game" — the tree is protected only to the extent that you take action *this year* to protect it.

Mr. James Clark standing by the trunk of the metasequoia he planted in Princeton, New Jersey, in 1948. Photograph taken in December, 1981, by W. Sauro.

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Front cover: *American persimmon* (Diospyros virginiana). *Al Bussewitz photo.*
Opposite: *American persimmons. Al Bussewitz photo.*

Mature American persimmon tree at the Arnold Arboretum, showing the typical widely spaced irregular branching pattern. Al Bussewitz photo.

Two Promising Fruit Plants for Northern Landscapes

by Edward Goodell

In recent years a trend toward "edible landscaping" has begun to emerge as a natural extension of standard gardening. Two books on the subject have been published (Britz; Creasy), and in Massachusetts a bill creating the innovative Massachusetts Fruition Program was passed by the legislature in 1980. With a budget of $64,000 this program promotes the planting of food-producing trees, shrubs, and vines.

Perhaps the most desirable characteristic in landscape plants is an ability to thrive in low-maintenance situations. This eliminates many commercial fruit species, however, as these usually have been highly selected for fruit production under the assumption that adequate care will be provided. Fortunately, there are many food-producing plants that, for various reasons, have never been developed. On the Arnold Arboretum grounds alone I found about 150 species, from *Actinidia arguta* to *Zizyphus jujuba*. The usual reason that such plants are not developed is that they have a deficiency in some characteristic, such as yield, keeping quality, or ease of propagation, that would limit their success as a commercial crop. On the other hand, their broader-based genetic makeup often allows them greater environmental adaptability, and they are therefore less needful of maintenance.

I chose the two plants described here for the quality of their fruits and their adaptability in low-maintenance situations. Many other plants deserve equal attention, including the juneberry, flowering quince, hazelnut, walnut, mulberry, elderberry, hickory, pine nut, grape, and various *Prunus* species.

Three major climatic factors must be considered in growing woody food plants in the Northeast: minimum winter temperatures, occurrence of late spring and early fall freezes, and the relatively short, cool growing season. Carefully choosing a favorable planting site (e.g., with good air and soil drainage) will enhance a plant's performance in any given climate. *Actinidia* will grow reliably in northern New England and New York (USDA plant hardiness zone 4; see map on page 119). The persimmon is recommended only for zones 5 and 6 in the Northeast.

Edward Goodell has been a student intern at the Arnold Arboretum for the past 2½ years.

The American Persimmon, *Diospyros virginiana*

If the world's population were polled as to its favorite fruit, the choice would probably be the persimmon. This may be surprising to most Westerners, but it is understandable when one takes into account the fact that the Oriental persimmon (*Diospyros kaki*) is the primary fruit in the diet of more than a billion Chinese, Japanese, Taiwanese, and Koreans. This persimmon, known as the kaki in the Orient, is also gaining a deserved popularity in the warmer portions of this country (USDA zones 7–10) both as a handsome landscape plant and productive orchard tree. Its bright orange, apple-sized fruits are grown commercially in California and now regularly appear in United States markets. Approximately 1000 cultivars exist in the Orient and vary widely in shape, size, color, and flavor. Selected through centuries for their superior fruits, these cultivars originated from the astringent, seedy, small-fruited wild species that is now rarely seen in its native China (Spongberg 1977).

Unfortunately, the Oriental kaki cannot be recommended for areas where winter temperatures dip below 0°F. Thus, for a cold-hardy persimmon we must turn our attention to the native American persimmon (*Diospyros virginiana*). Its large natural range extends as far north as southern Connecticut, west to Iowa, and south to Texas and Florida (Little). Under cultivation, American persimmons originating in the northern part of the range are quite hardy throughout USDA zone 5 (or −20°F average minimum temperature). Even though some cultivars of *D. virginiana* have been selected during the past hundred years, the species remains relatively wild compared to the highly domesticated Oriental kaki. But the success story of its Oriental relative may be an indication of what is in store for this native American fruit tree.

Throughout the persimmon's natural range, the fruits have been long valued as food. Hernando DeSoto's expedition to the Americas in the early 1500s reported persimmon pulp being dried by Native Americans. These "loaves" of dried persimmon kept from one year to another. Native Americans are also known to have added persimmon pulp to corn bread, and they even ground the seeds into a meal (Griffith and Griffith 1982). A beer made from fermented persimmons and honey locust pods was a common drink among southeastern tribes (Carr).

DeSoto's chronicler considered them "better than all the plummes of Spaine" and noted that "they make far better prunes of them." In commenting about the persimmons known to the Roanoke colony in 1585, Thomas Hariot wrote "they are not good till they be rotten (but then) . . . they be lushious sweet" (Roush).

It was Captain John Smith who first described the woeful surprise of eating an unripe persimmon. He noted, "If it not be ripe, it will drawe a man's mouth awrie with much torment." The incredible astringency of the unripe fruit accounts in part for the fruit's lack of widespread acceptance. But, as Captain Smith went on to say, "when it is ripe, it is deliscious as an Apricock." Subsequent colonists agreed and used persimmons in making puddings and beer. The present inhabitants of the natural range of *D. virginiana* also enjoy wild fruits, and commercial sources of trees for home orchards are now available. Each year, during the last weekend in September, some 25,000 visitors join the town of Mitchell, Indiana, in celebrating the persimmon harvest with a feast of persimmon culinary delights.

A 1978 market study conducted in Illinois evaluated the commercial potential of prepared persimmon products (Garrison). Although 85 percent of the participants were initially biased against persimmons, almost all responded favorably to the products' taste and expressed an interest in making persimmons a regular part of their diet.

The astringency of unripe persimmons is mainly responsible for the persimmon's unpopularity. For the fruit to be at its best, it must ripen on the tree before the leaves fall. This has been a major limiting factor in the Northeast, because persimmons are adapted to areas with relatively longer and hotter growing seasons. However, a few cultivars that have proved themselves in the North are available now. A second limiting factor is that the ripe fruits are soft and do not ship or store well. New artificial ripening techniques may soon allow unripe, firm fruit to be mechanically harvested, shipped to distant markets, and stored for long periods. But shipping qualities are not a crucial factor for the home orchardist, and persimmons can be preserved easily in home freezers. Persimmons are also considered difficult to transplant. They do have special transplant requirements, but if a few guidelines are followed they can be successfully established in good vigor.

The American persimmon has many attributes to recommend it. The ripe fruit has a rich flavor and high energy content. The texture of a ripe persimmon is somewhere between that of a baked apple and firm custard. The trees are productive over a wide range of soil types. They are long-lived, beautiful in fruit, and relatively unaffected by pests.

D. virginiana is a variable species. Several recognized botanical forms exist (Spongberg 1977), and two races have different numbers of chromosomes (Baldwin and Culp). One race (a tetraploid with 60 chromosomes) is geographically centered in southern Appalachia. This race is probably the primitive *D. virginiana,* its current range approximating the species' northern limit during the Pleistocene glaciations. The second race (hexaploid with 90 chromosomes) is thought to represent a more recent evolutionary change. It predominates in areas north and west of the southern Appalachians. This race, which may deserve a separate subspecies rank, is more vigorous, cold hardy, and drought tolerant than the first. The two races are generally not capable of fertilizing each other. Most of the cultivars suited for the North have been selected from the second race because it also tends to have larger fruit that ripens earlier (McDaniel 1982).

D. kaki also has 90 chromosomes, and efforts have been made to obtain an interspecific hybrid. Russian botanists have reportedly bred several hybrids, but similar attempts in this country have failed to yield a verified hybrid (McDaniel 1982). Seeds produced from controlled cross-fertilizations between the two species usually do not germinate, or if they do, the resultant seedlings show characteristics of the maternal parent only. Future attempts using embryo culture techniques may yield successful hybrids that combine the size and sweetness of the Oriental kaki with the greater cold hardiness of the native American persimmon.

Under natural conditions the persimmon grows best on alluvial bottomland and terraces, where it sometimes reaches approximately 100 feet and has a long slender trunk. It is also found on sandy well-drained soils, where it more commonly grows in a shrubby habit to 33 feet tall.

The American persimmon is usually found in deciduous woodlands in association with maple, poplar, hickory, oak, sassafras, or dogwood. It is very tolerant of shade, germinating and persisting in the understory but fruiting only lightly. Persimmons can also utilize full light conditions, as shown by their ready colonization of abandoned fields, fence rows, and other disturbed areas such as roadsides. Stumps and fire-damaged trees usually sprout profusely, and roots commonly sucker, producing persimmon thickets. The freely growing persimmon has been both praised as a conservation plant and cursed as an agricultural weed (Fletcher).

The dark persimmon bark is deeply fissured into square scales, in an alligator-skin pattern. Persimmon wood is close grained and heavy. The sapwood is light colored and the heartwood is dark brown like that of another member of the *Diospyros* genus, the tropical ebony. Persimmon heartwood is not suitable for lumber because it checks excessively during the drying process. However, the hard heartwood has been used for small wooden products, such as tool handles and golf-club heads, in which it has the attribute of polishing as it wears. Unfortunately, the heartwood develops so slowly that the persimmon has never become a commercially important timber tree.

The persimmon is very adaptable to site and soil conditions. Under cultivation, it grows satisfactorily "on very sandy soils, and on heavy clay loams, within a wide pH range" (McDaniel 1971). After an initially rapid growth rate, persimmons generally settle down to a pace of about a foot per year. Open-grown trees rarely grow taller than 30 to 50 feet. They have a roughly pyramidal shape. Young trees have ascending branches and an oval outline, but with maturity the branching becomes more sinuous and horizontal or even slightly pendulous. A specimen planted in 1896 at the Arnold Arboretum is a splendid example of the picturesque zig-zag branching of mature trees.

The deep green foliage often has an unusual slate-colored tint, which makes a persimmon tree stand out in the summer landscape.

Flowers of an American persimmon tree. Al Bussewitz photo.

Flowers of A. kolomikta. *Al Bussewitz photo.*

The individual leaves are oval and 4 to 6 inches long. They tend to droop from their stout petioles, giving the whole tree a languid quality. Fall coloration may be deep yellow mottled with green and red, but in northern areas leaves often fall without changing color dramatically. In winter the American persimmon may be readily distinguished by "the characteristic bark pattern; lack of terminal buds on branchlets, as well as solitary (vascular) bundle scars centered in the leaf scars . . ." (Spongberg 1979).

The leaves expand in May, and the flowers appear on the current season's growth when the leaves are about half-grown but do not open for several weeks. The flowers are often borne in practically every leaf axil. They are not readily noticed at a distance, however, because they are small and a faint green or cream color. The most apparent sign at flowering is the activity of bees visiting the nectariferous flowers. C. D. Eddy in 1927 described the honey as being of a "very fine quality" and noted that persimmons were rated as one of the more important nectar-producing plants in North and South Carolina. Wind pollination is also a possibility with the very light and powdery pollen.

Persimmon fruits remain light green as they enlarge during the summer. With the arrival of fall, they finally turn amber to deep orange with a light bloom on the skin. Better selections are 1 to 2 inches in diameter, about the size of a small plum. The average fruit is 50 percent high-carbohydrate pulp, and the remainder is seeds and skin. Hard freezes will darken and wrinkle the fruit, but persimmons often hang on the tree through midwinter.

Seedling persimmon plants begin flowering at four to eight years of age. The male plants are generally more precocious than the female (Campbell). A grafted cultivar will bear fruit within three years. A test planting of four-to-six-year-old cultivars yielded an average of 50

Deeply fissured square scales of the bark of the American persimmon tree. Al Bussewitz photo.

pounds per tree (Claypool). Wild trees, estimated to be 10 to 15 years old, averaged 73-pound yields. Most persimmon trees can bear regular, heavy crops. However, if pollination is excessive, an extremely heavy crop can be set. This may result in limb breakage, inadequate ripening, and a light crop the next year. Maximum yields are reached when the trunk diameter approaches 1 foot (approximately 25 years). Uncrowded trees should remain productive for another 50 years. American persimmons planted well over 80 years ago in Urbana, Illinois, show no signs of declining yields (McDaniel 1982).

The reproductive biology of *D. virginiana* is interesting in its complexity. Persimmons are mainly dioecious, with the urn-shaped staminate and carpellate flowers occurring on separate trees. The staminate flowers (on "male" trees) are about the size of a blueberry flower (3/8 inch in diameter). The carpellate flowers (on "female" trees) are about twice as large, and the petals are more spreading. Carpellate flowers are borne singly, whereas staminate flowers are normally in short, stalked clusters of three. The flower pedicels are persistent, so the sex of a tree can be easily determined even during winter.

Frequent exceptions to the dioecious conditions have been observed on cultivated plants. It was first noticed that some female plants would produce seedless, parthenocarpic fruit (without fertilization) when grown in isolation from pollen-bearing trees. Later, when some of these plants began to produce occasional seeded fruits, it was discovered that staminate flowers were occurring on weakly growing branches of normally female trees. Conversely, vigorously growing shoots of male trees will sometimes produce carpellate or perfect (bisexual) flowers.

This variable reproductive expression has been best documented in the persimmon cultivar 'Early Golden' and its descendants. J. C.

McDaniel of the University of Illinois, an authority on the American persimmon, has ventured the following theory about these plants.

"The fact that 'Early Golden' sometimes (probably frequently on old trees) can be self-pollinating with the aid of insects and that several of its descendants can, too, leads to the speculation that it may have descended from a line of sometimes self-pollinated trees, going back no one knows how many years. It could have originated from a naturally inbred line, and the inbreeding may account for the high concentration of good qualities (size, earliness, good texture and flavor) found in 'Early Golden' and a fairly high percentage of its predominantly carpellate progeny. The inbreeding could result, as it does in other ordinarily cross-pollinated crops, in some reduction of fertility; this may partially account for the fact that 'Early Golden' and its kin seldom mature the full complement of 8 seeds per fruit that is found in ordinary seedling *D. virginiana* when adequately pollinated at flowering season. Breeders have just begun to do controlled inbreeding with the 'Early Golden' family to test these theories experimentally."

Seedless fruit are smaller and their taste and texture may not be as good as those of seeded fruit (McDaniel 1973). Both yield about the same amount of pulp, because the flesh of seedless fruit contains fibrous materials in place of the undeveloped seeds (McDaniel 1982). However, seedless fruit seem to ripen earlier, a valuable characteristic in the North. Where space is limited, the ability to bear crops without a pollinator is another asset. One male tree to 12 females is the general guideline for correct pollination. Grafting a male branch onto an otherwise female cultivar is a good space-saving technique.

In the North early ripening is a crucial characteristic, as American persimmons are edible only when fully ripe. Unlike the Oriental kaki, which may be ripened artificially by one of several methods, the American persimmon must attain a soft, near ripe state before it will respond to methods of removing astringency. Most northern cultivars originated in the Midwest. They are all perfectly hardy in bud and wood throughout USDA zone 5 (−20°F minimum winter temperatures). Yet when taken north to the Great Lakes and east to New England, many cultivars may fail to ripen properly in summers that are relatively short and cool compared to those of the midcontinent. Members of the Society of Ontario Nut Growers are actively breeding early-ripening varieties for the lakes region. Presumably these will be adapted to New England as well. The search is also on for male trees that will flower and pollinate the first female blooms of the season and thereby lengthen the persimmon's ripening time (Campbell). The recommended cultivars for the Northeast are described on page 118.

Growing Persimmons

The main obstacle faced by the prospective persimmon grower in the Northeast is obtaining good plant material, and grafted cultivars are in short supply. The seeds and seedling trees that are generally available from many mail-order nurseries are almost always of unknown sex. A few nurseries do offer suitable cultivars for northern climates (see page 129). Cultivar scionwood for grafting is also often available, and requests may be honored for seed from parent trees that are known to produce superior offspring.

Perhaps the best means of obtaining a desired cultivar is to graft it oneself. Nut and fruit organizations are the best source of seed and scionwood of good selections (see page 129). Scionwood is also available at some nurseries, a few of which will do custom grafting upon request. Grafting or budding methods are similar to those used with apples. Both grafting and budding are done in spring or summer using a seedling rootstock that has proved to be winter hardy.

Stems that did not bear fruit during the previous growing season are preferable as scions because those that have borne fruit are known to die during the following winter. Spring grafting and budding are best done when the buds begin to swell (late April in Boston, Massachusetts). Grafts may succeed as late as June if the scions are completely dormant, but early grafts with a longer growing season ahead of them are more likely to survive the first winter. A small plastic bag covering the scion and graft union works well to prevent desiccation. This may be removed gradually after the buds break and the leaves begin to unfold. All growth from the understock should be removed as soon as the union has clearly healed.

Summer budding is also successful. August is the best time, but it may be done as late as four weeks previous to freezing weather. Budwood that is smaller in diameter than the rootstock allows for easier insertion of a bud. After winter, stock plants should be girdled just above grafted buds that have survived. Tying the vigorous new growth of buds to the dead portion of the rootstock above the graft union will prevent wind damage. Otherwise, a stake should be provided for support. The easiest way to propagate persimmon plants is from seed. Of course, the sex of a seedling cannot be known until it flowers, which may take more than four years. Cultivars in the 'Early Golden' group have a reputation for producing better than average offspring. With so few cultivars selected specifically for northern regions, raising the seedlings of the better cultivars that are available may be the best way for most people to obtain a persimmon tree adapted to their needs. Seedlings can be planted in a group and all but the better fruited plants subsequently eliminated.

It is advisable to collect seeds from ripe fruit. Excessive heat, cold, or drying can cause persimmon seeds to lose viability, but seeds have been known to germinate after six years of cold stratification (McDaniel 1970). Three months of cold stratification is needed for good germination. Sow persimmon seed in fall or early spring, about 1 inch deep with some additional light mulch on top to help retain moisture. Rodent predation has not been reported to be a problem. Seeds will germinate within a month in soil temperatures above 60°F. The seedlings quickly develop a long taproot and are tolerant of adverse conditions (Fowells) but perform best with ample moisture and no competition from weeds. Well-grown seedlings can reach approximately 1 foot high the first season and grow another 3 feet the second season.

If persimmons are grown in a nursery, the time to transplant them to a permanent site is at the beginning of their third growing season. A couple of factors make American persimmons notoriously difficult to transplant. The young trees have deep taproots and long surface roots, which are fleshy and inevitably injured during digging. A prior root pruning will induce fibrous lateral rooting and enhance transplanting success. Also, persimmon roots do not regenerate until after the top is fully leafed out and the soil has warmed. Luxuriant new growth is often mistaken as a sign of a successfully established transplant. If supplemental watering is discontinued, the top may wilt, because the damaged roots cannot supply the transpiring leaves with adequate water.

American persimmons can be successfully transplanted if a few precautions are observed. The most important is to warm the soil early to encourage rapid root regeneration. A black plastic mulch is a good way to do this, and it will also retain moisture and eliminate weed competition. The plastic may be applied before the planting date to speed the warming process. The best transplant hole is large and of good tilth. Pruning the top back ⅓ to ½ of its size will equalize damage done to the roots. Persimmon roots are normally dark throughout and should not be mistakenly pruned off as dead. Young persimmon trees respond favorably to irrigation with warm water from a slow-flowing hose exposed to the sun. White latex paint or an opaque trunk guard will prevent sun scald on the trunk. To help the young transplant harden off for winter, remove the plastic mulch and stop watering in August. The two secrets of successful transplanting are: (1) maintain a warm, moist soil and (2) do not mistake lush new growth as a sign that care is no longer needed.

Transplanted trees should not be fertilized during the first season, except for perhaps a cup of bonemeal incorporated into the transplant hole. Satisfactory yields are possible without special treatment, as shown by the heavy yields of wild persimmons and the similar performance of some trees at the Arnold Arboretum. Even so, fertilization will probably increase yields, especially on poorer sites. For maximum production the following regime has been recommended by the Society of Ontario Nut Growers:

(1) Apply 1 pound of 10-10-10 fertilizer for each inch of trunk diameter until fruiting age.

(2) With the onset of heavy fruiting, switch to a 5-10-15 formulation.

(3) Prevent fertilizers from contacting the trunk; that is, broadcast outward beneath the canopy.

(4) Only fertilize during early spring. Heavy feeding during the growing season can shock a persimmon tree, causing it to drop its leaves.

American persimmons, which grow relatively slowly (12 inches per year) and remain compact, have an interesting self-pruning characteristic. After two or three seasons of growth, some fruit-bearing shoots will dry up over the winter and release by abscission before the next growing season. This growth habit minimizes the need for supplemental pruning. The optimum tree form is a low-headed pyramid with widely spaced scaffold branches arranged in a spiral pattern around the central leader. Summer pruning will direct the tree's energy into fruit production rather than vegetative growth, keeping the tree small and productive. Spacing for mature trees on good soil needs to be about 35 feet.

All accounts agree that the American persimmon is practically pest free in the North. Observation of the Arboretum's *D. virginiana* specimens during 1981 revealed no insect pests on leaves, flowers, or fruits. Some plants did seem to have a minor leaf-spot disease. In areas with short growing seasons, the below-optimum photosynthesis in diseased leaves could result in fruits that are less sweet.

With autumn's approach persimmon fruits change color from light green to yellow and finally to a deep golden orange. A few soft fruits may be noticed on the ground. At this point the texture of persimmons still hanging changes from firm to increasing degrees of softness. At its softest the fruit will usually separate from the calyx, leaving it and the pedicel attached to the twig. This is a fully ripened fruit, and it should be delicious. A fruit that will separate from its calyx is very soft and must be handled carefully, however. Because of this, and since persimmons ripen gradually, it is often easier to make a few large harvests of fruits that are less than fully ripe.

Hand picking is the gentlest harvest method, but shake harvesting is less tedious and causes little damage if it is done over a cushioned ground cover. The best containers for collecting fruit are shallow, to minimize crushing the soft, ripe fruits.

The astringency of unripe persimmons is thought to be caused by the chemical compound leucodelphinidin (Griffith and Griffith). As a single molecule leucodelphinidin causes astringency, but polymeric chains of leucodelphinidin longer than four molecules lose their ability to react with the oral mucosa. Ethylene gas evolved during natural ripening or supplied artificially removes astringency by catalyzing the polymerization of leucodelphinidin molecules. The use of ethylene gas is the only artificial ripening method that Eugene and Mary Griffith acknowledge in their book, *Persimmons for Everyone*. In their opinion the prevalent notion that freezing can remove astringency began because the natural ripening period and the frost season often coincide.

American persimmons that are still firm and astringent can be fully ripened by being subjected to 50 ppm ethylene gas for 24 hours and then allowed to sit for several days at room temperature. Creating such a high concentration of ethylene gas is not practical in the average household kitchen, however.

American persimmon (D. virginiana)

In more practical curing methods it is unclear how ripe a persimmon must be when it is picked. The Griffiths state emphatically that the fruits must begin to soften on the tree. Others report successful off-tree ripening of firm, green fruit when it is stored either at room temperature or in a refrigerator. As with the Oriental kaki, this characteristic probably varies from tree to tree. I have not attempted to ripen green fruit artificially.

Storing the fruit in a plastic bag will enhance ripening by retaining natural ethylene gas at a higher concentration. Adding an apple or banana, preferably a ripe one, will further hasten the ripening process. Fruit softness is a measure of ripeness and may be checked without opening the bag. Tree-softened persimmons will ripen fully within a few days or a week, depending on the method used and their initial degree of ripeness. Ripe fruits keep for several weeks in a refrigerator.

Orientals eat their persimmons fresh, dried, and frozen, but never cooked. Traditional American dishes such as persimmon pudding show that cooked preparations can be good, too. Even so, low temperatures and short cooking times are recommended to avoid adverse changes in texture and flavor. The Griffiths' book is a thorough exploration of the culinary delights of persimmon cookery, with over 250 recipes for soups, salads, breads, frozen desserts, puddings, pastries, beverages, and other delicacies.

In preparing persimmons it is advisable to avoid ordinary carbon steel utensils, which will turn persimmon flesh unattractively dark. Stainless steel is best. Aluminum alone will not stain persimmons, but be wary of aluminum coatings on a steel base. If a utensil is going to darken the fruit, it will do so within five minutes of contact; otherwise it is safe to use. Pulping is usually the first step in persimmon preparations. A sieve with $^3/_{16}$-inch openings will separate the pulp from the seeds and skin and yet is not so fine that pulping is difficult.

Persimmons are ideally suited to preservation by freezing. The flesh remains in good condition and flavorful for years, even if thawed and refrozen. However, it is best to freeze the pulp in individual plastic bags of a convenient size for thawing one at a time. Whole fruits may be frozen and eaten like popsicles or pulped after thawing. Several persimmon recipes from the Griffiths' book are offered below. Either American or Oriental persimmons may be used.

Persimmon Spice Pudding

1½ cups flour
½ teaspoon salt
¾ teaspoon double-acting baking powder
¼ teaspoon cloves
¼ teaspoon nutmeg
½ teaspoon cinnamon
4 cups persimmon pulp
½ cup sugar
½ teaspoon soda
1 cup milk
1 egg
½ teaspoon vanilla
¼ teaspoon lemon extract
2 tablespoons butter, melted

Sift dry ingredients together. Combine persimmon pulp, milk, egg, vanilla, lemon extract, and melted butter. Combine two mixtures, stirring well. Pour into greased baking dish. Preheat oven to 350° and bake 45 to 50 minutes. Serve hot or cold with whipped cream, or with a hard sauce.

Persimmon Ice Cream

1½ quarts cream (30 to 40 percent milk fat)
½ pint milk
1 cup sugar
1 teaspoon soda
3 cups persimmon pulp

Beat first four ingedients lightly, adding in above order. Thoroughly chill mixture (with persimmon pulp chilled separately). Partially freeze before adding persimmon pulp, then complete freezing.

Persimmon Leaves Tea

Gather green persimmon leaves, wash them, and make tea by steeping them in boiling water. The tea has a pleasant flavor, suggestive of sassafras.

Or spread the leaves on paper in a warm place until they are thoroughly dry. Pack them in lightly sealed jars and heat the jars with their contents in a very low temperature oven for about 30 minutes. Remove the jars from the oven and tighten the lids immediately. If the jars are airtight the leaves will be dry and sealed in a partial vacuum. If properly done the leaves will keep indefinitely.

Dried persimmon leaves tea is considered better than that made from fresh ones. Persimmon leaves are high in vitamin C (ascorbic acid).

Persimmon Gingerbread

⅓ cup shortening
⅓ cup sugar
1 egg
¾ cup sour milk, buttermilk or yogurt
⅔ cup dark molasses
¾ cup persimmon pulp
½ teaspoon soda
1 cup whole wheat flour
¼ cup powdered milk
½ cup wheat germ *or* wheat germ flour
3 teaspoons double-acting baking powder
1 teaspoon cinnamon
1 teaspoon ginger
½ teaspoon salt

Cream the shortening and sugar. Add egg, sour milk, molasses and persimmon pulp. Stir well. Sift the remaining dry ingredients together and add them to the moist mixture with no more than 20 strokes. Oil a ring mold or 8-inch square loaf pan and dust with flour. Pour the batter into the pan and bake at 350° for about 45 minutes. Be careful not to overbake. Serve with whipped cream or sauce.

Persimmon Beer

Thomas Jefferson, the third president of the United States, enjoyed persimmon beer. Try it and judge for yourself!

1 peck persimmons
1 pound bran
8 gallons water

Combine persimmons, bran and about 1 gallon of warm water. Wash and mix them well. Place the mixture in a tub or barrel with a thin layer of clean straw on the bottom. Add the remainder of the water and set in a warm place to ferment. When the beer is ready for use, the persimmon pieces will rise to the top. Draw off the clear liquid and add molasses or brown sugar if additional sweetening is desired. Place brew in bottles, jugs, demijohns or a keg. Stopper tightly and store in a cool place. The beer is ready for use when cold, immediately after bottling, but if stored for two to three weeks in a cool, dark place it will improve in flavor. The beer is light, lively and pleasant tasting.

Persimmon Cultivars

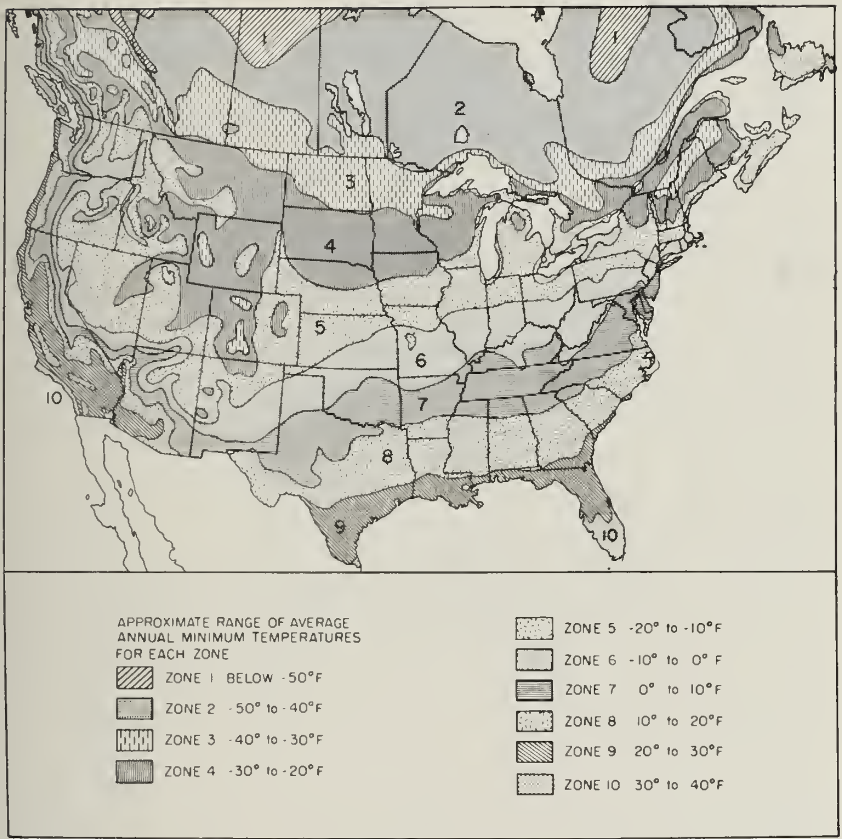
The following cultivars are the most suited to the Northeast (USDA zones 5 and 6). (Unless otherwise noted, my descriptions are drawn from those of Gerardi, Slate, Brooks and Olmo, and McDaniel 1973 and 1982.)

'Early Golden' is the standard for early ripening, nonastringent fruit. Originating near East St. Louis, it has been widely propagated since 1880 and is popular for its large, firm fruit with few seeds. It generally ripens in the first week of October in Ontario (Campbell), but during recent short, cool growing seasons it has failed to ripen properly (Society of Ontario Nut Growers). 'Early Golden' trees have a spreading branch habit and dense foliage. The young plants fruit precociously. With age they can occasionally self-pollinate by staminate flowers borne on weakly growing branches. 'Early Golden' is the matriarch of a family of selected cultivars that includes many of those best suited to northern regions.

'Garretson', introduced from Pennsylvania in 1920, is apparently a first- or second-generation offspring of 'Early Golden'. It has similar foliage and seed characteristics. From 1940 to 1966 it withstood winters at Geneva, New York, without injury. In the Geneva climate it is more productive than 'Early Golden' and matures its fruits more fully, beginning in early October. The fruits are orangy yellow with a red blush and heavy bloom. They are almost spherical and slightly smaller than those of 'Early Golden', about 1⅜ inches in diameter. 'Garretson' fruit has very good flavor, few seeds, and tender skin. 'Garretson' bears in the second season after grafting and like 'Early Golden' produces staminate flowers and self-pollinates with age. Its yields are just about optimum, heavy but not overly so, which would delay ripening in northern areas. 'Garretson' was the choice cultivar at the Geneva Experiment Station in 1966.

'Meader' is the sole plant surviving from a 1947 'Garretson' seedlot grown near Rochester, New Hampshire. 'Meader' regularly survives −25°F and matures 1¾-inch seedless fruits in the cool New Hampshire summers. Experience with 'Meader' at Geneva has shown a tendency towards overbearing. Even so, the largest of the variably sized fruits surpassed in size the fruit of any other cultivar grown there. The dull yellow fruits, which are somewhat furrowed and have a heavy bloom, sometimes develop unattractive dark patches. The skin is relatively tough compared to that of other cultivars, but the flesh is tender and may have a slight but not objectionable astringency. On the whole, the fruit quality is good but not excellent. 'Meader' will produce seeded fruit when grown near a suitable pollinator. Since some fruits of the original plant, which is isolated, have been observed to have seeds in recent years, it can be assumed that it, too, produces some staminate flowers and self-pollinates.

'Killen', selected about 1915 in Delaware, is another probable offspring of 'Early Golden'. It is similar to the latter in texture and seed



U.S. Department of Agriculture plant-hardiness zones in the United States and Canada

shape and in the time required for ripening. The fruits, which are slightly larger than those of 'Early Golden', begin ripening a few days later and continue over a longer season. 'Killen' performs well in southern Connecticut and Geneva, New York. Like 'Early Golden' it is strong growing, precocious, and produces some staminate flowers with age. 'Killen' has a record of producing high quality offspring: 'John Rick' and 'Florence' are two of its progeny, as are the male cultivars 'George' and 'Mike'.

'John Rick' was selected by J. C. McDaniel in 1958 and is receiving widespread acclaim for its large, handsome fruits. The orangy yellow fruits are blushed red and are up to 2 inches in diameter. The skin and flesh are tender and flavorful. Its small, soft calyx, which does not puncture other fruits in storage, combined with its overall attractiveness, makes 'John Rick' a prime cultivar for fresh marketing. It ripens about the same time as 'Early Golden' or perhaps slightly afterwards.

A five-year-old plant growing in St. Elmo, Illinois, yielded 42 pounds of fruit in 1977 (Wills). 'John Rick' has not shown an ability to produce staminate flowers like other members of the 'Early Golden' family. Seedlings of 'John Rick' are very vigorous and precocious but show moderate susceptibility to leaf diseases. If 'John Rick' can be shown to ripen fruit dependably in New England, it will then be highly recommended for its fruit qualities.

'Florence' has smaller fruit than its sibling 'John Rick', but its small seeds give it a high flesh-to-seed ratio, and its delicate flavor is one of the better among northern cultivars. Staminate flowers have also been observed on 'Florence'.

'Wabash', another cultivar suitable for northern climates, is not a member of the 'Early Golden' family. It was selected from the wild in southern Illinois and has smaller fruits and redder flesh than any of the cultivars named thus far. The fruit is sweet, aromatic, and seedless where pollinators are absent. It ripens even earlier than the 'Early Golden' group, beginning in mid-August at Urbana, Illinois. The leaves of 'Wabash' color more than those of most American persimmon trees, making it an attractive yard tree.

'Morris Burton' was introduced by a farmer from Mitchell, Indiana, who noticed that his cows always ate its fruits first. Most people who have tasted it agree with the cows, rating 'Morris Burton' as the most delicious persimmon they have ever eaten. 'Morris Burton' fruit is relatively small and soft but is among the earliest to ripen. Another advantage of 'Morris Burton' is that the ripe fruit falls free of the calyx.

'Juhl' and an older cultivar 'Hick' have shown some promise in trials at Geneva. The fruit color of both is clear yellow with a slight red blush and heavy bloom. The fruit of each is about 1⅜ inches in diameter, but 'Hick' is variable in size whereas 'Juhl' is uniform. 'Juhl' may have small dark spots on its skin. Both have tender skin and flesh without astringency. Neither plant overbears and the fruits of both ripen just before those of 'Garretson'. On the whole, the merits of each approach those of 'Garretson', with 'Juhl' perhaps slightly superior to 'Hick'.

'Richards', 'Evelyn', 'Utter', and 'Pieper' are mentioned in the Society of Ontario Nut Growers newsletter as selections with promise for areas with cool, short growing seasons. The latter three will produce seedless fruit when not pollinated. 'Pieper' ripens fruit in Geneva, and its foliage turns a beautiful yellow before falling, usually with the first heavy frost.

In areas where wild persimmon trees are not abundant, a male tree is needed for pollination if the female cultivar does not have the parthenocarpic ability to set fruit without being pollinated. There are two male cultivars of merit. 'William' is a handsome plant that provides copious pollen over a long period. It is the probable parent of 'John Rick' and 'Florence', as well as 'George', another heavily pollinating male.

Actinidia arguta: The Cold-Hardy Relative of the Kiwifruit

Actinidia arguta is a vigorously growing fruiting vine native to northeast Asia. It is a cold-hardy relative of the kiwifruit (*A. chinensis*), which has enjoyed a meteoric rise to commercial success in the last two decades. Large plantings of kiwifruit in California and New Zealand now supply northern markets.

Unlike the kiwifruit, *A. arguta* has rarely been cultivated except as an ornamental. Even though the fruits are sold regularly in northern Chinese markets, they are obtained solely from wild plants. The Chinese name for *A. arguta* is *van zhou*, the "soft date" or "juicy date." In Korea it is known as the "tara" or "wild fig." Elsewhere, Occidentals have named it the "Siberian gooseberry," "hardy kiwi," and "bower Actinidia," the last to denote its climbing habit. A member of the Arboretum staff, Peter Del Tredici, has dubbed it the "bowerberry," a name that appeals to me. A single name needs to be settled on.

All of the approximately 35 species of the genus *Actinidia* are native to eastern Asia (Li). The center of their geographical distribution is southwestern China. Two species are tropical, but the others are found primarily in the hills and mountains of temperate areas. The fruits of all species reportedly are edible, but those of *A. arguta*, *A. kolomikta*, and especially *A. chinensis* are most often collected for human consumption.

Five species, *A. arguta*, *A. kolomikta*, *A. polygama*, *A. melandra*, and *A. purpurea*, have been grown outdoors at the Arnold Arboretum and are apparently hardy to −5°F. The first three are native to northeastern China (Manchuria), which has a climate similar to New England's. The kiwifruit cannot stand our winter temperatures without protection and requires a long ripening season. *A. arguta* is the only species I have observed fruiting in New England.

The native habitats of *A. arguta* are in eastern Siberia, Manchuria, northern China, Korea, and Japan at altitudes from 330 to 6600 feet. *Actinidia* plants typically grow within the forest or at its edge. They are tall-growing vines (to 100 feet), often climbing into the forest canopy. The long arching shoots provide support by twining and by thrusting themselves upward on short divergent branches. The plants also grow as thickets in open areas, climbing over boulders and smothering small shrubs. *A. arguta* plants are very cold hardy. One explorer reported thick ice near the roots of a Manchurian specimen on June 10 (Woeikoff).

As a species *A. arguta* is polygamodioecious, which means that the flowers of most individual plants are either functionally male (staminate) or female (carpellate). However, there are some plants with perfect flowers, while others may have unisexual flowers of both sexes on the same plant. Furthermore, some plants vary their sexual expression from year to year as maples do.

The flower buds appear in May but remain tightly bound in their

A. arguta *fruits. Peter Del Tredici photo.*

sepals until June, long enough to avoid damage from late frosts. They are borne in small clusters from the leaf axils of the current season's growth. The blooms are strikingly beautiful but are largely hidden beneath the foliage and persist only a week. The individual flowers, about ¾ of an inch in diameter, have black anthers surrounded by five waxy white petals. They have a fragrant scent resembling lily-of-the-valley, which attracts bees and other pollinating insects. Pollination may also occur by wind since the pollen is very light and dry.

A. arguta is among several species in the genus that have been cultivated as ornamentals. The bright red petioles lend an exotic quality to the glossy green foliage, which is unusually resistant to disease and insects. The plants can thrive on a variety of soils, even under conditions of neglect. Because of these qualities the *A. arguta* vine can be recommended for its landscape value alone. Its only fault is its great vigor, which can be troublesome in small spaces.

The fruits of *A. arguta* are luscious. Their flavor is similar to that of the kiwifruit, which has been described as combining a multiplicity of flavors as various as strawberry, cantaloupe, banana, fig, watermelon, gooseberry, and rhubarb. Actually, it has its own very distinctive flavor, ranging from tart, during early ripening, to sweet at full ripeness. I much prefer fresh *A. arguta* fruits to seedless table grapes because of their unique, sophisticated flavor. In texture *A. arguta* resembles a fig or very ripe peach. The tiny seeds, like those of figs, have a barely perceptible crunch when eaten. *A. arguta* fruits are usually oblong in shape (¾ by 1¼ inches) and sometimes blocky with flattened sides. Somewhat bigger than large grapes, they weigh 5 to 10 grams. Unlike the kiwifruit, which has a pubescent skin that must be peeled, the smooth-skinned green fruit of *A. arguta* is eaten whole. Cross-sectional slices of the fruit reveal a glistening pattern of lime-green flesh surrounding a ring of chocolate-colored seeds embedded in a paler green core.

The fruits have a variety of culinary uses. They have traditionally been collected from wild plants and eaten fresh or preserved by drying in the sun. Dried fruit are cooked in breads and pastries or reconstituted for pudding and stew. Underripe and acidic *A. arguta* fruit can be used in pickles and relishes. In vitamin C content it reportedly equals the kiwifruit: 250–380 mg per 100 grams, or ten times that of a lemon. The fruits have a mild laxative quality.

The sliced fruit is visually appealing, a piquant addition to salads, especially fruit salads. It is also excellent in frozen preparations like slush coolers, frozen sherbet, and ice cream and can be preserved or used to make syrup. Fermented *A. arguta* fruits make a good wine with a particularly pleasant and interesting bouquet. (Wine made from kiwifruit is reported to be high quality, of a Sylvaner Riesling character.)

Kiwifruit keeps for an extraordinarily long time (4 to 12 months), and preliminary experience with *A. arguta* suggests that it will, too. In one experiment firm-picked fruit has been ripened to perfection in one month when held at standard room conditions. Ripe fruit has been stored in a household refrigerator for six to eight weeks with little or no deterioration in quality. Firm-picked *A. arguta* fruit in cold storage can probably equal the kiwifruit in its ability to keep through the winter. The slightly flattened sides of *A. arguta* fruits should make them easy to pack and ship with minimal damage.

Elwyn M. Meader, a breeder of many successful crop plants, has grown fruiting *A. arguta* vines for more than 20 years, and he believes *A. arguta* has high potential as a commercial crop for northern climates. Meader lives in Rochester, New Hampshire, where temperature minimums frequently reach −25°F, yet his vines bear fruit every year. They were given a test on Christmas Eve 1980, when temperatures rapidly dropped from 27°F at night to −20°F the next morning with high winds. Even this shock, which affected some apple cultivars in the region, had no adverse effect on the next season's *A. arguta* harvest. And there is no reason to believe that Meader's vines are unusually hardy. None of the couple of hundred seedlings he has grown in the past has shown evidence of winter injury. The report is the same about fruiting vines growing in a small area around Norfolk, Connecticut, known as the "icebox of Connecticut" because of its occasional −30°F minimum winter temperatures. *A. arguta* plants grown in Lithuania have reportedly withstood −45°F.

It is possible that *A. arguta* could achieve commercial success like its relative the kiwifruit, particularly north of areas where table grapes can be grown reliably. Delectable taste, pest resistance, storage qualities, and absolute cold hardiness are impressive attributes of this undeveloped fruiting vine.

Much research and development is still necessary for *A. arguta* to realize its commercial potential. For instance, its productivity has rarely been evaluated. A. D. Woeikoff, in his survey of Manchurian economic flora, states that few plants can equal its fruit-yield to foliage-area ratio. The horticultural staff at the Isabella Stewart Gardner Museum in Boston estimates at least 10 gallons of fruit is collected annually from two large vines in their courtyard. A more specific report from Lithuania calculates 110 pounds of fruit per vine. Based on this figure, an acre of *A. arguta* could be expected to yield 11 tons of fruit. Regardless of the exact yields, it is safe to say that some *A. arguta* vines fruit profusely on an annual basis. Seedlings flower in five to seven years and cuttings in three to four years. Several vines that are at least 60 years old show no signs of declining yields.

A. arguta and some relatives are available as seeds, seedlings, or rooted cuttings from a very few sources (see page 129). Evidence shows that many more male vines are produced from seeds than female or bisexual ones; perhaps as many as 5 to 10 males for each female. For optimum fruit set, a male plant for pollination is a good idea, though probably in an inverse proportion to what occurs naturally (1 male for 5 to 10 females). Ideally, bisexual selections will be made available with the ability to self-pollinate or at least cross-pol-

A. arguta *flowers*

linate with another fruiting cultivar. These can then be vegetatively propagated and the need for devoting space to nonfruiting male vines eliminated.

Propagation

A. arguta was grown and distributed by several nurseries after it was introduced into this country near the turn of the century. Many of the plants I have found date from these early introductions. Arboreta, public and private gardens, and the grounds of institutions are likely sites of fruiting plants.

Fresh seeds germinate much better than ones that have been allowed to dry out. Each fruit contains as many as 200 seeds. Separating the seeds from the pulp is done as it is with tomatoes. The pulp is macerated and allowed to soak in water for several days. After it is agitated, only the pulp and nonviable seeds will float. These can be poured off and the seed remaining on the bottom saved. To ensure uniform germination, the seeds need a period of damp chilling and should be mixed with three times their volume of damp (not moist) peat moss. This mixture must then be sealed in a plastic bag and stored at normal refrigerator temperature for about three months. When it is ready for sowing, the entire stratification mixture may be spread in a flat of sterile media. A light covering of milled sphagnum moss over this will reduce damping-off disease, to which the emerging seedlings are susceptible. Approximately 60 percent to 85 percent of the seeds germinate within 40 to 50 days. Another satisfactory method of germinating the seeds is to store the whole fruit in a refrigerator for a month or longer. After this the fruit can be macerated and the entire pulp planted without separating the seeds. The pulp will decay, and within one or two months after planting the seedlings will begin to emerge.

The seedlings rapidly develop an extensive root system and should be transplanted before they become visibly crowded. They respond well to fertilization and ample spacing, making rapid growth of one to several leaders 1 to 2 feet long. Slightly shaded nursery conditions are recommended, but containerized plants have been successfully grown on asphalt surfaces exposed to full sun and unimpeded winds. The thick waxy leaves seem to resist desiccation, but they can be wind-flailed when new and tender.

Actinidia can also be propagated vegetatively like grapes, with a similar high rate of success. Leafy cuttings taken in July and placed under mist root well. No single rooting hormone can be recommended at this time, but alcohol dips have been observed to be injurious. About 50 percent of dormant cuttings taken in spring just before the buds break also root and establish when simply stuck in an outdoor nursery row of good tilth. Profuse callus formation can inhibit root formation in some cases. For this reason summer budding and dormant grafting of the fruit are preferred by some nurseries. But the grafting must be done well in advance of the spring sap flow, or excessive callus will interfere with the graft union's healing process. Sections of root will sprout readily. One- and two-year-old stems can be rooted from layers by pegging them beneath a moist, friable soil.

One- to two-year-old plants may be transplanted to their permanent location. An eventual growing area of 13 by 13 feet is advisable for these vigorous climbers. Plants of unknown sex may be grown much closer together until their bearing qualities can be evaluated and the less desirable plants rogued out. Care must be taken to allow some pollen-bearing plants to remain. These will preferably be within 35 feet of the fruit-bearing plants and will flower at the same time.

The literature on kiwifruit culture stresses the importance of sturdy trellis supports, and this would also apply to *A. arguta.* Trellises suited for grapes are unsatisfactory under the weight of mature kiwifruit vines heavily laden with fruit. An overhead arbor casts a cool shade and allows for easy picking of the hanging fruit. Fruits harvested from the ground after dropping are usually in acceptable condition. Wherever a climbing vine is needed, these vigorous growers can rapidly fill the space.

Pruning probably will enhance yields. The fruiting occurs on the basal portion of relatively short stems. These can be distinguished by their close internodes of less than 2¼ inches as compared to the long, arching vegetative vines with internodes generally longer than 3¼ inches. Without pruning, the vegetative vines overgrow and shade future fruiting vines. Their photosynthesis will be reduced, causing them to initiate fewer flower buds for the next year's crop. Early June is a good time to prune the long vegetative shoots to about eight leaf nodes from their base. This will direct the sun's energy into fruit production and formation of the next year's flowers. Only enough vegetative growth should be left to replace the old framework of the plant occasionally or expand its size. Winter pruning is useful to

A. arguta *vines at the Gardner Museum in Boston. Peter Del Tredici photo.*

remove damaged and tangled vines and to reduce the length of strongly growing shoots.

A. arguta tolerates infertile soils and has no known insect or disease problems (Spangler and Ripparda). Like the kiwifruit, which also tolerates a wide range of soil types, *A. arguta* probably will not tolerate poorly drained soil. The Japanese beetle and golden nematode have been recognized as pests of the kiwifruit but neither seriously reduces plant vigor. I have observed no insect or disease damage on *A. arguta*. Even gypsy moth caterpillars do not feed on the foliage.

Cats can pose an unusual problem for *Actinidia* growers, for they are attracted to the aroma of bruised leaves and roots of the plants. This is especially true of *A. polygama*, and to a lesser degree *A. arguta*. Cats may even dig up small transplants. Many of the chemical constituents of catnip leaves are also in *A. polygama*. In *Narcotic Plants* Entoben says the Chinese use the leaves of *A. polygama*, known as "metatabi," to sedate large cats in zoos. The psychoactive constituents apparently affect humans as well. In China an infusion of table wine and *A. polygama* leaves is prescribed as a sedative.

A. arguta is an excellent fruiting vine for residential and urban plantings. It is a vigorous ornamental, has no pest problems, tolerates neglect, and bears remarkably delectable fruit. It also has good potential as a commercial crop where the kiwifruit cannot be grown. Although high-quality plants are in short supply, a few sources do exist. If *Actinidia* vines are planted more widely, as they deserve to be, the selection of improved fruiting cultivars will follow. At present only a few experimenters in this country are cultivating *Actinidia* species for their fruit. Homeowners and landscape professionals can take part by planting seedlings or propagating existing plants known to fruit well. The effort will be rewarded for many years to come by both the low-maintenance, ornamental foliage and the delicious fall harvests.

Foliage of A. arguta. *Edward Goodell photo.*

Edward Goodell would like to hear from anyone who knows the location of fruiting *Actinidia* vines. Please contact him at the Arnold Arboretum, Jamaica Plain, Massachusetts 02130.

Acknowledgments

I wish to acknowledge the invaluable comments and support of the following reviewers, whose contributions immeasurably upgraded the information: Henry Hartman, Frederick McGourty, Daniel C. Milbocker, V. O. Virkau, and Gregory Williams. Finally, I dedicate this work to Elwyn M. Meader, whose numerous successful introductions of new food plants and generous sharing of information is an enduring inspiration for me.

Resources

Much of the information above derives from the work of the Northern Nut Growers Association and the North American Fruit Explorers. Both of these organizations are dedicated to improving less developed food plants by distributing plant materials and evaluating their performance. Each has an open membership policy and publishes informative journals for anyone interested in taking part in its activities.

North American Fruit Explorers — membership organization dedicated to promoting the growing of all types of fruit- and nut-producing woody plants. Publishes *Pomona* quarterly. Membership information: Ray Walker, Box 711, St. Louis, MO 63188.

Northern Nut Growers Association — organized in 1910 to promote minor fruit and nut culture in northern North America. Publishes a highly informative quarterly and report on the annual meeting. Dues $10.00, payable to: John English, Treasurer, R R 3, Bloomington, IN 61701.

Massachusetts Fruition Program — innovative state program promoting fruit and nut tree growing; $64,000 has been appropriated for plant purchases. For information contact: Massachusetts Fruition Program, Department of Food and Agriculture, Government Center, Boston MA 02022. Telephone (617) 727-6632.

Nurseries

The following is a list of nurseries specializing in tree crops. Many are run as small part-time businesses. Orders should be placed well in advance, because supplies are often limited. Most have catalogs available upon request.

Alexander's Nurseries, Box 309, Middleboro, MA 02346. Seeds and rooted cuttings of selected *Actinidia argnta* vines.

Beaverlodge Nursery, Box 127, Beaverlodge, Alberta, Canada T0H 0C0. Very hardy (zone 2) fruit trees and shrubs, including improved cultivars of juneberry (*Amelanchier* sp.).

Campberry Farms, c/o Mr. R. D. Campbell, R R 1, Niagara-on-the-Lake, Ontario, Canada L0S 1J0. Improved strains of nuts and native fruits including persimmons.

Dave Lawyer Nurseries, Route 2, Box 95, Plains, MT 59859. *Actinidia* seeds and seedlings.

Earl Douglass, Red Creek, NY 13143. Seeds and seedlings of Chinese and American chestnut hybrids.

Farmer's Seed and Nursery, Fairbault, MN 55021. Cold-hardy fruiting selections of rose, juneberry, cranberry, viburnum, elderberry, table grapes, and *Prunus* species.

John H. Gordon, Jr., 1385 Campbell Boulevard, North Tonawanda, NY 14120. Seeds, seedlings, and root stocks of chestnut, hazelnut, northern pecan, walnut, hickory, nut pine, persimmon, mulberry, and oak.

Grimo Nut Nursery, R R 3, Lakeshore Road, Niagara-on-the-Lake, Ontario, Canada L0S 1J0. Good selection of walnut, hickory, nut pine, chestnut, northern pecan, hazelnut, mulberry, and edible-kerneled apricot cultivars and seedlings. Custom propagation available.

Gurney's Seed and Nursery, Yankton, SD 57079. Chestnut and persimmon seedlings as well as a selection of other native and standard fruits and nuts.

Hess Nurseries, Box 326, Route 553, Cedarville, NJ 08311. Primarily landscape plants, also juneberry and pine nut seedlings.

International Tree Crops Institute, Appalachian Regional Office, Route 1, Gravel Switch, KY 40328. *Actinidia arguta* seedlings and chestnut and persimmon seedlings and cultivars.

Jersey Chestnut Farm, 58 Van Duyne Avenue, Wayne, NJ 07470. Selected chestnut seedlings and persimmon cultivars.

Kelly Brothers Nurseries, Dansville, NY 14437. Fruit cultivars and nut seedlings.

Leslie Wilmoth Nursery, Route 2, Box 469, Elizabethtown, KY 42701. High quality seedlings and cultivars of walnut, pecan, chestnut, hickory, hazelnut, and fruit trees. Custom propagation available.

Louis Gerardi Nursery, R R 1, O'Fallon, IL 62269. Seeds, seedlings, and cultivars of a wide range of nut trees; also persimmon and mulberry.

Mellinger's, 2310 West South Range Road, North Lima, OH 44452. Wide variety of food-producing plants.

Miller Nurseries, Canandaigua, NY 14424. Seedling chestnuts and wide selection of fruits.

Nebraska Nut and Fruit Tree Seed Program, Nebraska Nut Growers Association, Box 4644, Lincoln, NE 68504. Seed packets of native nut and fruit trees.

New York State Fruit Testing Cooperative Association, Geneva, NY 14456. New and antique cultivars of all commercial fruits, also elderberry and mulberry cultivars. Catalog available to members, annual dues $5.00.

Ray Guidi Nursery, 193 Curtis Avenue, Dalton, MA 01226. Seedlings of native and hybrid nut trees.

Saginaw Valley Nut Nursery, c/o Richard D. Goldner, M.D., 8252 Dixie Highway, Route 3, Birch Run, MI 48415. Good selection of cultivars and seedlings from the walnut family, adapted to cold winters and short growing seasons.

St. Lawrence Nursery, R D 2 Route 56A, Potsdam, NY 13676. Exceptionally hardy fruits and nuts.

Robert G. Seip, R D 1, Box 683, Alburtis, PA 18011. Hickory, walnut, hazelnut, chestnut, and persimmon cultivars and seedlings.

Southmeadow Fruit Gardens, Grootendorst Nursery, Box SM, Lakeside, MI 49116. Extensive listing of choice antique fruit varieties.

Archie Sparks, Beaver, IA 50031. High quality black walnut cultivars, seeds, and seedlings.

Stark Brothers Nursery, Louisiana, MO 63353. Chestnut and persimmon seedlings and cultivars. Largest supplier of home orchard plants.

Talbott Nursery, R R 3, Box 212, Linton, IN 47441. Persimmon cultivars, and chestnut and walnut seedlings.

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R. albiflorum

Collecting in the West

by Robert Nicholson

During September 1981 I had the good fortune to spend several weeks on a plant- and seed-collecting expedition for the Arnold Arboretum. The trip brought me over 5000 miles of road and eight states in the American West, a terrain sculpted by wind and water and draped in a mantle of botanical wonders.

The purpose of the trip, in addition to that of expanding the Arboretum's collections, was to obtain seeds of plants that may be either endangered or of special interest to the plant sciences or nursery trades. I also wanted to collect herbarium specimens for certification and exchange, as many of the species I was looking for are poorly represented in herbaria throughout the world.

My trip began in the still air of libraries and herbaria, where I spent many hours combing herbarium sheets to gain a familiarity with the plants and sifting through the often cryptic locale data of former collectors. As my stack of notes grew, one element began to emerge and engage my fascination: the mysterious existence of plant disjunctions.

A disjunction, as the name implies, involves a discontinuity within a taxon's range. For example, the primary range of the Cascade azalea (*Rhododendron albiflorum*) is the Cascade Mountains, from British Columbia to Oregon, and scattered populations exist in the Rocky Mountains of Alberta, Canada, northern Idaho, and western

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Robert Nicholson has made several collecting trips for the Arnold Arboretum.

The barren northwest slope of Agassiz Peak at 11,600 feet

Montana. However, an outlying population exists in central Colorado, about 500 miles from the others. A distribution pattern such as this can raise intriguing questions as to the taxon's origins and continued existence.

E. C. Pielov, in his book *Biogeography*, created a classification scheme that groups disjunct populations according to their origins. According to his scheme the causes of a gap in the range of an organism are as follows:

(1) Splitting of a once-continuous range because of:
- (a) Geomorphological changes, i.e., an uplift of mountains
- (b) Climatic changes
- (c) Evolutionary differentiation and migration

(2) Establishment of new populations over long distances (jump dispersal) owing to:
- (a) Natural causes
- (b) Human agency

Disjunctions, therefore, are islands of botanical life, populations of plants that exist far from the mainland of a species' range. These populations may differ from primary populations — for example, they may be hardy in a greater range of habitats — and so are of interest to collectors. They also challenge the botanist to determine the cause of the split from the main range. Was it the gradual uplift of the mountains or the slow drying within the new mountain's rain shadow? Was it the movement of birds in migration or the lethargic sculpting of the glaciers?

P. aristata *on the southern slope of Agassiz Peak at the same elevation*

The Rhododendrons of Slavonia

The first disjunct population I encountered grew near Slavonia, an abandoned mining town in central Colorado, close to the Wyoming border. In the Routt National Forest, on the edge of the Zirkel Wilderness, grows the state's only native rhododendron species, the Cascade azalea (*R. albiflorum*). This species is better known as a component of the humid lowland forest as well as the subalpine areas of the Pacific Northwest. It favors high-altitude wetlands and tends to form low clumps around lakes and streams. It has an oblong deciduous leaf and in early summer bursts into creamy white blossoms about one inch in diameter.

The species was first found in the Rocky Mountains of Canada by a Scotsman, Thomas Drummond, in the wilderness years of the early 1800s. Sir William Hooker rendered the first description in *Flora Boreali-Americana* in 1840 and called it "a very beautiful and most distinct species which would be a great ornament to our gardens if it could be introduced." The latter qualifier proved prophetic, as horticulturists labored to grow it. A Dr. Graham of the Royal Botanic Garden, Edinburgh, was the first to record its flowering nonsitu and wrote: "This very distinct species was raised at the Botanic Garden from seed gathered by Mr. Drummond in British America in 1828. It does not grow freely and flowered rather sparingly in the open border for the first time in July 1837. It is to be regretted if it is found difficult of cultivation for Mr. Drummond stated it formed a very handsome shrub."

Colorado spruce (P. pungens)

The Cascade azalea has also proved difficult to grow in eastern North America, probably because of the oppressive summer heat.

I thought then that this odd Colorado population, growing so far out of range, might offer a genotypic variation that would be suitable for cultivation. One segment is centered near Slavonia and another, three miles to the northeast, near Gilpin Lake. I reached the area via a long dirt road and found no buildings or remnants of the former town. The area is now a favorite starting point for hunting trips into the Zirkel Wilderness, and on the day I arrived packs of hunters sporting state-of-the-art bows were methodically preparing for their foray into the wild. After I had prepared my own hunting gear — a few seed envelopes and some pruning shears — I crossed a stone and wire bridge and headed up an east-facing slope. It was traversed by several streamlets and springs and supported a profuse growth of mosses. Only a few hundred feet from the bridge I found my first Cascade azalea, and I soon discovered that the plant grew in profusion throughout the area. To see such an unusual plant so common in situ was indeed a rare pleasure.

A canopy of Colorado spruce (*Picea pungens*) and Douglas fir (*Pseudotsuga menziesii*) dominated the slope but surrendered somewhat in the wetter areas. The transition zone between the forest and the open mossy area was the niche the rhododendron settled into, forming large mounded patches of yellow fall foliage. There, hidden in

Douglas fir (P. menziesii)

the cool tuck of a mountain in the wilderness, was a plant whose creamy white display in spring must stir the hearts of any who happen upon it. I searched hundreds of branches for seed but found all the capsules disappointingly green. Luckily, I was able to arrange for a later shipment from Michael Calhoun, a local resident with a special interest in the azaleas.

The background of these unique Coloradan populations is fascinating from both biogeographical and historical perspectives. The plants have had only sporadic contact with humans. I had been told at the Denver Botanical Garden that the first discoverer of the stand probably was George W. Kelly, an amateur botanist in Colorado. Now 86 and in the process of writing his 10th book, he generously answered my inquiries about the area in a warm letter. "I am just an amateur botanist but spent many wonderful days in the Slavonia area years ago. This is a real island of botany, almost identical to the coast area many miles to the west. . . . My discovery was the first local recognition of the plant, previously all woody plants were just bushes. I was probably the first to make a herbarium collection. So far as I have heard, this group in the Slavonia area is the only one in the state." Without doubt George Kelly has done the most to make the botanical world aware of the stand, and it was his herbarium specimens that first directed me to the still-extant population.

Rocky Mountain maple (A. glabrum)

The earliest published reference to the population is an article that named the plant as a new species, *Azaleastrum warrenii.* Aven Nelson of the Rocky Mountain Herbarium received a single specimen dated July 14, 1911, from Edward R. Warren, a Colorado Springs naturalist. Warren wrote to Nelson, "I found it at my camp on the lower slope of Mt. Zikel, at the head of navigation [for prairie schooners] on the 'Ute Pass Trail'. If I remember correctly, it was quite abundant. It was a low plant, perhaps not more than a foot high. . . . I evidently did not collect much of it, for I have but a single twig left and am sending you half the flowers and leaves from it."

Nelson split the plant (as *A. warrenii*) from *R. albiflorum* on the basis of the glandular, ciliolate leaves of the former, which otherwise were glabrous. Five years later, in 1918, J. Francis Macbride transferred the species to the genus *Rhododendron.* Because of the paucity of pressed material, little comparative analysis with *R. albiflorum* was done and *R. warrenii* remained obscure.

In 1936 Louis O. Williams in *Annals of the Missouri Botanical Garden* compared three collections from the Coloradan populations with specimens of *R. albiflorum* from the Northwest. He believed that the two species were the same, and other botanists in the area concurred. The plant is now considered *R. albiflorum.*

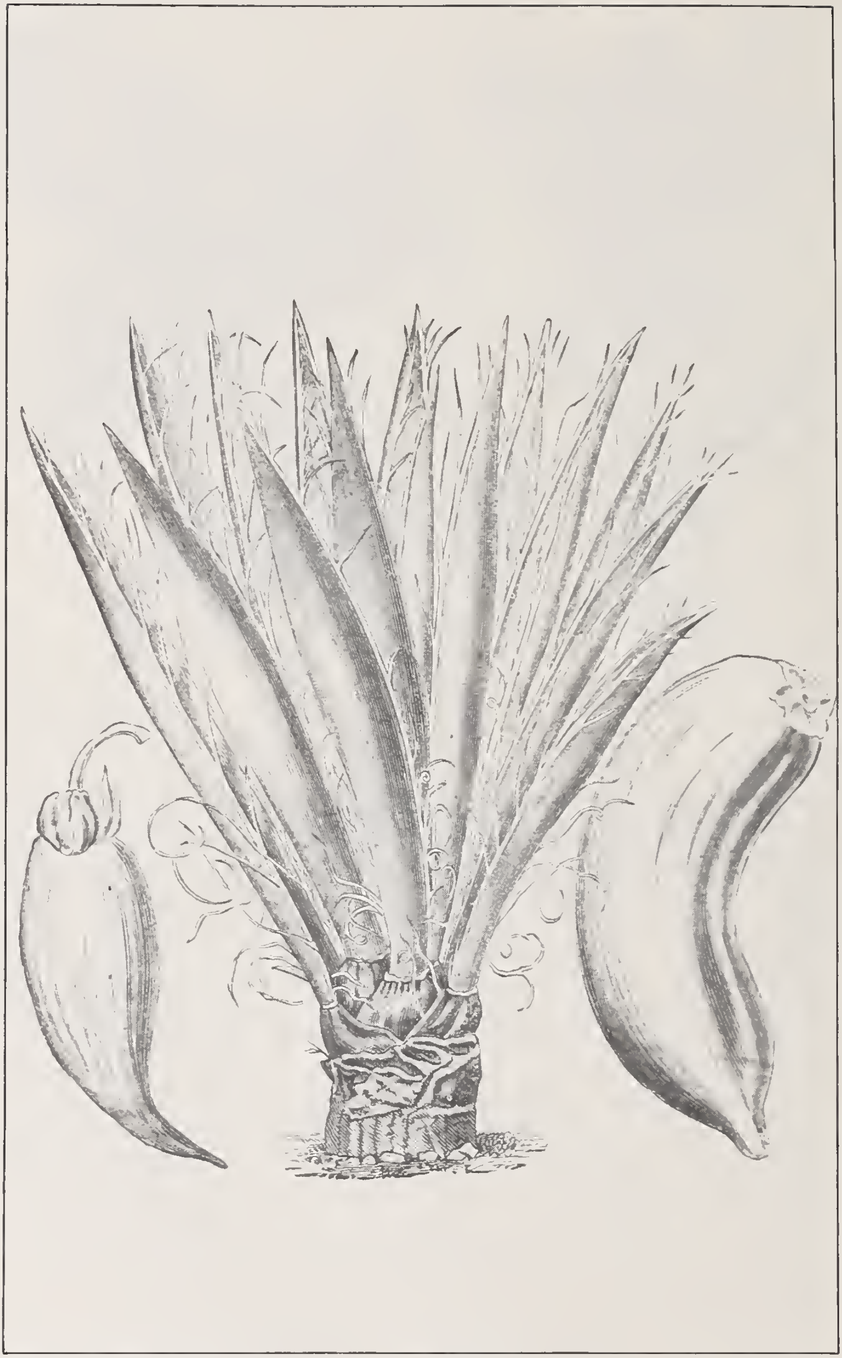
The few isolated populations of *R. albiflorum* east of the Cascades

Cliff fendler bush (F. rupicola)

Pacific trillium (T. ovatum)

probably originated by different means. Those in Alberta may be the result of jump dispersal following the Wisconsin glaciation. But the disjunct population in Colorado, which may have evaded glaciation, could have resulted either from jump dispersal or range splitting. Rhododendron seed is so small and light that it could easily have lodged itself in fur or feather. Wind is also a dispersal agent for small light seeds, and it is conceivable that seed from the Cascade populations could have been carried east in a powerful storm. Volcanoes are another possibility but a highly unlikely one. *R. albiflorum* is a component of the Cascade flora and inhabits the sides of both active and extinct volcanoes. The recent Mt. St. Helens eruption, which spread ash as far east as Colorado, raises the question as to whether the seeds could have been blown into the stratosphere and carried eastward. Whether the seed could survive the intense heat and poisonous gases of the blast is highly questionable, but it is an idea that gives botanists a big bang theory to call their own. Of course, it is possible that other populations will be found within the 500-mile disjunction, rendering it less dramatic.

Since George Kelly has noted the presence of other West Coast disjuncts, such as Pacific trillium (*Trillium ovatum*) and Lewis mimulus (*Mimulus lewisii*), near Slavonia, it would follow that it is a refugium rather than the end point of a jump dispersal. We might



Banana yucca (Y. baccata)

Engelmann spruce (P. engelmannii)

Knowlton hornbeam (O. knowltonii)

speculate that the Cascade azalea once had a wider range than it has now. Two events probably diminished the range. First, the Cascade and Sierra Nevada mountains uplifted, blocking Pacific rainstorms and creating dryer environments on their east sides. Second, the Wisconsin glaciation buried the more northerly populations under a sheet of ice. The few populations in Colorado survived probably because they were unaffected by glaciation and because the mountains on whose bases they grow held enough rainstorms to sustain them.

After leaving Slavonia, I spent two days in the Mesa Verde National Park, clambering up and down the jagged canyons looking for the cliff fendler bush (*Fendlera rupicola*), the banana yucca (*Yucca baccata*), and the Rocky Mountain maple (*Acer glabrum*). Next, in southwest Utah, I reached the summit of Abajo Peak, an 11,445-foot mountain capped by Engelmann spruce (*Picea engelmannii*) and offering a number of interesting rockery plants on the exposed rock faces. To the north of that summit, near Moab, Utah, I searched in Negro Bill Canyon for the Knowlton hornbeam (*Ostrya knowltonii*). Although this is one of the rarest North American trees, it is not presently listed at any American botanical garden. It remains so as I failed to locate the species at this site. However, I was able to collect seed from two intriguing cliff dwellers — the monkey flower (*Mimulus eastwoodii*) and the columbine *Aquilegia pallens* — growing in a cliff-face crack where enough moisture was seeping out to support their tenuous existence.

During the following days I visited Oak Creek Canyon, Arizona, a botanical treasurehouse that contains four distinct vegetation zones over its 20-mile length.

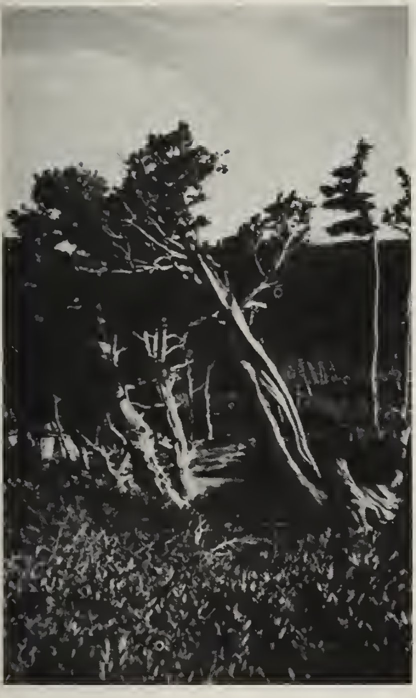
Arizona's Isle of Antiquity

To the north of Oak Creek Canyon and overshadowing the city of Flagstaff, Arizona, rise the peaks of the San Francisco Mountains. Humphrey's Peak, the highest in the group, is Arizona's champion mountain and reaches 12,633 feet. Treeline ceases about 1000 feet below that and is chiefly represented by the low matted growth of the bristlecone pine (*Pinus aristata*). This population was the main reason for my visit there, as it is Arizona's only population of bristlecone pine and is 325 miles away from the nearest neighboring population.

The species itself was first discovered by Charles Parry in the high mountains of Clear Creek, Colorado, and subsequently was described by George Engelmann in the *American Journal of Science* in 1862. Engelmann (1880) accurately described both the habitat and habit of the plants: "In sheltered situations it forms a tree 40 to 50 feet high and 1 or 2 feet in diameter, but on the higher bleak mountains it is a stunted bush often exceedingly slow, as a stick of scarcely more than one inch in diameter brought back by Dr. Parry shows nearly fifty annual rings, some of them 1/60 of a line, and none more than 1/6 of a line wide."

The species is most notable for its glacial growth but also for its thick bottlebrush growth of needles and for the white dandrufflike resin exudations that spot these needles. Until recently *P. aristata* growing in the White Mountains of California were regarded as the oldest living organisms on the planet. However, in 1970, on the basis of needle characteristics, D. K. Bailey split the species into two. The Coloradan, New Mexican, and lone Arizonan populations were kept as *P. aristata*, while the more renowned Californian populations and those in Nevada and Utah became a new species, *P. longaeva*. Bailey's work was taxonomically sound and has generally gained acceptance, but it does complicate the biogeographic history of these plants gripping the lava rock of the San Francisco Mountains.

The first collector to scour these mountains is believed to have been E. Palmer in 1869, but the earliest specimens taken of *P. aristata* were probably those of Bischoff, a member of the Wheeler expedition of 1871. Pilgrimages have been made by numerous botanists since to study both the rare Arizonan alpine flora and the vegetation in the zones below. C. Hart Merriam in 1887 was especially attentive to the acute differentiation of the region into vegetation zones that he distinguished on his climb up the mount: ". . . it may be said that in ascending from the hot and arid desert of the Little Colorado to the cold and humid summit of the mountain, no less than seven zones are encountered, each of which may be characterized by the possession of forms of life not found in the others." Merriam (1898) noted that these zones surround the mountains as skewed concentric rings, each zone of plants terminating farther up the mountain on the warmer southwestern side than on the colder northeastern. In some cases this



Bristlecone pines (P. aristata) *at Mt. Evans, Colorado. Robert Nicholson photo.*

altitudinal difference can be as much as 900 feet from one side of the range to the other.

Other significant work on the mountains was done by E. L. Little (1941), who compiled the most complete list of the alpine species (49 in all), and by Thomas Moore (1965), who hypothesized on the origins of the flora. My own ascent of Agassiz Peak began on the western side at the end of the access road. The Arizona Snow Bowl, a ski lodge, is situated at 9600 feet, so I could hike to the upper peaks on its cleared slopes. Despite the ease in walking, however, the trip still had its share of difficulties. As I passed the 10,000-foot level, a thunderstorm blew in from the west and seemed to stall against the peaks. The thunderclaps were both frequent and loud, and at that altitude one had the feeling of being within the storm rather than under it. After contemplating a run for the bottom, I instead opted to huddle next to a Douglas fir and attempt to keep panic at bay. The rains soon became heavier and, lacking rain gear, I had to improvise quickly with the plastic garbage bags I used for herbarium specimens. As I sat and looked up the forested incline, the storm released its final surprise, a barrage of dime-sized hailstones. The forest floor was alive with the white pebbles, which bounced frantically down the slope after their earthward plunge.

The storm finally slid over the peaks and I pushed upward towards the timberline, the upward limit of normal-sized trees. Both *Picea* *engelmannii* and *Pinus aristata* reach timberline and extend upward to treeline, surviving as a stunted matted form known as krummholz. Here I took a number of specimens but no seeds, as these trees were barren. At that elevation on the mountain the skewed nature of the vegetation zones became amazingly apparent. Above the tree line on the west side, a short walk of a few hundred feet around the cone of the mountain to the southwest side put me directly back into the krummholz zone.

The last 500 or so feet of Agassiz Peak is the alpine zone. Here and there on the coarse gray volcanic rock were a few ground-hugging plants. Little enumerated some 49 species on the peaks, but the long-term warming trend of the Southwest dooms many. I was able to collect seed from a number of interesting alpines, most notably *Heuchera versicolor* (Saxifragaceae), which should be a first-rate plant for rock gardens or for ground cover. The lack of oxygen at that altitude more than once tested my determination to collect. All movement seemed draining, and my lightweight Olympus camera felt like a cinderblock around my neck.

Prior to Bailey's split of the species, the nearest populations of *P. aristata* had been those in the mountains of southwest Utah, some 150 miles north of the San Francisco Mountains. With the new differentiation the closest population shifted to the east, some 325 miles away in the Sangre de Cristo Mountains of New Mexico. How then did the species come to migrate to Arizona, and why is there such a large disjunction between the populations despite the existence of plausible sites for colonies?

During the Wisconsin glaciation, the entire Southwest was subjected to a lowering of yearly average temperatures. As a result, vegetation zones existed at lower altitudes, and the alpine and subalpine floras undoubtedly grew over both a far greater and a more southerly range. With the glacier's retreat the climate warmed, and the cold-loving species began a migration upward for survival. Those populations that ran out of altitude were like nonswimmers stranded on a rock in the incoming tide. There was simply no place left to move to and they perished.

At the San Francisco Mountains, and nowhere else for 325 miles, the correct conditions existed for the continued survival of *P. aristata*. That such a large disjunction exists is puzzling, for between the Arizonan and New Mexican populations a number of peaks reach altitudes of over 11,000 feet. If we assume that these peaks were the bridge by which *P. aristata* spread from New Mexico, what can account for the species' absence now? Bailey suggests that the subalpine conifers on these peaks present too much competition for the pine, yet the same conifers are found in the San Francisco Mountains. It could be that an insect infestation or disease eliminated the bristlecone pine from these stations, but it is certainly a question that needs further investigation.

Pacific dogwood (C. nuttallii) *flowers*

In the Valley of the Dogwoods

I spent my last days of collecting in Central Idaho. After a long drive through the sparse plain of Southern Idaho on a dark night, I found another of my targeted disjuncts, the Pacific dogwood (*Cornus nuttallii*). The site is known to botanists and nurserymen throughout the northwestern states, and the disjunction is among the most remarkable in the United States.

On the edge of the Clearwater National Wilderness is the small village of Lowell, Idaho. Here two rivers, the Lochsa and the Selway, merge to form a third, the Clearwater. These rivers have cut deeply through the land, and their escarpments are steep and well forested. Along their banks, and extending upwards onto the hillsides, grow several species notable as belonging to the northwestern coastal flora, a flora native to an area 300 miles west on the opposite side of the Casades. Indeed, the Lowell area is the only area east of the Cascades where *C. nuttallii* is known to exist. The Pacific dogwood was the primary reason for my visit to the area, but I also was successful in collecting seed of other species such as the giant arborvitae (*Thuja plicata*), the great silver fir (*Abies grandis*), the Pacific yew (*Taxus brevifolia*), and the red alder (*Alnus rubra*).

Especially thrilling to me was the discovery of a stand of Oregon maple (*Acer macrophyllum*), one large matriarch and her few sapling offspring. The parent tree measured approximately 75 feet in height, and its twin trunks each measured 2 feet DBH. As I had never heard of

Western yew (T. brevifolia)

the species being reported in Idaho, I at first thought I had a real find. Subsequent talks with Idaho botanists, including Frederic Johnson, revealed that the stand was known. Locals believe that the parent tree was either a planted specimen or an escape. A coring to determine the tree's age would surely help settle the question. I dug dozens of seedlings from around the tree and brought them back to the Arboretum in the hope that they would prove to be hardier here than their West Coast relatives.

But most remarkable among the area's woody species is the Pacific dogwood (*C. nuttallii*). It has a large range, extending from British Columbia down into the Sierras of California. It is also one of the largest dogwoods, reaching 100 feet in prime locations. Its flowers, like those of most dogwoods, are inconspicuous, but the petallike bracts that surround them number between four and seven and are somewhat larger than those of its eastern relative, the flowering dogwood (*C. florida*).

Giant fir (A. grandis)

The species has an erratic flowering schedule, having been reported blooming in both spring and autumn. When I visited the Idaho population in late September, some flowers still remained on the trees, and a local resident told me that was their third flush of the year.

The species itself was easy to find and could not be labeled uncommon. The stand begins about 9 miles west of Lowell and seems to grow best within a 4-mile radius of the town. The population stays within the narrow confines of the three river valleys and continues intermittently about 25 miles northeast along the Lochsa River and about 12 miles southeast along the Selway River.

The population is interesting not only for its disjunct location but also for a bit of its early history, a near brush with the area's first itinerant botanists Meriwether Lewis and William Clark. In early September 1805 the party of Lewis and Clark traveled through the

Pacific dogwood (C. nuttallii)

Lolo Pass from Montana and continued their long trek to the mouth of the Columbia River. They proceeded down the Lochsa River watershed and cut north into the Bitterroot Mountains. At one point in their arduous trek, at Hungery Creek, they were within 5 miles of making the initial discovery of the species' most disjunct population. As it developed, Lewis and Clark were the first to discover *C. nuttallii*, but only west of the Cascades.

The Idaho population remained nestled in the deep river valleys and passed unnoticed by the botanical world for another 85 years. J. B. Leiberg was the first to give it attention in print, in a U.S. Geological Survey forestry report in 1900. He was quick to perceive the unusualness of a *C. nuttallii* population in Idaho: "That the species should occur in the basins of the Clearwater drainage is remarkable. Its home in this latitude is in the Cascades and so far as is known, it does not grow at any intermediate station."

Since Leiberg's report, a number of other coastal disjuncts, such as red alder (*A. rubra*), and endemics, such as *Phlox idahonis*, have been documented in the region, singling it out as a refugium. The formation of this refuge has been thoroughly explained by Rexford Daubenmire. He postulates that the course of the disjunction is a sequence of events including the formation of the Rocky Mountains, the uplift of the Cascade Mountains, and the Wisconsin glaciation.

Beginning in the Oligocene Epoch and continuing into the Miocene Epoch, the Rocky Mountains were formed and separated the continent into eastern and western regions. During the late Pliocene Epoch the Cascades were formed by a combination of volcanic process and uplifting, effectively splitting the *C. nuttallii* population into two. To the east of the new mountains, a rain shadow formed and dried up the lowlands between the Cascades and the Bitterroot Mountains, reducing the range of many species, including *C. nuttallii*.

With the onset of the Wisconsin glaciation, the climate of eastern Washington and northern Idaho was altered by a lowering of temperatures, which drove the more tender species to lower altitudes and latitudes. The Clearwater River drainage area became an important refuge. It was the first area south of the glaciation with a warm, deep valley and an adequate moisture regimen. Here, it has been speculated, were driven the last intermountain populations of *C. nuttallii*, and it is here and only here that they survive today.

The question now remains as to whether this population is a hardier race tempered by the elements through the ages or whether it is a race that was able to migrate to the warmest area. I collected 3 pounds of seed from a dozen sites within the population, and some 400 seedlings have been grown from this seed. These seedlings are now being tested at the Arnold Arboretum and a half-dozen East Coast nurseries.

Weather data from the Fenn Ranger Station on the Selway River suggest that climatic extremes in the Clearwater drainage area are comparable to those in Boston, so with any luck a few more refugia for *C. nuttallii* may be created in East Coast gardens.

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Introducing *Cedrus deodara* 'Shalimar'

by GARY L. KOLLER

As my bus sped through the Japanese countryside, I was captivated by the meticulous order of the fields, with their small plots of vegetables set in rows of seemingly mathematical precision. Here and there, near a house or at the edge of a field, I caught glimpses of a conifer that was unfamiliar to me. The tree caught my eye because of its elegant and yet informal silhouette. Upon inquiring I found the plant to be the deodar cedar (*Cedrus deodara*), a tree native to the Himalayan Mountains. That was in 1969 and before I learned how plants "migrated" from their homelands to become rather common elements of alien territories.

The memory of those trees remained with me even though I didn't see the species again until 1972, when I went to study horticulture at Longwood Gardens in Kennett Square, Pennsylvania. At Longwood a multistemmed specimen stood between the palm display greenhouse and the experimental greenhouses. That specimen was younger and smaller than those I remembered in Japan, but it retained the density of needles and branches and the gracefulness of the pendent branch tips. Soon after my arrival at Longwood I began to look into the background of the deodar. I discovered that the tree can grow much higher than its usual 60 to 80 feet; in its homeland some specimens are said to exceed 200 feet. As a species the deodar is marginally hardy in the Philadelphia area, flourishing during mild winters but suffering wind damage to needles and twigs, or succumbing entirely, during very severe winters.

When I came to the Arnold Arboretum in 1976, I discovered that its collection contained specimens of two deodar forms that are more cold hardy than the tree at Longwood. Called 'Kingsville' and 'Kashmir' (Fordham 1969), they had been selected by the nursery trade and are commercially available. To call our specimens of these two cultivars

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ornamental would have been generous. Large sections of the limbs were dead; the needles that remained exhibited marginal scorch; and new growth was sparse and lacked vigor. Both specimens were small, and I am sure their sorry state reflected a combination of stresses imposed by recent transplanting, poor siting, dry soils with no supplemental water during the reestablishment period or times of drought, and the plant's own vulnerability to severe winters. It is fair to say that the two more cold-hardy cultivated forms of deodar were barely surviving at the Arnold Arboretum in Jamaica Plain, Massachusetts. Passersby would never have taken a second glance at these pitiful specimens.

The Arboretum also had another deodar cedar, which had been selected from a seed batch as exhibiting greater tolerance to our climatic conditions. The seeds had been obtained in India by Mr. Henry Hosmer, a member of the Friends of the Arnold Arboretum who traveled to India and Afghanistan during the autumn of 1964. According to our records Mr. Hosmer collected the seeds at Shalimar, India, and sent them back from Afghanistan in October 1964. As no town named Shalimar appears on maps of India, it is probable that Hosmer was referring to an old and highly respected garden of that name at Dal Lake. Srinagar, in the Kashmir region. While *Cedrus deodara* probably does not occur naturally at this location, it is quite likely to be among the planted collections.

In due time seedlings were grown from the Shalimar seeds, and one individual not only survived but thrived. It grew rapidly and during spring 1973 was planted in our permanent collections on the bank immediately northeast of the Hunnewell Building. The tree is approximately 17 feet tall and 15 feet across. It has four trunks, and the largest is 3½ inches in circumference at breast height. The needles are lustrous, green, and free of any signs of damage or environmental stress, although they are somewhat sparse. The tree as a whole is thin, but it appears to be healthy. I attribute its lack of vigor to site conditions rather than to the plant itself.

The successful growth of this individual enticed us to experiment with vegetative propagation to increase the selection. After repeated attempts we succeeded in rooting a quantity of cuttings and placed them in a row in our greenhouse nursery. Seven individuals of the same accession and age were planted in the west greenhouse nursery. In 1982, at ten years of age, they were approximately 9 feet tall. These plants were observed as a group and compared with *Cedrus libani* var. *stenacoma* and the deodar cedar cultivars 'Kingsville' and 'Kashmir', which were all grown in nearby sections of the nursery. Each spring our seedling and its vegetatively reproduced progeny looked better and exhibited less winter injury than the other plants. In observing the row of rooted cuttings from 1976 until 1982, we noted the following. In most winters there was little or no damage to needles and none to stems and twigs. During the winters of 1979–80 and 1980–81, which were colder and drier than normal (temperatures reached −6° F), needle injury was minor, with the terminal ends of the needles turning brown. The plants recovered rapidly the following spring. During winter 1980–81 needles on the lower branches browned, probably as a result of sunlight and heat reflecting off the snow. Also, the terminal leaders of several individuals deteriorated for a distance of 1 to 3 feet. Al Fordham, the former chief plant propagator at the Arboretum, believes this to be due to deodar weevil, for he has observed this insect damaging the other specimens of *Cedrus*.

Our continuing observations support the conclusion that while our cedar is not ironclad in its hardiness it appears to be hardier here in winter and summer than either 'Kingsville' or 'Kashmir'. Our seedling is therefore worthy of additional testing, and to facilitate that we have decided to add a cultivar name to distinguish this genotype. The name we have chosen is 'Shalimar' to commemorate the place where it is believed to have originated.

The next step in evaluating the tree's potential for popular use is to see whether it can be propagated with relative ease and efficiency, as plants that are very difficult to propagate are rarely successful commercially. The process of learning to propagate difficult and unusual species is one of the activities of the propagation staff at the Arnold Arboretum. We conducted numerous propagation tests on *Cedrus deodara* 'Shalimar' in which we managed to kill a large number of cuttings. However, a method of studied trial and error as to time of taking cuttings, hormone applications, soil medium, wounding, and humidity control gradually identified one means of achieving an 83 percent success rate. Our propagation staff recommends taking cuttings during January and selecting shoots from last season's growth. The cuttings are treated with a quick (5-second) dip of the base in 10,000 ppm IBA dissolved in 50 percent ethanol. Wounding or not wounding the base of the cuttings seems to make no difference in the position, amount, length, or quality of the roots. In all cases roots were initiated at the basal end of the cutting and tended to consist of a few long, coarse strands. The soil medium consisted of equal parts of sand

Cedrus deodara Cuttings Available

A limited number of *Cedrus deodara* rooted cuttings or scions for grafting are available. We will honor requests for them until April 1, 1983, for a fee of $15.00, for which recipients will be billed. The fee will help to offset the costs of testing, preparing, packaging, and mailing. Requests should indicate whether two rooted cuttings or 25 scions are desired. Please send requests to: Gary L. Koller, Supervisor of the Living Collections, Arnold Arboretum, Jamaica Plain, MA 02130.

and perlite, and the cuttings were given bottom heat of 75° F. The cuttings were placed in closed cases without mist. The ambient air temperature of the greenhouse was maintained at approximately 55° F. Rooting took place in 10 to 12 weeks. Root quality varied, but as long as any roots were evident the plants were potted. Cuttings are normally potted in early spring and put out a new flush of growth almost immediately. The tip of the new growth is weak and droops for some time, but as the plant grows it becomes erect and develops a strong central leader without the aid of staking.

As we introduce *Cedrus deodar* 'Shalimar', we hope that it will eventually be included in that category of plants that catch the eye and be recognized for its dependability and beauty in northern landscapes.

Reference

Fordham, Alfred J. 1969. "The Deodar Cedar." *Plants and Gardens*, 25 (2) 33.

Acknowledgments

Drawing of *Trillium ovatum*, page 141, reprinted, by permission, from Mary E. Parsons, *Wild Flowers of California*, Roxana E. Ferris, editor; Dover, 1966.

Drawings of Engelmann spruce (page 142), Colorado spruce (page 138), Douglas fir (page 139), Knowlton hornbeam (page 143), and Rocky Mountain maple (page 140) reprinted, by permission, from Robert A. Vines, *Trees, Shrubs, and Woody Vines of the Southwest*, University of Texas Press, 1960.

Recipes on pages 116 and 117 reprinted, by permission, from Eugene and Mary E. Griffith, *Persimmons for Everyone*.

Erratum

In our last issue the shading on the map on page 103 was lost in reproduction. It was meant to indicate the contiguous distribution of the spruces of the world, which extends northward to the treeline across the North American and Eurasian land masses.

Opposite: Cedrus deodara *in Seattle, Washington, in 1949. Donald Wyman photo.*
Back cover: *American persimmon tree* (Diospyros virginiana). *Edward Goodell photo.*

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