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Bark of mature river birch tree (*Betula nigra*)

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Front cover photo: Cone of the umbrella pine (*Sciadopitys verticillata*). *Back cover:* Needles of the same species. Al Bussewitz photos.

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Walnuts for the Northeast

Edward Goodell

The walnut has been held in high esteem since ancient times. The Romans considered it preeminent among nuts and gave it the name *Jovis glans* (Jupiter's nut), from which the modern taxonomic name for the walnut genus, *Juglans*, has been derived. Several species of walnuts are popular throughout the Western World today, both for their fine wood and flavorful nuts. Large commercial walnut industries exist in the Mediterranean region of Europe and on the west coast of the United States (primarily California, with 200,000 acres). Although walnuts are grown throughout much of this country, they have never been grown widely in the Northeast. Several types can be grown here, however, including the Persian walnut (*Juglans regia* L.), the black walnut (*J. nigra* L.), the butternut (*J. cinerea* L.), and the Asian walnuts (*J. ailanthifolia* Carr, *J. mandshurica* Maxim., and *J. cathayensis* Dode), all of which have nutritious, flavorful nuts. We will explore in the following the merits of these types and their cultivation in the northeastern United States and adjoining areas of Canada.

Any talk of walnuts must begin by addressing the toxic effect walnuts are said to exert on neighboring plants. Pliny the Elder, in the first century A.D., wrote, "the shadow of walnut trees is poison to all plants within its compass. . . ." While it is true that walnut species (and some hickories) produce a toxic chemical identified as juglone (5-hydroxy-1, 4-napthoquinone) the actual phytotoxic effect varies considerably depending on (1) the different levels of tolerance among plants, (2) whether or not the roots of adjacent plants contact the walnut root, and (3) the amount of air present in the soil. Although the black walnut probably has the most notorious reputation for allelopathy (as destructive chemical interaction between plants is known), this phenomenon has been increasingly documented throughout the plant world, and it is worth noting that tall fescue grass (*Festuca arundinacea* Schreb.) exerts a similar deleterious effect on walnuts (Rietveld 1981).

Toxic juglone is oxidized from hydrojuglone, a nontoxic substance found in all parts of the walnut plant. Oxidation of hydrojuglone occurs in the presence of air and during contact between walnut roots and the roots of other plants that contain oxidizing compounds. Hydrojuglone is highly reactive, however, and in the continued presence of air quickly breaks down into harmless substances. Root-to-root contact is therefore the only means by which damage can occur unless plants are in soil that is poorly drained, and therefore poorly aerated.

Tomatoes, apples, most ericaceous plants,

Black walnuts (*Juglans nigra*) ripening on the tree. Al Bussewitz photo.

and many conifers are known to be adversely affected (MacDaniels 1976 and 1980). The effects of walnut toxicity are noticeable either as flagging, wilted leaves (in tomatoes) or more commonly as a long-term gradual stunting of the plant. On the other hand, many plants are not affected at all, including numerous grasses and vegetable crops, many legumes, some *Rosa* and *Vitis* species, and most native hardwoods. This immunity may result from either a root zone that does not coincide with that of the deep-rooting walnut or an actual tolerance to the toxic properties of juglone.

According to current information we can be optimistic about the prospects of successfully growing a wide range of plants in association with walnuts. A general precaution is advised: locate susceptible plants with a long life span outside the eventual root zone of walnuts. This is urged especially in wet soils, where the toxic effect is more likely. However, during the initial period of growth walnuts can be grown near even susceptible plants (as root spread is narrow and contact therefore avoided). For example, at an orchard spacing of 6 meters on-center black walnut can be interplanted with vegetable crops, small fruit, and/or Christmas trees for at least 10 years.

Persian Walnut

The common commercial walnut is the Persian walnut, *Juglans regia.* This was the only walnut known to the Ancient Romans. *Juglans regia* came to Rome from Persia via Greece, and Roman conquerors spread it throughout southern Europe to England.

On the North American continent *Juglans regia* is often called the English walnut, presumably because it was introduced here by English colonists. However, it is not grown extensively in England. Most horticulturalists call it the Persian walnut in deference to its origin.

The Persian walnut is native to the area between the Carpathian Mountains in eastern Europe and the Himalayan Mountains in northern India, a swath across the Balkan Peninsula, Turkey, Iran, Afghanistan, and the adjoining areas of the USSR. A geographically disjunct population occurs in northern China (*Icongraphia Cormophytorum Sinicorum* 1972 and Meyer 1911). Wild plants are normally found in mixed broadleaf forests, along stream banks, in valleys, and on mountain slopes (Komarov 1936). In sheltered valleys, where it thrives, *Juglans regia* may grow 20–35 m high with a straight, upright trunk and a large, spreading crown. Normally the wood is purplish brown, hard, and satin-smooth and shiny when polished. The nuts of wild trees generally have thin shells and large kernels. Various subspecies have been proposed based on nut shape, growth habit, and geographic origin (Komarov 1936 and Rehder 1940).

Persian walnuts have always been valued trees within their native and naturalized range. The timber is used in Europe for fine woodwork and veneer. Trees that are successful in the northeastern United States have come from colder regions of the species' range, Romania, Hungary, Czechoslovakia, Poland, USSR, and Germany, where they have traditionally been popular yard trees. Outstanding selections are currently being propagated and tested for commercial orchards in these countries (Shreve 1981).

Most selections of Persian walnuts cold

Carpathian walnuts, (*Juglans regia*) above, originated in the Carpathian Mountains of southern Poland.

hardy enough for North America derive from seed collected in the Carpathian Mountains of southern Poland. Reverend Paul Crath, a native of the Ukraine, worked as a Presbyterian missionary in that region between 1924 and 1936, after having been ordained a minister in Canada. Reverend Crath was keenly interested in the *Juglans regia* trees he found commonly growing in Poland, where minimum winter temperatures could reach −40°F. He believed that some of these trees would succeed in cold areas of North America. Through arrangements with members of the Northern Nut Growers' Association and the Wisconsin Horticultural Society, he sent back several tons of seed (Devitt 1953). The resulting trees, often called Carpathian walnut trees and known for their cold hardiness, became widely established from British Columbia to Nova Scotia and are still being selected for their hardiness, nut qualities, and yields.

Reverend Crath's introductions were not the first cold-hardy Persian walnuts brought to North America, however. Since the late 1700s German immigrants had been bringing hardy *Juglans regia* seed from their homeland to Pennsylvania and farther west. The descendants of these seedlings are on the average less tolerant of cold than the Carpathian walnuts, but several are among the most hardy and productive cultivars. Other promising introductions have been made from the Russian Ukraine, the Himalayan Mountains, and northern China. A great deal of potential still exists for collecting genetically superior seed from the cold-temperate areas where the Persian walnut has been grown since antiquity.

In a 1936 letter Reverend Crath described the trees of the Carpathian region:

> We examined 79 walnut trees in and around Cosseev. The age of the trees varied from 15–100 years. Trees 30 years old and over were from 60 to 75 feet tall, and from 1 to 3 feet in diameter. Of the 79 trees, only 3 trees were damaged by the frost of 1929 (45 degrees below zero) (Rahmlov 1962).

Experience on this continent has shown that with good site conditions a cold-hardy Persian walnut tree will rapidly grow to the size and shape of a very large apple tree. The canopy is globe shaped and dense, the bark pale gray, and the roots deep. When fully dormant, some Persian walnuts may tolerate temperatures between 30°F and 40°F without damage (O'Rourke 1969).

However, injury can occur at much higher temperatures (−13°F) if mild weather precedes a drop in temperature. Persian walnuts will grow on a variety of soils, but poor drainage invariably renders them more susceptible to winter injury. High vigor and good nut production require a fertile, nearly neutral soil and room for extensive root development.

Persian walnuts are monoecious. The staminate catkins expand from lateral buds of the previous season's growth. The clusters of 1–3 (occasionally 4–5) pistillate flowers are borne at the tips of the current season's shoots. Pistillate flowers, and the nuts that subsequently develop from them, normally appear only on growth originating from the terminal buds. On some cultivars the lateral shoots also bear flowers, which increases their yield. It is unclear as to whether all Persian walnut trees are self-fertile or not (personal communication from L. H. Wilmoth, July 21, 1982). Regardless, the overlap in staminate and pistillate flowering times would rarely be enough to ensure a good crop. Several cultivars are notable for their self-fruitfulness, but even these seem to benefit significantly from cross-pollination with another cultivar.

In the North the most common cause of crop damage among Persian walnuts is their tendency to produce leaves and flowers before the possibility of late frosts has passed. In Ontario, Persian walnuts are most successful within 20 km of the Great Lakes, where the cool spring climate delays vegetative growth. The gradual onset of winter there also ensures a more complete dormancy and less damage from cold. Under optimal growing conditions Persian walnut seedlings bear fruit within 4–8 years and grafted cultivars within 2–5 years. A few seedlings from a Russian source have been reported to flower in their second year (McDaniel 1978). Pistillate flowers are generally produced several years before staminate flowers. In their eighth growing season, productive cultivars may bear 0.03–0.06 m^3 of nuts. Large trees may yield 0.2 m^3 (Grimo 1979). Reverend Crath reported harvests of 45–115 kg from mature, native Carpathian trees. Persian walnuts bear crops annually, though weather conditions have a considerable effect on yields. Individual trees are known to continue bearing for more than 100 years.

Juglans regia is unique among walnuts in that its nuts fall free from the husks at ripening time. This feature, combined with easily cracked shells, places Persian walnuts among the more desirable of nuts. The kernels can usually be extracted in large or whole pieces from the relatively thin-shelled nuts by hand. The kernels are high in protein (20 percent) and fat (60 percent) and account for 40–60 percent of the total nut weight.

On the west coast of this country, Persian walnut trees are valued for their appearance and are grown in yards, parks, and along streets. In the cold areas of eastern Europe and northern China, they have long been valued for their nuts and timber also. Now, however, selections hardy in the northeastern United States offer nuts and timber of a quality similar to that of the European and Chinese types.

Growing Persian Walnuts

Many Persian walnut growers in the North are cultivating the seedlings of superior trees in the hope of finding improved types. Plants grow readily from seeds sown in the fall, or after a relatively short (6–8 weeks) artificial cold-moist treatment. They will also germinate satisfactorily after dry storage if they are first soaked for several days in clean water that is changed daily. Spring planting is best, about 4 cm deep with a light mulch. Cans or wire mesh placed over the seeds will protect them from rodents, crows, and pheasants.

Planting sites for Persian walnuts must be chosen carefully. Adequate soil drainage is important, as moist soil delays the onset of winter dormancy, causing freeze damage (splitting) to the trunk. The soil must allow deep roots to penetrate 1.5 m, have an approximately neutral pH (pH 7) and be fertile enough to grow a good cover crop. Adding dolomitic lime or fertilizer, or planting a legume in the preceding year is recommended to improve the soil.

A single Persian walnut tree will eventually occupy a space 15 m in diameter but can be planted at half that spacing to hasten orchard production. Seedlings may be grown to bearing age for evaluation on only 3-meter spacings. Seedlings of good parentage are likely to yield one tree in ten "exceptional enough to be made permanent" (Society of Ontario Nut Growers). The hole to which the seedling is transplanted must be larger than the spread of the root system. A kilogram of bonemeal mixed into the planting soil (preferably one year in advance) is a requirement for healthy growth. Any injured roots must be trimmed off before planting, and the remaining roots carefully spread when the soil is sifted over them. It is best to place the root collar at, or slightly below, ground level. When the seedling is in place, the soil must be tamped down and watered thoroughly. A trunk guard, or a piece of woven wire coated with white latex paint, will protect against sunscald and rodents. The young tree will not be able to compete with weeds and will respond favorably to mulch as it grows.

Persian walnuts must not be fertilized in the first year, and only in the early spring thereafter. These trees use large amounts of nitrogen and phosphorus: one recommendation is 0.2 kg of 20–10–10 granular fertilizer per 3 cm of trunk diameter until the trunk diameter reaches 15 cm. After that the application rate is doubled, up to a maximum of 11–13 kg per tree with a 5–10–15 formulation. This tends to reduce vegetative growth and increase nut production.

Pruning requirements are minimal. Many Persian walnuts independently exhibit the ideal conical or dome shape, requiring only the removal of branches that are dead, rubbing, or malformed. A high, clear trunk can be maintained for lumber production.

Persian walnuts grown in the Northeast are potentially susceptible to several pests and diseases (Payne and Johnson 1979), including the husk fly, the coddling moth, the butternut curculio (insect larva), an anthracnose fungus, a bacterial blight, and a bunch disease (which causes numerous shoots to emerge in close proximity). Choosing disease-resistant plants, removing leaves from beneath the trees after leaf fall, and timing sprays carefully will provide successful control. Trees exhibiting a bunching pattern in the branches should be removed entirely, as should trees that sucker excessively from the lower trunk. The latter is an indication of either bunch disease, walnut blight, a genetic lack of hardiness, or wet soil.

During the ripening period, squirrels poach nuts before they have fallen, but a smooth trunk collar (0.5 m high) will keep them out of the treetops as long as no access is provided by an adjoining tree or building. Even so, the nuts must be harvested frequently if squirrel populations are dense in the immediate area.

Treatment after the harvest involves drying the walnuts in an airy location for about five days. During this period the kernel loses its milky texture, becoming crisp and sweet. Like most foods, walnuts sold commercially do not compare in taste to those grown at home. Storing walnuts is best accomplished either in-shell, using rodent-proof aerated containers in an unheated room, or by freezing the kernels alone. Nuts with well-sealed shells usually retain their kernel quality until the next harvest season. Frozen kernels will store for years with very little change in quality.

Persian walnuts have much to recommend them. They are attractive landscape trees, having pale bark and a dense, round crown. Several cultivars are hardy at average minimum temperatures as low as −30°F if soil and air drainage are adequate.

Black Walnut

The black walnut is a native American tree that grows wild throughout eastern North America except most of New York and New England. It is among the most valued cabinet-wood and veneer trees on this continent. A commercial cracking industry in the Midwest is supported by wild collected nuts. The nuts are valued for their flavorful kernels and their shells, which are used in the manufacture of a multitude of useful products.

Soil conditions are a major influence on the growth of black walnuts. These trees do best on soils that have a neutral pH, are fertile, and have adequate water. They grow slowly on wet lands, shallow topsoils, and those that are acidic and infertile. Sapling black walnuts are intolerant of shade and are generally suited to sites where white ash (*Flaxinus americana*) grows well (Fowells 1965).

While truly wild black walnuts are uncommon east of the lower Hudson River Valley, they have often been planted as yard trees and sometimes have become naturalized.

The black walnut tree is large and straight-trunked, with an open spreading crown. The pale green pinnately compound leaves cast a dappled shade. An identifying characteristic during the dormant season is the stout, upright branchlets. These resem-

Black walnuts (*Juglans nigra*)

ble the branches of white ash, but the walnut branch arrangement is alternate instead of opposite. Black walnuts normally have deep tap roots, which when established permit them to coexist with groundcovers and allow them to tolerate some degree of drought. These trees are also tolerant of fire and smog (Duke). Their growth rate is highly dependent on site and soil conditions and genetics; 1 m per year in height is possible.

The ornamental value of the black walnut tree lies in its stately form and the dappled shade it affords. The leaves fall relatively early without spectacular coloration. The decaying husks leave an amber stain on hands, clothing, and concrete. Black walnut trees with an unbranched trunk at least 3 m high will produce both timber and nut crops. Nuts can be harvested until the lower section reaches prime veneer log size (55 cm). Trunk diameters of orchard-grown trees can be twice that of similarly aged trees grown in timber plantations, presumably because the superior care and the wider spacing of the trees in orchards are more favorable for girth increase. Careful pruning is required in the early years to produce a straight log free of large knots.

The black walnut, the preferred commercial walnut, has a distinctive flavor, which is not diminished by cooking. The kernels contain approximately 20 percent protein, 15 percent carbohydrate, and 60 percent fat, as well as small amounts of mineral nutrients and vitamins A and B.

Unfortunately, obtaining this nutritious nut meat can be a frustrating experience. In fact, removing the nut from its messy, staining husk and then extracting the kernel from its hard shell is hardly worth the effort with most unselected black walnuts. This is not the case with several cultivars selected for their ease of cracking.

Cracking qualities depend on shell thickness and the internal shell structure. The kernel cavities of most unselected black walnuts have many partitions and deep invaginations, whereas those of named cultivars usually have fewer, and kernels can be extracted in large pieces. Also, the nuts of cultivars are usually 25 percent kernel, 5 percent more than the average for unselected seedlings.

Grafted cultivars may begin bearing nuts within two or three years, though substantial production must wait until trees are past 10 years of age. Crop yield is more closely correlated with crown size and trunk diameter than age. A vigorous tree is the best insurance of a plentiful nut crop. The biggest challenge in managing walnut trees for nut production is to maintain regular annual yields. Even the annual variation in yield is irregular. Providing adequate sunlight, nutrition, and water and controlling pests minimizes yield variations but does not necessarily eliminate them.

Black walnut cultivars have been selected primarily for ease of cracking and productivity. Very little information is available on their performance in New England, however. Although over 500 cultivar selections have been identified by the Northern Nut Growers' Association, most have not been widely propagated or tested. The performance reports that do exist vary considerably, depending on climatic, cultural, and site factors. Observations in New York, Michigan, and Ontario offer the best indication of desirable cultivars for New England. The most important characteristic for this region is a capacity to ripen nuts in growing seasons of less than 180 days. Those that have generally received high ratings when grown in northern latitudes are listed on page 16.

Growing Black Walnuts

Black walnut seeds and seedlings are widely available from commercial and state nurseries. In fact, enough are sold each year to establish about 2880 hectares of plantations (Funk 1979). Seedling trees rarely equal cultivars in nut quality or productivity. A homeowner desirous of a single tree is better off purchasing a grafted cultivar. For larger plantings, seedlings are more cost-effective, and some may turn out to have improved characteristics for the Northeast. Seeds or seedlings should be obtained from parent trees with desirable traits: climatic adaptation, superior productivity and nut quality, and perhaps timber form. A large, well-filled nut produces a larger seedling. Cold stratification for 120 days results in the most prompt germination. Fall planting usually satisfies this cold requirement. Seeds sown in fall tend to germinate more quickly and in greater numbers than those sown in spring. The hulls need not be removed before planting the nuts. About 50 percent of unhulled seed will germinate. A higher germination rate can be achieved by hulling the nuts, placing them in a container of water, and discarding those that float. A well-filled nut will sink if the float test is given before appreciable drying has occurred (within 3 days of hulling).

Black walnuts are planted in the same way as Persian walnuts. The results of a study of various methods used to protect the nuts from squirrels favored placing fresh cow manure over sown seeds as an "effective, biodegradeable repellent" (Williams and Funk 1978). Due to the fact that they germinate in relatively low numbers, black walnuts should be seeded at approximately twice the desired density. Planting nuts 10 cm apart produces tall, straight seedlings that are easy to graft or transplant. It is advisable to plant several seeds wherever a tree is desired. Later (anytime within three growing seasons), all of the surviving seedlings must be removed except the one showing the best vigor and form.

In general, direct seeding is better than transplanting. Black walnuts develop a deep taproot quickly, which is often damaged in transplanting and is a setback for the entire tree. After three to four years, trees in a plantation tend to be about the same size regardless of whether they were grown from seed or transplanted (Funk 1979).

A wide hole with room for the roots to spread is best. Many labor-saving planting methods have been devised for transplanting large amounts of black walnuts, but the primary consideration is to ensure that the roots are spiraling. The survival and growth of transplanted seedlings is directly related to their size. Only year-old seedlings with a stem diameter greater than 5 mm should be planted.

It is important to provide favorable conditions for young black walnut trees. Trees that are vigorous when young are usually vigorous when older also. The most critical factors affecting growth rate are soil moisture, weed competition, wind exposure, and, to a lesser extent, nitrogen supply. Weeds should be controlled with mulch for at least two years (preferably three or four) after planting.

Favorable soil conditions are crucial for healthy growth and nut production. The soil must be well drained. It should allow roots to penetrate at least 1.5 m. A near neutral pH should be maintained with dolomite applications. Trees bearing nuts have high nitrogen and phosphorus requirements. About 0.5 kg of 10–10–10 fertilizer per centimeter of trunk diameter is recommended for adequate nutrition.

Another way of improving the soil's fertility is to interplant black walnuts with nitrogen-fixing plants. Russian olive (*Elaeagnus umbellata*), black locust (*Robinia pseudoacacia*), European alder (*Alnus glutinosa*), and hairy vetch (*Vicia villosa*) have all proved to enhance black walnut's growth rate, especially on less than ideal sites (Funk 1979 and Ponder 1981). These fast-growing nitrogen-fixing species shelter the young walnuts from wind and reduce weed competition somewhat. Additionally, the walnut growth is forced upward, which reduces pruning requirements.

The general pruning recommendation for black walnuts is to maintain a single dominant leader and evenly spaced lateral branches. The bottom section of trunk can be developed as a valuable veneer log by pruning the branches when they reach 3 cm in diameter. Pruning can be done up to half of the tree's total height without adversely affecting the growth rate. This method keeps the knots small and confined to the central core of the veneer log. Bey (1979) provides further information on pruning for timber production. Planting black walnuts in frost pockets increases the need for pruning, because the terminal buds are more likely to suffer freeze damage, resulting in many competing lateral shoots.

To my knowledge black walnuts growing in eastern Massachusetts have not been seriously afflicted with diseases or insects. Husk-fly maggots frequently infest the husk in early fall, turning it into a mass of black slime, but a study has shown no correlation between husk maggots and nutmeat quality (Gibson and Kearby 1976). However, some pests can affect nut production (Payne and Johnson 1979). Walnut curculios can damage tender growth and cause some nut loss. Removing infected nuts that drop prematurely is the best control. Anthracnose fungus infections of foliage and fruit cause nuts to fill poorly. Wet weather conditions mean more severe infections. Anthracnose-resistant cultivars will retain healthy foliage longer and produce better crops. Fungicide sprays during spring provide successful control. Apparently, black walnuts can be infected with walnut bunch disease without showing the normal brooming symptoms. Instead, it appears as empty or dark and shriveled nuts. There are no reliable controls for this disease. Infected trees should be destroyed.

The entire husk and enclosed nut fall during or shortly after leaf fall. The nuts that fall early are less likely to be well filled. Freshly fallen nuts are the best ones to collect. At this stage the hulls separate easily and the kernels have not had time to become stained and lose flavor. Rubber gloves (not vinyl) will protect hands from the corrosive, staining juices. The hull of a freshly harvested, well-filled black walnut will shuck off with one tap of a rubber mallet. The hulled nuts can then be washed, and dried either on newspaper or in a wire basket for about one week. The dry nuts are best if stored in a cool, airy location, and rodent-proof containers are advisable.

Cracking by hand is usually done with a hammer or screw vise. Pouring hot water over the nuts and allowing them to steep 24 hours helps to soften the shells, which prevents then from shattering when cracked. The wire cutters used by electricians can be employed to extract the kernels. Kernels frozen in plastic bags keep well.

The Butternut

The butternut, another native American tree, has a more northerly geographic distribution than its cousin the black walnut. The butternut range occupies much of New England and the St. Lawrence River Valley of Quebec, west to southern Minnesota, and south to Missouri and southern Appalachia. But rarely is it more than an occasional component of forest stands. Butternut occurs primarily on stream banks or valley slopes where the soil is moist but well drained. However, it is known to grow better than black walnut on dry, rocky soils, especially those of limestone origin (Fowells 1965).

The butternut tree is short, averaging 13 m high. Thick branches generally begin low on the trunk and rise into a broad, open crown. Butternut bark is light brown or gray and becomes deeply ridged with old age. The compound leaves resemble those of black walnut but are quite hairy and sticky in comparison. The same rust-colored, sticky pubescence also covers leaf petioles and young branchlets in their first year's growth and is especially noticeable on the nut husks. Another identifying characteristic is the leaf scar. In black walnut it is notched

Butternuts (*Juglans cinerea*)

without a downy fringe, whereas in butternut the leaf scar is not notched but does have a downy fringe.

Butternuts are among the most hardy *Juglans* species, surviving −40°F within their natural geographic range. In spring bright green staminate catkins droop from the basal portion of the previous season's growth. The 5–8 pistillate flowers are borne on spikes at the end of new growth. The single or clustered 5–7 cm egg-shaped nuts ripen in early fall. A thin adhering husk encloses the deeply ridged, thick shell. The kernels, which are sweet and oily, are generally regarded as the best among walnuts for flavor but are normally impossible to extract in large pieces. A few cultivars exist, selected primarily for their ease of kernel extraction and nut size. Cold storage is advisable, but nuts in shell reportedly keep a year or more under cool, ventilated conditions (personal communication from Stephen Breyer, July 15, 1982).

Nut production begins within six or seven years from seed (McDaniel 1979), but butternuts never seem to yield as well as black walnuts. Six bushels of nuts in hull is an exceptionally high yield from a mature tree, and large annual variations in yield are to be expected. Butternuts may produce nuts for more than 70 years.

Native Americans extracted oil from crushed butternuts by boiling them in water. In New England the flavorful kernels are still combined with maple sugar in candy. Like that of the sugar maple tree, the sap of butternut also makes a good syrup, but more boiling is required to thicken it. The husks and inner bark yield a true dye. During the Civil War, the backwoods Confederate troops were sometimes dressed in homespun 'uniforms' of butternut-dyed cloth, and they became known as butternuts (Peattie 1966).

Butternut wood accepts a high polish and is easily worked. It was once a favorite for carriage interiors, because of its combination of beauty and lightness, and is still valued. In Wisconsin, one of the major states supplying butternut lumber, it is second only to black walnut for its economic value. The wood is also rot resistant.

Relative to other nut trees, butternuts are quite short-lived, beginning to decline in 75 years. This inherent trait is compounded by susceptibility to two fungal diseases: the butternut dieback (*Melanconis juglandis*) and the butternut canker (*Sirococcus clavigignenti juglandacearuem*). These factors, along with pollution and elimination of habitat, threaten the butternut throughout much of its range.

In the colder regions of northeastern North America, growing butternuts may be the only way to harvest high-quality nuts. Cultivars are available with nuts that can be cracked easily and flavorful kernels that can be removed in large pieces. These trees are fast growing with broad canopies offering dappled shade.

The Asian Walnuts

Three walnut species are native to east Asia: the Japanese walnut (*J. ailanthifolia* Carr), the Manchurian walnut (*J. mandshurica* Maxim.), and the Chinese walnut (*J. cathayensis* Dode). These are closely related to the American butternut and are often included in the same subsection of *Juglans*. However, the modern authority on the walnut family, W. E. Manning (1978) places the Asian walnuts in a separate subsection on the basis of their differences in embryo development. In the field Asian walnuts can supposedly be distinguished from the butternut by their notched leaf scars, but the difference is not readily discernible. Asian walnuts bear nuts in hanging racemes that are usually much longer than butternut clusters. The Asian walnuts cross readily with other *Juglans* species, and fertile hybrids may result, especially in crosses involving the butternut.

Confusion exists about the correct scientific name for the Japanese walnut and its smooth-shelled variety called the heartnut (Rehder 1945). The name formerly accepted for the Japanese walnut, *J. sieboldiana* (Maxim.), can no longer be used because it has already been given to a fossil plant. The current consensus, with which Manning concurs, is to name the Japanese walnut *J. ailanthifolia* Carr and the heartnut *J. ailanthifolia* var. *cordiformis* (Maxim.) Rehd.

The Japanese walnut is a common forest tree of mountain regions in Japan (Sargent 1894), whereas the heartnut is a cultivated variety (Ohwi 1965). The two are identical in habit and foliage, differing only in nut characteristics. The Japanese walnut is rough and pitted like a butternut. The heartnut is smooth, heart-shaped, and valued for its ease of cracking and kernel extraction. Seedlings of both Japanese walnut and heartnut may produce either type of nut.

The Manchurian walnut is native to northern China, Korea, and the Amur River region of Siberia. It may grow to 20 m tall, either in mixed forests (in valleys and floodplains) or isolated on the gravelly soils beside mountain streams. Its growth habit and racemes of 6–17 nuts are similar to those of the other Asian walnuts. The nuts vary in shell structure, are round to elongate, 2.7–5.5 cm in length, and (like butternuts) have a sharply ridged to relatively smooth shell. The Manchurian walnut is extremely hardy, on a par with the butternut. It is cultivated in cold areas of the USSR, Europe, and the Canadian plains. No nut-producing selections have been made in this country. The Lithuanian magazine *Musu Sodai* in 1976 reported a selection hardy to −40°F that blooms first on old wood and again in 2–3 weeks on new growth (personal communication from Victor Vircau on July 19, 1982).

The Chinese walnut is a close relative and perhaps only a geographic race of the Manchurian walnut. It grows in the highlands of central China and is considered less hardy. Mature plants at the Arnold Arboretum survive temperatures as low as −10°F without noticeable damage.

Because of its ease in cracking, the heartnut (*J. ailanthifolia* var. *cordiformis* has received the most attention among the Asian walnuts. In its native Japan it is cultivated in orchards and marketed. Heartnut trees grow rapidly (to 6 m in eight years) and bear nuts at five years of age. They reportedly adapt to a wide range of soils, from sand to clay, and some will grow in zone 4 (avg. min. temp. −30°F) (Metcalf 1980). However, heartnuts seem to be adapted to a maritime climate similar to Japan's, because they suffer damage from early fall freezes and late spring frosts.

With the exception of certain cultivars, heartnuts are said to bear nuts freely but rarely heavily. Gellatly (1966) reported a

Heartnut (*Juglans ailanthifolia* var. *cordiformis*)

90 kg harvest from the cultivar called 'OK'. Five to 15 nuts occur in pendant racemes. A recently ripened soft husk may be twisted off by hand, leaving only a few fibers attached to the shell. Even if the nuts are not husked immediately, the kernels are less apt to be stained than are those of black walnuts.

Heartnuts usually have well-sealed shells and good keeping qualities. They can generally be split into two heart-shaped halves either by tapping the shells while holding the nuts on edge or by using a channel-lock tool. A certain degree of drying can enhance the cracking process. The kernels have a mild flavor similar to that of the butternut but not quite as highly regarded. The kernels are about 50 percent oil and 25–35 percent of the total nut weight.

The heartnut and butternut apparently cross-pollinate readily, resulting in a fertile and remarkably vigorous hybrid known as the buartnut (*J. cinerea* × *J. ailanthifolia* var. *cordiformis*). Several selections combine the hardiness and flavor of butternuts with the ease of cracking and potentially greater yields of heartnuts. Two different cultivars are needed for pollination and subsequent nut production.

In the Asian walnuts and their hybrids, we have nut-producing, ornamental shade trees for the North. Several features give them an overall exotic appearance: long hanging catkins; large, compound, seemingly tropical foliage; and pendant strings of nuts. The stout branches and broad top provide a dappled shade. Asian walnuts thrive on a variety of soils. Most are hardy thoughout zone 5 and some in zone 4. The primary disease threat to these walnuts is the bunch disease.

Walnut Cultivars

A considerable number of commercial nurseries supply walnut cultivars. Many of them are quite small, however, and managed on a part-time basis. As their stock may be small or sold out, it is best to place orders one-half year or more before spring planting. Nurseries usually sell scionwood for do-it-yourself propagation, and some offer custom propagation services.

Walnuts are considered difficult to propagate vegetatively. The most common means is by grafting. Among the most successful methods are: a modified side-graft, 75–80 percent (Funk 79); a root cleft-graft, 75 percent (Groenwald 1981); and greenwood budding, 90 percent (Davie and Davie 1977). I have used the sprouted-seed grafting method described for chestnuts (Jaynes 1980) with fair results. A warm post-graft environment will enhance the success of all grafting methods. Heartnuts and Persian walnuts can be layered (Gellatly 1966 and personal communication from Stephen Breyer, July 5, 1982), and both rooted cuttings (Shreve 1975) and root cuttings of black walnut have proved successful (Jaciw and Larsson 1980). Purchasing walnut cultivars is the best route for most people.

Persian Walnut

The following descriptions are drawn primarily from those of Ashworth (1969), Brooks and Olmo (1972), and Grimo (1979). With the exception of 'Hansen', which is highly acclaimed, little agreement exists as to how they should be ranked.

'Broadview' originated in British Columbia from seed brought there by a Russian immigrant from the Black Sea region. Opinions differ about its kernel flavor. The nuts, which are medium to large, ripen in September at about the same time as McIntosh apples. In cracking quality they approximately equal those of 'Franquette', the standard commercial walnut cultivar in California. The nuts are 46 percent kernel and keep well in storage. 'Broadview' is considered one of the most productive cultivars. The original tree withstood temperatures as low as −30°F, but subsequent reports indicate marginal hardiness in zone 5.

'Hansen' is probably the most favored, cold-hardy Persian walnut cultivar. It was introduced in 1952 from northwestern Ohio. The original tree may be over 100 years old and presumably is of German origin. 'Hansen' has the ability to fruit on lateral as well as terminal shoots, resulting in early (2 years after grafting) and numerous nuts. The trees remain small and are resistant to disease and husk maggots. The nuts mature early and are relatively small but at 60 percent have one of the highest percentages of kernel. The round shells are thin and smooth. The kernal flavor is mild and sweet. 'Hansen' is another self-fertile cultivar.

'Holton' is a promising cross between 'Hansen' and 'Broadview'. Preliminary observations indicate that it combines the best qualities of both parents. Like 'Hansen' it is a hardy and a precocious bearer of nicely shaped and flavored nuts, which resist damage from husk maggots. The 'Broadview' parentage is evident in the vigor of the tree and its relatively large nuts.

'McKinster' is a Crath seedling originating form the Columbus, Ohio, area. The nuts are large (48 percent kernel) and have a good flavor. This fairly productive cultivar, which self-pollinates, is well adapted to Ohio and favored in the lower peninsula of Michigan.

'Somers' is a Crath seedling from the same source as 'Greenhaven'. 'Somers' consistently bears attractive high-quality nuts. The kernel usually constitutes more than 55 percent of the nut, and its oil content is more than 64 percent. The early ripening of 'Somers' (early to mid-September) often precedes husk-maggot damage.

Black Walnut

Over 500 black walnut cultivars have been selected and named. The following are among those that have received high ratings when grown in northern locations. The descriptions are compiled from reports by Brooks and Olmo (1972), Funk (1979), MacDaniels (1974 and 1941), and Zanger (1969).

'Sparrow', from Illinois, has a very thin hull, which is easy to remove. It cracks well and has a high kernel content (29 percent) and very good flavor. Its anthracnose-resistant foliage is retained late into the fall. The nuts ripen fairly early and vary in size according to site conditions.

'Emma K', from Illinois, has a thin shell, a high kernel content, and excellent flavor. It bears nuts regularly in southern Ontario but may not fill all of them. It appears to be resistant to both anthracnose and aphids.

Other cultivars that have received high rating for northern areas are 'Burns', 'Snyder', and 'Thomas'. Less-tested black walnuts with potential value for New England include: 'Beck', 'Sparks #127', 'Sparks #147', and 'Davidson'. The latter three have been selected in Iowa for their ability to flower on lateral as well as terminal shoots. (This characteristic leads to earlier and heavier yields.)

Butternut

Butternuts tend to be difficult to propagate and are not in high demand, so nurseries may not have stock on hand. A few of the better-known and available cultivars are: 'Ayers', 'Booth', 'Chamberlin', 'Craxezy', 'Creighton', 'Joy', 'Kinnyglen', 'Kenworthy', 'Love', 'Van Sickle', and 'Weschcke'. All of these are reported to be cold hardy in the North.

Heartnut

Most heartnut cultivars were selected primarily before attention was diverted to the introduction of Carpathian walnuts. The following cultivars are most likely to be available. The descriptions follow Campbell (1981), Gellatly (1966), and McDaniel (1979). 'Brock' is a relatively recent and promising cultivar from Pennsylvania. 'Etter', also from Pennsylvania, has excellent cracking qualities and is 33 percent kernel. It may be resistant to bunch disease. 'Etter' seedlings are often equal to or superior to their parent. 'Fodermaier' nuts are 37 percent kernel but rarely crack in whole pieces. Even so, it is a highly regarded heartnut. 'Fodermaier' seedlings generally produce good quality nuts.

'Marvel' and 'Rival' are both progeny of 'Fodermaier'. Other heartnuts of value include 'Canoka', 'OK', 'Rhodes', 'Schubert', and 'Wright'.

Buartnut

I was not able to discover any nurseries that offer grafted buartnut trees. The following cultivars may be available as scions or by custom propagation: 'Corsan', 'Dunoka', 'Fioka', 'Hancock', 'Leslie', 'Mitchell', and 'Wallich'.

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Propagating Leatherwood: A Lesson in Humility

Peter Del Tredici

It is often assumed that because I work in the greenhouses of the Arnold Arboretum, I should be able to solve any plant-propagation problem that comes along. With all that heat and light, the reasoning goes, you should be able to make dead sticks sprout. Unfortunately, technology is not always the most effective solution to the difficulties that arise with plants. This fact was brought home to me rather dramatically recently in attempting to determine the seed-germination requirements of *Dirca palustris,* the Atlantic leatherwood.

This beautiful little shrub is native to the east coast of North America, from New Brunswick to Florida and east to the Mississippi. In the wild, *Dirca* tends to form dense thickets in the forest understory, growing best in moist areas that have a high limestone content. Henry David Thoreau tracked the plant down in its native haunts in Brattleboro, Vermont, on September 8, 1856:

> . . . for the first time I see growing indigenously the *Dirca palustris,* leather-wood, the largest on the low interval by the brook. I notice a bush there seven feet high. In this form it is somewhat like a quince bush, though less spreading, its leaves are broad, like entire sassafras leaves; now beginning to turn yellow. It has remarkably strong thick bark and soft white wood which bends like lead (Gray says it is brittle!), the different layers separating at the end. I cut a good-sized switch, which was singularly tough and flexible, just like a cowhide, and would answer the purpose of one admirably. The color of the bark is a very pale brown. I was much interested in this shrub, since it was the Indian's rope. Frost said that the farmers of Vermont used it to tie up their fences with.

The great tensile strength of the bark of leatherwood has been noted by nearly all botanical writers — before and after Thoreau — who have discussed the plant. None, however, have presented quite so memorable a description as the late Edgar Anderson, former dendrologist of the Arnold Arboretum and long-time botanist at the Missouri Botanical Garden:

> Delicate though the flowers may be, the species is well deserving of its popular name as anyone will find who attempts to gather the flowering twigs without a sharp knife. The branches are surprisingly limber and the bark is tough and strong. One can actually tie the twigs in bow knots. If one attempts to snap off a branch quickly, the wood itself may break and separate from the bark. It may even come away altogether, leaving the startled flower-gatherer with a perfectly bare twig in his hand and on the bush, dangling like an empty glove, the bark with its flowers and leaves still intact.

Horticulturally, *Dirca* is noteworthy for reasons other than its bark, not the least of which is that it produces bright yellow flowers in early April, when most other plants are still dormant. Another point of interest is its tendency to develop a single stem. This habit, which is unusual for a shrub, gives the plant the appearance of a miniature tree and makes it extremely useful in rock gardens and perennial beds. Despite leatherwood's preference for moist, shady sites in the wild, it will tolerate full sun under cultivation. Interestingly, when grown in the open the plant assumes a more compact habit of growth, and the foliage, which is light green in the shade, takes on a distinct yellowish cast.

Because propagation data on leatherwood were either nonexistent (Schopmeyer 1974) or imprecise (Esson 1949), I undertook a seed germination project in 1979. At that time there were two *Dirca* plants at the Arboretum, both collected in New Hampshire in 1961. In early June the mature fruits were falling off. They were green at that point, with a slight tinge of yellow. The fruit is a berry with a fleshy outer seed coat and a hard, black inner coat surrounding a single large embryo.

I followed my usual practice when processing seeds preparatory to sowing them: I put them in a plastic bag and set them on a headhouse bench until the fleshy part of the fruit softened enough so that it could be easily washed off. This "fermentation" clean-

The Atlantic leatherwood (*Dirca palustris*) produces bright yellow flowers in early April.

ing, as it is called, usually takes about one week and works wonders with fleshy fruits like those of *Malus*, *Cornus*, and *Sorbus*. While this technique is not generally recommended in the seed germination literature (Schopmeyer 1974), it has long been used successfully with many types of plants at the Arboretum.

After a week I removed the rotting *Dirca* fruits from the bag and washed them clean with water. I then subjected the seeds to various tests: some I sowed immediately in the greenhouse, some I stratified (this involves packing the seeds in a moist medium and storing them in a refrigerator for three months), and some I treated with the plant hormone, gibberellic acid (GA_3). To my disappointment, none of these treatments produced a single plant.

Trying again in 1980, I collected 1177 seeds and designed an experiment that I thought would cover all possible types of seed-dormancy mechanisms. I put all the fruits in a plastic bag for fermentation cleaning, except for 77 that I pulled out at the last minute to use as a control. These I sowed in a flat, which was then planted outdoors to simulate the conditions the seeds would have been subjected to had they been allowed to fall from the plant.

The remaining 1100 seeds were allowed to rot for several days, after which they were cleaned and then subjected to every possible seed-germination test I could think of: stratification in the refrigerator, as well as in the greenhouse, gibberellic-acid soaks, and scarification with a knife. Finally, I carefully excised over 400 embryos from their seed coats and gave them the same treatments.

To my amazement, of the 1100 seeds so carefully cleaned and treated, not a single seedling was produced, but of the 77 uncleaned ones planted outdoors, 47 seedlings germinated the following spring — a staggering 61 percent. Here I had brought to bear nearly 10 years of experience in botantical research, along with a barrage of hormones and climate-control devices, when success could be achieved only by doing nothing. Humility is what I learned from that experiment.

In 1981 I collected another 600 fruits from *Dirca* to see if perhaps my experience in 1980 had been a fluke. This time I set up a surefire test. I divided the seeds into six lots: some I cleaned by hand, peeling the thin green skin off with my fingernail; some I cleaned by the usual fermentation method in a plastic bag; and some I left uncleaned. I then planted replicate lots outdoors under shade cloth and indoors in a greenhouse heated to a minimum of 45°F in the winter time. The results are shown below.

Treatment	*Location*	*Seedlings Produced*
100 seeds uncleaned	outside	32
100 seeds uncleaned	inside	25
100 seeds hand cleaned	outside	54
100 seeds hand cleaned	inside	9
100 seeds fermentation cleaned	outside	1
100 seeds fermentation cleaned	inside	0

In all cases, the seeds sown outdoors did better than those treated in the same manner but sown indoors, and as a whole, the uncleaned seeds performed almost as well as the hand-cleaned seeds. Fermentation clean-

Flowers of Atlantic leatherwood (*Dirca palustris*)

ing was, of course, a disaster all around. More than anything else, this experiment demonstrates that some plants propagate themselves best when left to their own devices. With *Dirca palustris,* letting nature run its course is not only easy, but also very effective.

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When Is a Pine Not a Pine?

B. June Hutchinson

Although it is commonly called the umbrella pine, the luxuriant *Sciadopitys verticillata* actually is not a pine. In fact, it possesses no immediate plant relatives, and its ancestry is more remote than that of most other conifers. The foliage is still another unusual aspect of this tree: it is comprised of two types of leaves. The dark green needles that grow in distinctive whorls at intervals along its branches are one type, and the small brown scales along the stems are another.

E. H. Wilson (1876–1930) called the umbrella pine "one of the most distinct of all conifers" in appearance. Planted as a landscape specimen in the Northeast, it forms a dense pyramid and retains its lower branches well into maturity, unlike many of the conifers. Wilson wrote that he saw the umbrella pine growing in the forests of Japan (to which it is native) as a tall, narrow-crowned tree up to 30 m in height, but in this country it is slow growing and reaches 8 m at most after 50 years.

This remarkable tree first became known to Europeans when the Swedish botanist Carl Peter Thunberg (1743–1828) published a description of it in his *Flora Japonica* (1784), a work based on his observations during a 15-month stay in Japan from 1775 to 1776. However, Thunberg's mention of the new evergreen was largely overlooked by botanists since he described it as a species of the well-known genus *Taxus.* When German-born physician and botanist Philipp Franz von Siebold (1796–1866) saw the tree, he realized it was unique. The description of *Sciadopitys verticillata* in his *Flora Japonica* (1842) excited plant enthusiasts. Yet it was not until nearly 20 years later that umbrella pines were successfully propagated in England by nurseryman John G. Veitch, who brought seeds from Japan in 1861. The following year the tree was grown for the first time in the United States at the Parsons Nursery in Flushing, New York. Although it is still not widely available in the United States, a few fine nurseries in New England sell the umbrella pine. Unfortunately, the long handling time in the nursery, due to slow growth, decrees a high price for these unusual plants.

Dr. Sidney Waxman, of the University of Connecticut, has introduced several cultivars of the umbrella pine, which have been propagated from cuttings. His article in the *International Plant Propagators' Society Proceedings* (volume 28, p. 546–50) provides instruction on propagating by this method. The Arnold Arboretum has successfully propagated umbrella pines from seed. The seeds required three months to germinate regardless of pretreatment. Arboretum trees produce cones in alternate years.

Umbrella pine (*Sciadopitys verticillata*)

As described by both C. S. Sargent and E. H. Wilson, the native habitat and plant companions of the umbrella pine can guide the use of the tree in the North American landscape. Wilson wrote that it usually occurs as a solitary tree or in small groves, scattered through dense forests of pine, fir, Hinoki cypress, hemlock, maple, magnolia, and katsura. Sargent reported finding it in association with native pines, particularly Japanese white pine (*Pinus parviflora*) and Japanese red pine (*P. densiflora*). In combination with the Japanese maple against an evergreen background, the umbrella pine is an exciting study in leaf contrasts and form for close-up viewing near a window or doorway. Another handsome grouping, which has textual appeal, occurs naturally in Japan: a small grove of umbrella pines in combination with hemlocks, accompanied by lower plantings of rhododendron and underplantings of *Shortia.* Mildly evocative of prehistoric landscapes and matched in boldness of foliage and evolutionary age, *Sciadopitys* and magnolia are effective landscape companions. With a *Magnolia* × *soulangeana* 'Brozzoni', for example, a small grove of three or more *Sciadopitys* is elegant, particularly if sited in front of other tall evergreens. These combinations can be used in several landscape applications, including border, edge, screening, and foundation plantings. The textural richness and symmetry of the umbrella pine are set off to good advantage in both formal gardens and the surroundings of contemporary houses. The form of this Japanese plant would not be suitable among the naturalistic groupings of plants in informal country gardens, however. Umbrella pines are perfectly hardy in the Boston area and hold the dark green color of their thick, shiny needles through the coldest winters. Easy to grow and not susceptible to any serious diseases, they appreciate shelter from strong winds and some soil moisture. Planting sites should not be hot or dry but can be shaded.

Distinctive needles of the umbrella pine (*Sciadopitys verticillata*)

Facts about the umbrella pine (*Sciadopitys verticillata*)

Landscape Height	7.5 to 9 meters
Spread	4 to 5 m
Texture	Medium
Growth Rate	Slow
Hardiness	Zone 5
Family	Pinaceae
Native Range	Japan
Native Habitat	Scattered through dense forests of mixed hard and soft woods.
Introduced	1861

B. June Hutchinson is a consultant to the Arnold arboretum, a writer, and a landscape designer. She is currently working on one of four volumes in the forthcoming guidebook to the Arnold Arboretum (supported in part by a grant from the National Endowment for the Humanities), from which this article was excerpted.

The River Birch

Anne Carlsmith

Landscape designers are always looking for beautiful and adaptable low-maintenance trees. Since the number of these trees currently available is low, however, the result is often another planting of honey locusts or maples. Yet alternatives do exist, and worthy candidates are often overlooked by the nursery trade. One such is the river birch, *Betula nigra* L.

In comparison to the white-trunked members of the birch family (Betulaceae), the river birch has long been ignored, though it is a graceful tree, with a warm red bark that exfoliates to pink-white. It is also adaptable to both flood and drought and is more disease-resistant and heat tolerant than any other birch.

When young the river birch (also known as the red birch) is delicate. If left unpruned, it becomes multitrunked in its first or second year, breaking at ground level into several splayed stems. It is twiggy, with many horizontal subbranches that recurve slightly. The youngest twigs are lustrous red and darken as they grow, eventually becoming marked by narrow lenticels. The bark then separates into thin flakes, which curl into strips and cling to the wood indefinitely. Bark color varies from tree to tree: the outer bark may be bright or subdued and the inner bark may be nearly white.

Young river birch trees (*Betula nigra*) growing at the edge of Jamaica Pond in Boston, Massachusetts. Bruce Applebaum photo.

As the tree matures (40 years), the bark thickens, darkens, and becomes deeply fissured, beginning at the bases of the trunks. The larger branches acquire a rough and broken surface, while the smaller ones continue to exfoliate. The mature river birch has an open habit and fine foliage texture; the leaves (4–8 cm long) are deep green and very lustrous. Monoecius, *Betula nigra* forms three-clustered staminate catkins in the fall, which become conspicuous when they elongate to 8 cm in spring.

The river birch lives up to its name in its willingness to thrive in damp soil or soil that may be inundated for weeks in the spring. This characteristic makes it a special asset to the landscape designer: all authorities agree that it is one of the finest trees for damp ground. In addition, it has the advantage of being drought-tolerant and therefore has potential as a street tree.

Betula nigra owes its adaptability to the floodplain habitats of which it is characteristic. In the wild it grows along the banks of streams, on the edges of ponds, and in swamps, habitats that may be flooded in spring and dry in summer. It attains its largest size (27 m) in the damp bottomlands of the Gulf States and is most prevalent along the larger, slow-moving silt-laden rivers. It grows thickly along the Mississippi and its tributaries, holding the muddy banks against erosion.

The river birch is the only birch growing in the South, and it has the widest distribu-

Leaves of the river birch (*Betula nigra*). Bruce Applebaum photo.

tion of all the North American birches. Its natural range extends from New Hampshire south to Florida and west to Texas and Minnesota. Donald Wyman has noted that it does well even in California (Wyman 1977a). Native stands are sparse in zone 4, however, and trees there are both smaller in stature and less long-lived (Steele and Hodgdon 1975). In New England the average stature at 30 years is 15–18 m, whereas in the South it can be as high as 27 m.

Bronze birch borer, the most destructive of birch pests, has virtually no effect on the river birch, and leaf miner, another birch pest, has very little. Atmospheric pollution apparently is harmless also: Henry Arnold lists the river birch among the trees that have sprung up spontaneously in Central Park and eventually replaced the installed plants (Arnold 1980). A low soil pH appears to be the only definite requirement of the river birch. Chlorosis occurs at pH levels higher than 6.5 (Dirr 1983).

'Heritage', the only river birch cultivar, was selected for both a light bark color and a prolonged period of exfoliation. Neither the species nor the cultivar is readily obtainable. Weston Nurseries in Hopkinton, Massachusetts, supply the species (and will supply the cultivar in spring 1984). Oliver Nurseries in Fairfield, Connecticut, and Mellinger's in North Lima, Ohio, supply the cultivar.

Peeling bark of a young river birch. Peter Del Tredici photo.

Growing the River Birch

Ready germination from seed is another asset of the river birch, but the seeds must be collected early. This is the only *Betula* species that ripens its seeds in spring or early summer. Small and lightweight, they are dispersed by the wind and often carried long distances. Much of the seed falls near the tree, however, so collection is not difficult. Nurserymen report that seedlings grow so quickly from seed that propagation by rooted cuttings is unnecessary. A caliper of 8–10 cm has been noted at 15 years. 'Heritage', reproduced by cuttings, grows equally quickly.

Many nurseries list all the birches as difficult to transplant, except when balled and burlapped and moved in very early spring. (Most reputable nurseries dig them only at that time.) Again the river birch is the exception. Gary Hightshoe describes it as "easily transplanted [in] early spring or late autumn" (Hightshoe 1978). The tree is quick to throw out adventitious roots when flooded and generally shows the rooting vigor of all fast-growing trees.

Birches in general are "bleeders," that is, they are slow to heal if pruned in spring, when sap flow is heaviest. Pruning in fall and early winter is preferable.

Donald Wyman has observed a tendency in the river birch to form weak crotches, but a grove of mature trees in the Arboretum shows no evidence of it (Wyman 1977b). Planted from seed collected in 1877, these trees show the typical habit of the mature river birch in New England.

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COLLECTOR'S NOTEBOOK

Orchids for Everyone

Richard E. Weaver, Jr.

Bletilla striata

Orchids hold a fascination for plant growers that few other plant groups can match. For the gardener their beauty and rarity, and the challenge of cultivating many species, make orchids particularly desirable subjects. Growing hardy native orchids has become a somewhat controversial subject, however, because most of those offered commercially have been collected in the wild, and wild populations of many species are becoming seriously depleted. Native orchids are also difficult to propagate. Only a few species, notably the large yellow lady's-slipper (*Cypripedium calceolus* var. *pubescens*), increase reliably in cultivation. In addition, most native orchids are nearly impossible to grow from seed with techniques presently available, and they have not yet responded to propagation by tissue culture, like many of the tropical epiphytic orchids.

But those of us who want to grow orchids in our gardens now have an alternative. Several Asiatic species can easily be propagated both vegetatively and from seed, so we can obtain and grow them without having to worry about endangering the species in the wild. In addition, these species are more attractive than many of our native orchids; they are easy to cultivate; and they are hardy in most parts of the United States. I am referring particularly to *Bletilla striata,* often sold as the "hardy Chinese orchid," and several of the Japanese species of *Calanthe: C. nipponica, C. tricarinata,* and *C. discolor* and its varieties.

Because the propagation of many hardy orchid species is difficult, gardeners are often reluctant to attempt it. But I urge them to try. *Bletilla* and *Calanthe* are good choices with which to start, because success is virtually assured.

Before attempting to propagate these plants, it is important to understand some basic facts of orchid growth. Most orchids grow sympodially, that is, each shoot grows to maturity and then stops growing, whether it flowers or not. That shoot is then succeeded by a similar one, which develops from an axillary bud borne on the rhizome. Old shoots often live for several years, still capable of food production and storage but incapable of growth or flower production. In terrestrial orchids the rhizome is usually underground. In many genera the shoots themselves consist of two distinct parts: an aboveground part, which includes the foliage and produces the flowers and in temperate regions usually dies back at the end of each season; and an enlarged underground part, attached to the rhizome, which serves as a food-storage organ. The underground part varies in structure and appearance from genus to genus, but in *Bletilla* and *Calanthe* it is a pseudobulb similar to the aerial ones of epiphytic orchids (in *Bletilla* the structure is often referred to as a corm).

The pseudobulbs of *Bletilla* and *Calanthe* live for several years, and if an established plant of either genus is dug up the structures appear as a string of beads, attached by the rhizome. The old pseudobulbs, referred to as backbulbs, function primarily to store food, but associated with each are latent buds often not visible to the unaided eye. Normally such latent buds would eventually decay along with the backbulbs, but these have evolved as a safeguard, so that if the leading tip of the rhizome is damaged, or if the season's aerial shoot is destroyed (perhaps by a late frost), one of these latent buds will break dormancy and develop into a shoot. Thus the damaged plant will still be able to grow.

These latent buds also enable us to propagate *Bletilla* and *Calanthe*, as well as other orchids, by vegetative means. If we separate them, and the backbulb to which they are attached, from the leading shoot, each will develop into a separate plant. The procedure is simple. For *B. striata* dig up the plant in the spring before the new shoots have emerged, and carefully clean the pseudobulbs so that each one is clearly distinguishable. Be extra careful to avoid damaging the leading buds in the process. Sever the rhizome between each pseudobulb with a sharp knife or pruning shears. The pseudobulb with well-developed buds may be replanted in the garden, and the shoots should develop and flower normally. The backbulbs should be planted in a propagating frame, covered with about 5 cm of soil and mulched lightly. They must never be let dry out. The backbulbs should produce small shoots the first season, and the resulting plants should flower the second season. My experience has been that backbulbs up to five years old should produce shoots if treated in the manner described above.

The procedure for *Calanthe* species is similar. The backbulbs of this genus are borne very closely together, however, and I prefer to separate them by gently twisting them apart. If a knife is used, it is important to inspect the backbulbs carefully for any latent buds in order to avoid damaging them. Again, the leading pseudobulb can be replanted in the garden. The backbulbs can be planted in a propagation frame, but because the shoots they produce are delicate and slow-growing I prefer to start them in a seed pan. I use a medium consisting of 2 parts peat moss, 1 part vermiculite, and 1 part perlite. The backbulbs should be situated so that their tops are just below the surface of the medium. Place the pans in a shaded spot in a greenhouse or outdoors, and keep the medium moist. The tender shoots are very attractive to slugs, so it is best to apply a commercial slug bait as soon as the shoots appear. Leave the plants in the pans under fluorescent lights or in filtered sunlight until the following spring and then plant them in their permanent place in the garden.

Other orchids with corms or underground pseudobulbs should respond similarly to *Bletilla* and *Calanthe*. Experimentation should produce some interesting and valuable results. I hope that success with these will lead to experimentation with other species and that eventually methods will be found for propagating more of these wonderful plants.

Richard E. Weaver, Jr., the former horticultural taxonomist at the Arnold Arboretum, now operates WE-DU Nurseries in Marion, North Carolina.

BOOKS

Flowers of the Wild: Ontario and the Great Lakes Region by Zile Zichmanis and James Hodgins. Toronto: Oxford University Press. 272 pp.

GARY L. KOLLER

Flowers of the Wild: Ontario and the Great Lakes Region, is likely to become the first book I reach for when I am looking for a reference guide to wildflowers. The text, which covers 127 plants, is terse and includes the same categories of information on each plant. The categories are: habitat, longevity, flower and fruit characteristics, ecological status, and cultivation. The accompanying pictures are well composed and sharp in image, and the color reproduction is superb. I have encountered few books on plants with better photography. Botanically accurate line drawings, which are carefully stylized to accent characteristics that aid in identifying the plant, supplement the photographs. The drawings also illustrate characteristics that may be unclear or not represented by even the best photograph.

Each plant is represented on two pages, with text occupying approximately one-quarter to one-half page and the line drawing a full page.

My only complaint is with the name of the book, which might lead one to think that the plants treated will not be found outside Ontario and the Great Lakes Region. Most of these plants can be found in the wild or in cultivation in New England and elsewhere when environmental conditions are similar to those of southern Ontario. Most, if not all, can be found well labeled and beautifully exhibited at the Garden in the Woods, Hemenway Road, Framingham, Massachusetts.

Books with photographs and graphics of this quality are rare. I commend the authors on producing a book that organizes information on wildflowers in a convenient package, conveys the beauty of wild plants to the most uninformed reader, and pleases the most avid wildflower enthusiast.

Plant Extinction: A Global Crisis by Harold Koopowitz and Hilary Kaye. Washington: Stone Wall Press. 239 pp. $16.95.

MARK PLOTKIN

Many important international conservation programs initially focused on preventing the extinction of large mammals like the tiger or the rhinoceros. This has proved to be a shrewd choice, as these animals appeal to the general public and generate a great deal of sympathy (and, therefore, dollars) to finance programs for their protection. The importance of these early efforts to elicit public support in industrialized nations for conservation programs in developing countries should not be underestimated — that organizations were able to raise funds to save foreign wildlife species, which many of the donors would never see outside a zoo or a television screen, was truly a noteworthy achievement.

Nevertheless, the success of these projects solved only a small part of the problem. As Grenville Lucas, of the Royal Botanic Gardens at Kew, has stated, "the appeal of animals like the panda and the muriqui is universal, yet you cannot save the animals if you do not save the plants." A major problem then is "saleability" — how does one interest the general public in plant conservation?

What is undoubtedly one of the best methods is presented in a new book by Harold Koopowitz and Hilary Kaye entitled *Plant Extinction: A Global Crisis.* By showing how crucial a role plants play in our daily lives (for example, the use of the rosy periwinkle [*Catharanthus roseus*] in treating cancer. the authors vividly illustrate that plant conservation is not an esoteric exercise but an urgent necessity.

Plant Extinction contains intriguing information on both the ancient, current, and future uses of plants and the causes of the rapidly accelerating pace of species extinction. The authors have thoughtfully included data on the status of plant conservation in biomes throughout the world, the politics of conservation, and the essential role that the hobbyist can play. Although a more in-depth citation of references would have made this book more useful to the scientific community, *Plant Extinction* is both enjoyable and informative and will undoubtedly prove useful to the teacher, the hobbyist, and the general public.

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Arnoldia Landscaping Contest

Among the numerous inquiries that come to the Arnold Arboretum by phone and letter, one of the most frequent is, "What can I plant under my mature Norway maple (*Acer platanoides*) or European beech (*Fagus sylvatica*)?" These are trees that cast intense shade and whose roots are shallow, fibrous, and dense, factors that are unfavorable for underplantings.

We would like to hear about plantings that have not only survived but thrived beneath these and other shallow-rooted trees. Readers can help by sending descriptions, photographs, or comments on plantings they know to have been successful. Advice will also be welcome on special planting or maintenance techniques that enhance the establishment and growth of the understory plants under these difficult conditions. We would like information specifically on the following kinds of plantings: annuals, ground covers, herbaceous perennials and bulbs, deciduous and evergreen shrubs, hedges, and vines and methods of support.

Information submitted will be presented in a future issue of *Arnoldia*. All information will be credited to the contributor, and all contributions will be acknowledged. Participants submitting the five most original photographs prior to October 1, 1984, will receive a plant of *Styrax japonica* 'Pink Chimes' or another rare ornamental plant. Help us to assist others by sharing your expertise. Contributions should be addressed to: Gary L. Koller, managing horticulturist, Arnold Arboretum, Jamaica Plain, MA 02130.

Mature river birch (*Betula nigra*)

The Arnold Arboretum of Harvard University, a non-profit institution, is a center for international botanical research. The living collections are maintained as part of the Boston park system. The Arboretum is supported by income from its own endowment and by its members, the Friends of the Arnold Arboretum.

Spring 1984

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arnoldia

Native tapping trees of *Hevea guianensis* during the years of the Second World War, when wild rubber stands of the Amazon helped to replace plantation production interrupted by the Japanese occupation. R. E. Schultes photo.

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Front cover photo: Leaves of the American smoke tree (*Cotinus obovatus*). *Back cover:* trunks and branches of the same species.

Page

The Tree that Changed the World in One Century

Richard Evans Schultes

I can assure you that on that 14th of June (1875) when Mr. Wickham arrived at Kew in a hansom cab with his precious bags of seeds, not even the wildest imagination could have contemplated its result. . . .
— Sir W. T. Thiselton-Dyer
Kew Bulletin (1912), p. 65

History is usually written in the context of political, social, or religious changes. Yet it might well be written from the point of view of the effects that plants have had on the development of mankind and civilization.

It is safe to say that no single species of plant has, in the short space of 100 years, so utterly altered lifestyles around the globe as *Hevea brasiliensis,* a member of the spurge family, which today is the source of 98 percent of the world's natural rubber. Stop for a moment and try to imagine life without rubber!

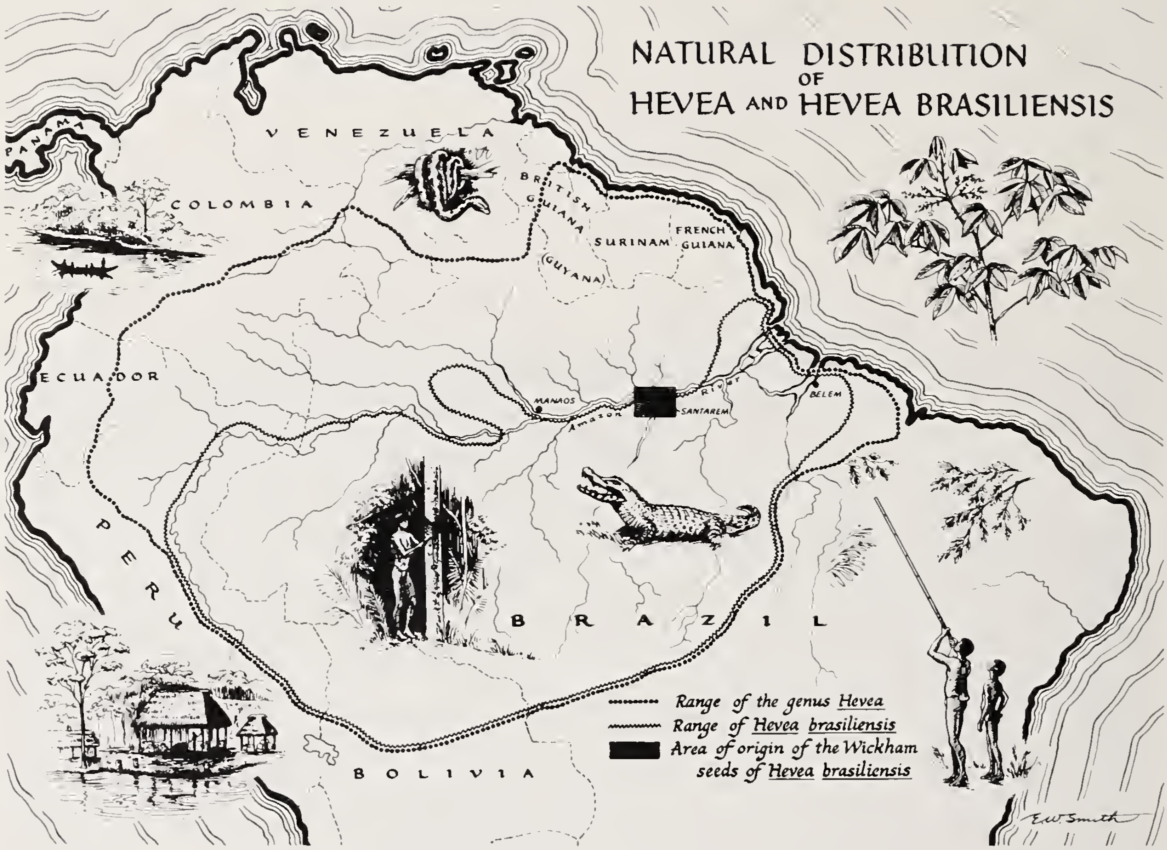
The introduction of this Amazonian tree from the wild and its domestication in the 19th century was the work of the British botanical gardens, especially the Royal Botanic Gardens at Kew, and is unquestionably the most outstanding example of the value of such institutions in bettering life on earth.

Rubber-yielding trees and vines grew in the Old World, yet, curiously, no significant use of their product had been made anywhere in the Eastern Hemisphere. When Columbus arrived in the West Indies, he noted that the natives were playing a game in which rubber balls were employed, but the rubber for these balls came not from *Hevea* but from *Castilla elastica,* of the fig family.

As early as 1755, King John of Portugal tried to foster a rubber industry in Belém do Pará at the mouth of the Amazon River: rubber shoes were manufactured for export to Portugal, but the quality was so poor that the industry did not prosper. The process of vulcanization, which has made rubber the useful product that it is now, had not yet been discovered.

After Goodyear discovered vulcanization in the 1830s, rubber became a product with ever-increasing uses in the industrializing nations, and demand for it increased at a vertiginous rate. The only source was the wild stands of *Hevea* — especially *H. brasiliensis* — hidden away in the dark corners of the vast Amazon forests. The demand for rubber in Europe and the United States rapidly became so great that production from forest trees rose from 31 tons in 1827 to 2607 tons in 1856. This dramatic increase was accomplished by the virtual enslavement of whole tribes of Indians. Tapping the trees in the jungles for four or five months a year, away from their agricultural lands and sources of

A group of rubber tappers bringing in their daily harvest of latex from forest trees in the Amazonian region of Colombia. R. E. Schultes photo.



Natural distribution of *Hevea* and *H. brasiliensis.*

nourishment, falling prey to tropical diseases and malnutrition, and often suffering from exposure, mistreatment, torture, or even assassination if they did not bring in enough rubber, they were being exterminated by this forest industry, directed primarily by unscrupulous "rubber-barons" who resided in the cities of Manáos and Iquitos, usually in sumptuous luxury.

The modern age of rubber had its beginnings in 1876, a "rubber revolution" that was the consequence of an incredible series of sometimes fortuitous events.

Hevea became known to the scientific community when in 1775 the French botanist J. B. C. F. Aublet described the genus from material collected in French Guiana. He not only described the genus and its first species, *H. guianensis,* but detailed the native method of exploiting it for rubber and appended numerous ethnobotanical data on the use of the seeds by the natives as food. Twenty-six years later, K. L. Willdenow, a German botanist, described a second species, *H. brasiliensis,* from material collected at the mouth of the Amazon River. Subsequent botanical exploration of the Amazon Valley — notably that carried out by the British botanist Richard Spruce — continued to add new species to the genus, which now comprises 10 species and three varieties.

Not all of the species yield a latex capable of producing rubber: only *H. guianensis, H. benthamiana,* and *H. brasiliensis* have sufficient caoutchouc to give a usable rubber; and of these, *H. brasiliensis* supplies the best product.

When in 1823 a Scot, Charles Macintosh, discovered that rubber would dissolve in naphtha, it acquired many new uses, leading to the establishment of factories in England, France, and the United States. These factories failed, however, because the product still became sticky in the heat and brittle in the cold.

This problem was overcome in 1839 when a Bostonian, Charles Goodyear, discovered vulcanization, a process that greatly altered the physical properties of rubber and changed the history of the significance of this vegetal product and its effect on human life. It led immediately to new and hitherto unexpected applications and a host of new industries. It also sparked the "rubber boom" of the Amazon, then the only source of natural rubber: production from the South American forests rapidly increased.

Exploitation of wild rubber is a difficult and frustrating operation. The natives, living during the tapping season under such abominable conditions, produced a poor-quality product. The latex was frequently laden with bark, dirt, and stones and adulterated with other rubbers, since often the tappers were punished if they did not procure stipulated quotas. Furthermore, each individual had to labor from dawn or predawn until nearly noon to tap 100 or fewer trees in his forest circuit, then return to his shack and begin the long process of coagulating the latex. Large balls of rubber were formed by pouring the latex little by little over a pole that was rotated in smoke rising from an inverted funnel.

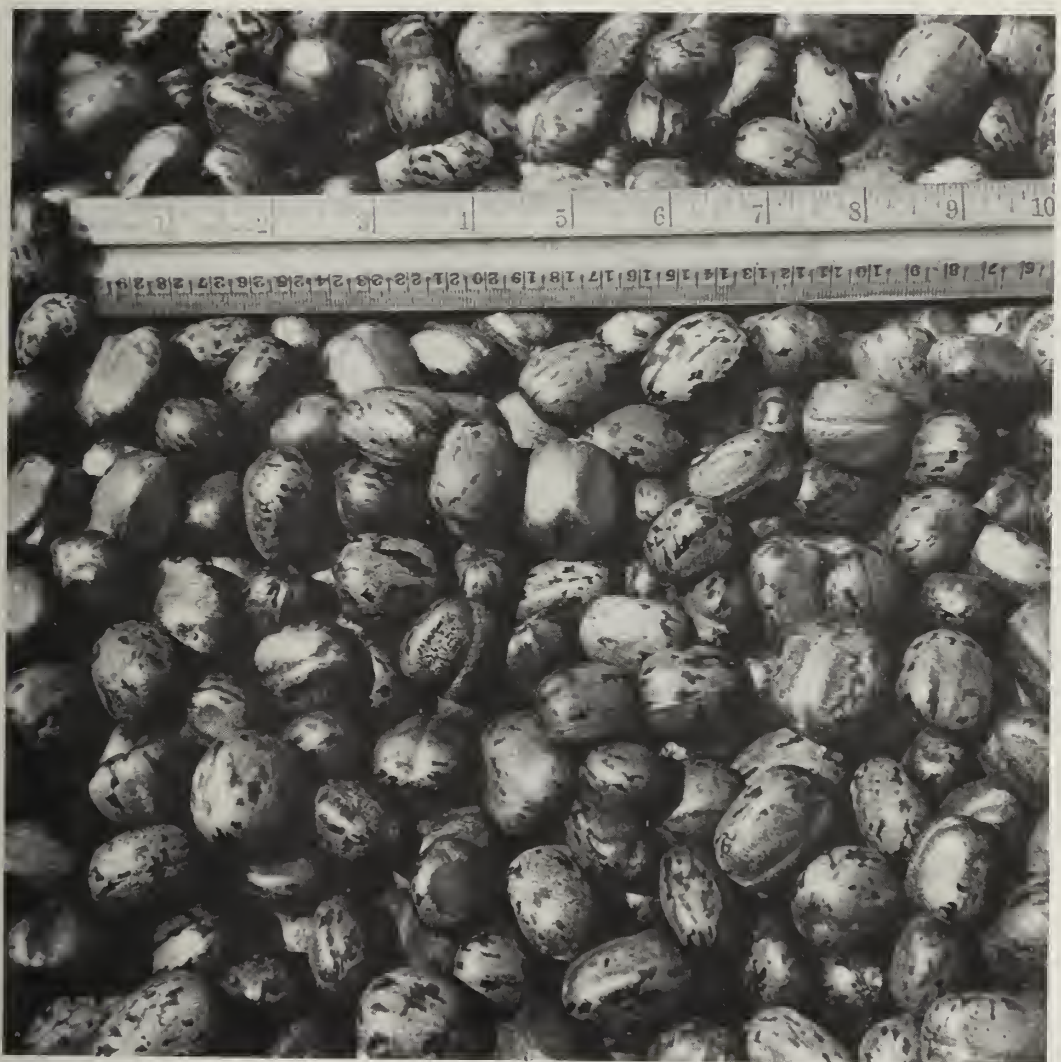
The death knell for this primitive industry was sounded when the era of scientifically managed plantation practices began in 1876, the year that rubber seeds were first germinated successfully in the Royal Botanic Gardens at Kew. The domestication of the rubber tree served civilization in two ways. First, it provided an abundance of high quality rubber at low cost, without which many of our great advances in industry, medicine, domestic appliances, and transportation would have been impossible. Second, when plantations finally came into full production in the second decade of the 1900s, the forest industry was all but obliterated, with the result that thousands of native tappers were liberated from the intolerable and inhuman exploitation to which they had been subjected for nearly 100 years. And, undoubtedly, whole tribes — e.g., the Witotos of the northwestern Amazon, a truly noble race of Indians — were saved from virtual extinction.

Domestication of the rubber tree occurred at the time the British were seeking new crops for their tropical colonies. The introduction of the quinine-bark tree into India from the Andes had just been highly successful. Sir Clements Markham, who had directed the introduction of that tree, was convinced that the rubber tree could be developed as a plantation crop that would be a good substitute for the coffee crop, which a fungal disease had almost exterminated in Asia. He had Mr. James Collins prepare a summary of what was then known about

Parts of *Hevea brasiliensis,* the rubber tree.

rubber. Collins wrote: "In 1870, I came to the conclusion that it was necessary to do for the caoutchouc-producing tree what had already been done with such happy results for the cinchona (quinine) tree." Sir Joseph Hooker, director of Kew Gardens, knew of Spruce's discoveries and studies of *Hevea* in the Amazon, and he fully supported Markham's view concerning the future of *Hevea* cultivation.

Several earlier attempts had been made to introduce *Hevea* seed from Brazil, in 1873 and 1875. None were successful. *Hevea* seed, its latex rich in sugars, quickly ferments in the heat of the tropics, and the embryo is killed. But success eventually came.



Seeds of *Hevea brasiliensis.* R. E. Schultes photo.

An Englishman, Henry Wickham, who had spent many years living near the Amazon and Orinoco and who in 1872 had published a book on his travels in tropical South America, had previously sent seeds of *Hevea* to Kew with no success. Fully realizing that earlier shipments had failed because of slow transport, Wickham resolved somehow to surmount this difficulty. Then a fortuitous event happened! In 1876 a steamboat from England had sailed up the Amazon laden with cargo; it found no return load. "I determined," Wickham wrote, "to plunge for it. I had no cash on hand. The seed was even then beginning to ripen. I knew that Capt. Murry must be in a fix, so I wrote chartering

the ship." Wickham sent out his Indians to collect the seed and pack it properly in wicker baskets. The ship raced downstream from Santarém, 400 miles up the Amazon, and called in at customs in Belém at the river's mouth. Customs officials, told of the delicacy of the plants "for delivery to Her Britannic Majesty's own Royal Botanic Gardens of Kew," immediately, and with intelligence unusual among bureaucratic officials, dispatched the ship, which steamed off to England.

All of the earlier shipments had been sent on sailing vessels. The few days saved by using a steamboat ensured successful germination in Kew's hothouses. Of the 70,000 seeds, 2800 germinated — a rate of 4 percent, astonishingly high for *Hevea,* even in the field.

Young trees from this introduction were sent to Ceylon, where several of the original trees still are living in botanical gardens. From Ceylon some went to Singapore and other parts of the empire in the tropics. The domestication of this tree, which has in one century so drastically changed life around the world, would not have been possible without a chain of botanical gardens and a far-sighted director at Kew like Hooker.

In Brazil stories are rife concerning the British "seed steal." At that time Brazilian law permitted the exportation of seeds, and collection and exportation were carried out openly. Many Brazilians are persuaded to believe that rubber seeds were "stolen" or "smuggled" out of the country, however,

Henry Nicholas Ridley examining one of his early experiments in tapping systems of *Hevea brasiliensis,* Malaysia. Photograph courtesy of Rubber Research Institute of Malaysia, Kuala Lumpur.

and fail to realize that Brazil's major agricultural industries are based on plants introduced from foreign countries: coffee (originally from Abyssinia), rice (from India), sugar (from Southeast Asia), soybeans (from China), jute (from India), cacao (from Colombia and Ecuador). In fact, most of the world's principal plantation crops are produced in regions far from their original homes.

When the Brazilians realized that the British plantation efforts were to be successful, they prohibited further exportation of

The oldest tree of *Hevea brasiliensis* in Malaysia, from one of nine seeds planted in 1877. Photograph courtesy of Rubber Research Institute of Malaysia, Kuala Lumpur.

Trunk of *Hevea brasiliensis* with hypertrophied growth due to former tapping with *machadinho* ("little ax") in the Amazon of Brazil. P. Alvim photo.

rubber seeds, and that prohibition held until very recently. Consequently, the vast rubber plantation system of the Old World was based primarily on these original seeds, which were collected from a single locality and from a single (and not the most promising) ecotype of *Hevea brasiliensis.* It is believed that the 70,000 seeds came from 26 original trees. In view of this, the enormous improvement in the commercial rubber tree in the space of 100 years seems incredible. The earliest plantation set out in Ceylon yielded 400–450 pounds of dry rubber per acre per year; there are new clones of the rubber tree that now yield more than 3000 pounds, and, with a recently developed chemical treatment of the bark, some clones may almost double that amount.

Many names of major importance are connected with the historical accomplishment of domesticating a wild tree of the humid Amazon. These include Aublet, Spruce, Macintosh, Goodyear, and Wickham, mentioned earlier. But Wickham and two others — Ridley and Cramer — were perhaps all-important in the creation of the great plantation industry that supplies the world with more than 98 percent of its natural rubbers. Wickham, who lived to a venerable old age, was rightfully knighted in the late 1920s for his part in the creation of the rubber industry.

Henry N. Ridley was appointed director of the Botanic Gardens in Singapore in 1888. It was my unexpected good fortune in 1950 to spend several days chatting with Ridley in his 95th year. He lived near Kew Gardens and was overjoyed to review some of his hopes, his trials, his successes in the early history of rubber in the Far East with a young botanist who was studying the numerous species and their ecotypes in the wild in South America. It was during these personal exchanges that I realized that Ridley was in fact one of the major founders of our modern rubber plantation industry.

When Ridley took up his position, he found only nine original trees and some 1000 young plants left from the original introductions to the Malay Straits in 1877. He immediately raised 8000 more plants from seed imported from Ceylon. These trees, from the original Wickham stock, became the mother trees of much of the rubber that eventually covered a large portion of Malaya.

Next Ridley began his celebrated experi-

Pieter J. S. Cramer (left). The identity of the other man is unknown. The tree is one of the original Wickham trees in the Botanical Garden, Ceylon. Photograph courtesy of Dr. O. S. Pires, Rubber Research Institute of Sri Lanka, Agalwatta, Sri Lanka.

ments on tapping methods. At that time trees in the Amazon were slashed according to a great variety of makeshift techniques, frequently to the detriment of the tree. The most prevalent method involved the use of the "machadinho" — a small ax used to make deep incisions in vertical lines up and down the trunk, causing eventually enormous hypertrophied tumors, which later prevented efficient tapping.

Ridley tried cutting off very thin layers of the bark with a sharp knife in a sloping channel, avoiding injury to the cambium, since in *Hevea* all of the latex-bearing vessels are external to the cambium. He began with the well-known herring-bone method and recommended infrequent tapping to allow the trees to rest. Eventually, he learned that more frequent tappings would not harm the tree and abandoned the herring-bone system and cut in slopes from right to left, since cuts in this direction were shown to give higher yields. Among numerous other discoveries, he experimentally showed the advantages of tapping done in the morning rather than the afternoon.

Ridley's advances, perhaps more than any other, assured success of the Asiatic plantation industry. By 1897 all tapping in Asia was based on Ridley's scheme of reopening the wound. The sudden increase in world demand for rubber further stimulated research into efficient and higher-yielding tapping techniques, in all aspects of which Ridley took part. His experiments led eventually to the spiral system of tapping, which today is nearly universal in plantation practice.

Ridley made another significant contribution to the rubber industry of the future in his campaign to establish rubber as a plantation crop. A series of events led him to this: a serious fall in the world price of tea, the devastating fungal disease of *Coffea arabica*, and poor results with cacao. Another factor was the increasing use of the automobile; automobile tires gradually became the greatest single consumer of the product. Ridley seized the opportunity, and soon planters were establishing rubber.

Again it was my good fortune in 1950, when Dr. P. J. S. Cramer was retired in Utrecht, Holland, to spend three days chatting with *oude Piet* ("old Pete"), as the uni-

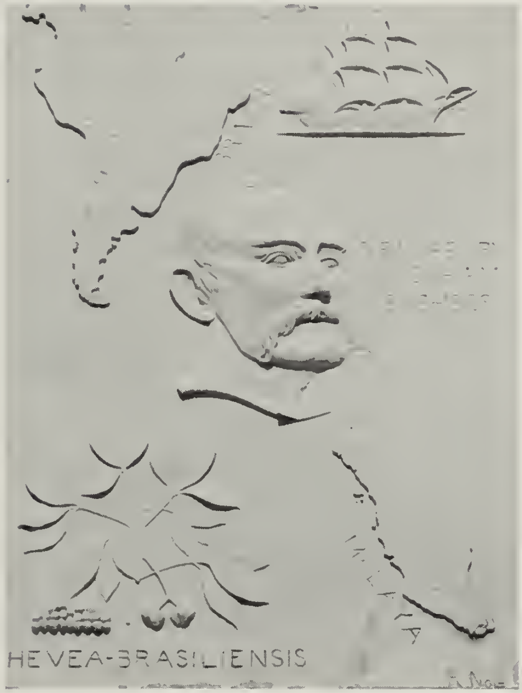
When I started in 1888 in an attempt to
cultivate Rubber for profit it was com
paratively little used to what it is today
and to what it will be in the future
In calculating the amount that would be
required in 1900 I calculated for bicycle-tyres
(the poor mans carriage) but not for tyres for
motor vehicles as they were hardly invented
and I thought they would only be a rich
man's toy for many years. However we (I
and my one assistant) were ready for all
eventualities in time for the boom.

I shall be very interested in your discoveries
when you publish them. Your literature
of your programme has not come to hand
yet. I look forward to its arrival
I should like to see the photographs of
the dwarf variety you mention. It must
be a very curious plant
My wife sends her warmest greetings to you
and I too wish you the greatest success
and happiness in your work in Colombia

Yours sincerely
Henry N Ridley

versity students affectionately called him. We reviewed the initial introduction of *Hevea* stock to the Dutch East Indies from the British Malay Straits — material derived from the original Wickham seeds — and his early successful efforts to introduce from South America seeds of several other species of *Hevea* for eventual genetic studies. He told me about the difficulties he experienced in attempting to convince commercial developers that the planting of seeds (instead of using clonal material) was not the best way of establishing plantations of rubber trees. In these three days we experienced a remarkable camaraderie based on our very divergent experiences with *Hevea,* and I acquired an abiding understanding of the difficulties encountered by these pioneers: Ridley and Cramer.

When the Dutch had established a plantation crop from material originating in Penang, Malaysia, Cramer carried out the first variation analyses on *Hevea brasiliensis.* These early studies indicated that the species is extremely variable, especially with respect to yield of latex, an important commercial consideration. Through his analyses Cramer demonstrated the impossibility of predicting yield of rubber from plantations established on seed material, mainly because of cross pollination. He predicted that vegetative selection, cloning, and generative selection or breeding would lead to improvements in yield. All his predictions proved true. Cramer's studies led to the eventual vegetative reproduction of high-yielding clones, which today is basic to all rubber-plantation practice.



Plaque commemorating Sir Henry Wickham's successful introduction of seeds of *Hevea brasiliensis* from the Amazon in 1876. Photograph courtesy of the Rubber Research Institute of Malaysia, Kuala Lumpur.

Later, in 1918, Cramer patented a method of marketing budwood from high-yield cloned trees, which *ad infinitum* would provide the basis of plantation material. He also invented the Testatex knife, patented in 1931. This knife has a vertical series of V-shaped blades, and when pressed into the stem or trunk of young nursery plants measured the length of the "drip" of the exuding latex, thereby indicating yield potential long before the trees matured at seven years.

The famous Colombian author José Eustacio Rivera wrote one of the great novels of

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Letter to the author from Henry N. Ridley in his 95th year.

A modern plantation of *Hevea brasiliensis* in Malaysia. Photograph courtesy of Rubber Research Institute of Malaysia, Kuala Lumpur.

Latin America on life on the Amazon during the rubber boom. The title, *La Voragine* (*The Vortex*), refers to the belief that the jungle mysteriously swallows up the rubber tappers. One magnificent passage describes the almost fearful worship of the rubber tree in those days: "I have been a rubber tapper. I am a rubber tapper. I have lived in the muddy swamps in the solitude of the forests with my crew of malaria-ridden men cutting the bark of the trees that have white blood like that of the gods."

If we consider the changes for the good of mankind that "white blood" brought about when the rubber tree was finally domesticated, perhaps we might agree that it was actually blood of the gods!

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In Praise of the American Smoke Tree

Gary L. Koller and Don O. Shadow

Have you ever wondered why one introduced species within a genus flourishes in the nursery and landscape industry while a native American plant with notable traits remains obscure? An example of this occurs in the genus *Cotinus*. *Cotinus coggygria* Scop., the common smoke tree or smokebush, whose native range extends from South Europe to Central China, is frequently seen in residential landscapes here. It is sought after because of its many fine qualities: a long period of midsummer floral and fruit ornamentation, showy plumose fruit panicles (which create the smokelike effect that gives the plant its common name), vivid autumn foliage colors, ease of culture, and longevity (the oldest plants extant at the Arnold Arboretum are 108 years old and healthy). Our native American smoke tree, *C. obovatus* Raf., on the other hand, is rarely seen. It is often missing even in the horticultural literature. Older books on landscaping omit it completely. When it is included, it is described in almost disparaging terms: "the fruiting panicles are not showy — it is useful only for autumn color — where the smaller smoke tree will suffice, the American species can be omitted." Writers always attempt to compare the American species with its Asian relative. We have observed fruit panicles in the wild that are quite showy, though it is fair to say that those on the Arboretum's trees are not. We shall lay comparison aside here and give our native species the attention it deserves.

Robert A. Vines, in his book *Trees, Shrubs and Woody Vines of the Southwest*, states that *Cotinus obovatus* occurs on "rocky limestone hills of Texas, Oklahoma, Arkansas, Missouri, Alabama, Tennessee and Kentucky. Nowhere very abundant or widespread." Thomas S. Elias, in *Trees of North America*, says that it generally grows in limestone soils of dry, rocky slopes, in mountain canyons, or on high hills. It is found at elevations up to 1000 m. Because it inhabits locations with hot humid summers and relatively mild winters, many assume that it will not thrive under the soil and climatic conditions of northern landscapes. Yet we have found a planting as far north as the Landscape Arboretum at the University of Minnesota. Dr. Harold Pellett, on the staff there, told me that the arboretum had had success with seed of a cultivated plant from the Morton Arboretum in Lisle, Illinois, in 1963. Today, one of the resultant seedlings, which grows in an exposed site, is nearly 5 m tall. It is stem hardy at temperatures above approximately −25°F. The minimum temperature at which the roots are cold hardy has not yet been determined. Information on the original native locale of this plant is unavailable. A more cold-hardy genotype may yet be found.

A second welcome feature of the Amer-

ican smoke tree is its adaptability to various soil conditions. In Tennessee it occurs on south-facing rock outcroppings of limestone, where the pH is 6.5 to 7.0. Very little soil is present on top of the rocks, so the roots must invade the cracks and crevices to anchor the plant and obtain moisture and nutrients. In the same area it also grows in sites with better soil, where it associates with *Juniperus virginiana*, *Rhus aromatica*, *Viburnum prunifolium*, *Cercis canadensis*, and *Quercus prinoides*. At the Arnold Arboretum a 102-year-old specimen flourishes in highly acidic soil near the edge of a meadow. Peter Del Tredici, of the Arnold Arboretum staff, observed the plant thriving in alkaline clay soils in the Chicago area. Excess soil moisture, however, may detract from optimum autumn foliage coloration.

The relatively low stature (8 to 12 m) of this tree makes it suitable for small or crowded landscape sites, where it can serve as an alternative to dogwood, crabapple, and hawthorn.

The fall-foliage colors of this tree are stunning. At the Arnold Arboretum few plants match it in terms of brilliance and intensity. In full sun the colors are scarlet, orange-scarlet, and claret and in shade apricot, gold, and yellow. A. C. Downes acclaimed the plant for its fall colors in 1935 in *The Gardeners' Chronicle:* "seen with the autumn sun shining through its translucent leaves, decked out in all shades of flaming orange and scarlet, it has been a sight not easily forgotten. . . . It is just the translucent quality of its foliage that causes the warm fiery glow that is its great charm. Other plants can show colors as vivid in themselves (as, for example *Rosa nitida*), but their thicker leaf blades rob them of the wonderful effect. . . ."

Soil moisture and soil nutrition seem to affect autumn brilliance. One writer suggested that when grown on rich soil that is high in nutrients, the resultant lush, soft growth produces poor fall color. A. J. Anderson, in a 1945 issue of *The Gardeners' Chronicle*, said "the most beautifully colored examples I have seen are growing on an exposed, dry bank of poverty stricken soil. A moist, rich medium should definitely be avoided as it always results in vigorous, sappy growth which is detrimental to autumn coloring." Fall weather also seems to affect color brilliance. At the Arnold Arboretum one plant varies from very colorful to dull depending on sunlight and temperatures in early October. In the wild, autumn color varies substantially from one plant to the next.

Emerging spring leaves exhibit colors from soft bronze to purple, which are particularly attractive with backlighting, which exposes the sparse hairiness of the leaf surface. Summer color of fully expanded leaves is a dark green.

The bark of the American smoke tree provides pattern and detail in the winter landscape. Bark plates have bases lifted slightly and pulled away from the stems, creating a fish-scale-like effect. The scale pattern varies among individuals, and the plant could benefit from selection for this characteristic. Plants must reach approximately 20 years of age before the mature bark pattern develops. At this point the plant can be pruned to expose the bark to view. The bark can be an interesting focal point of a winter landscape. The tree can also be planted en masse to

A 102-year-old American smoke tree (*Cotinus obovatus*) at the Arnold Arboretum. Barth Hamberg photo.

create a mini-forest of textured stems.

Cut logs of the American smoke tree match *Juniperus virginiana* in durability and longevity and have been used as fence posts and walking sticks. When the tree is cut for logs or burned over by fire, the stump has the ability to resprout quickly, resulting in multistemmed specimens. As a result, most wild plants are multistemmed and not very straight. Color on freshly cut wood samples varies from bright yellow to pale orange. Extract from the wood was an important source of a natural dye, especially during the Civil War period.

Flowers and fruit are borne in large terminal panicles. Attached to the upper end of each panicle are slender stalks clad in fine hair. These create the smokelike effect, which in the wild varies in color (from light brown to fleshy tones and pale purple), size, and density. The sexes occur usually on separate plants but occasionally on a single plant. In the horticultural literature the male plant is reported to be superior for "smoke production." All of these factors suggest that selection could produce a more beautiful tree. Fruiting is said to be sparse in the wild. Seed is often difficult to find, as squirrels gather it before it ripens.

The height of the plant varies considerably, though this may be attributable to environmental conditions. The largest plant documented is a national champion tree at the Deane Hill Country Club in Knoxville, Tennessee. The tree is 13 m high, with a crown spread of 10 m, and a trunk girth of 1.5 m. The oldest and largest plant at the Arnold Arboretum came from seed sent by Charles Mohr of Mobile, Alabama, in 1882. As of February 1984 this plant stands 9 m tall, with a crown spread of 8 m and 5 stems arising from ground level, of which the largest two are 45 cm in circumference. In poor soils and under harsh environmental conditions in the wild, the plant can be found in spreading thickets free of other species. Such varied growth habits allow great opportunity for the selection of individuals for specific purposes.

The common smoke tree (*Cotinus coggygria*). Pamela Bruns photo.

Arboretum to Distribute American Smoke Tree to Friends

During spring 1984 the Arnold Arboretum will distribute approximately 3000 plants of *Cotinus obovatus* to Friends of the Arnold Arboretum. The plants were specially grown for the Arboretum at Shadow Nursery, Inc., a wholesale grower in Winchester, Tennessee, near the natural habitat of *Cotinus obovatus.* Don Shadow scouted the area for suitable plants from which to take cuttings and chose several for brilliance of autumn foliage. Stock plants grew as wild invaders beneath the electric power lines, where they had been cut back to prevent their interfering with the wires. Don's staff fertilized these plants in situ and hoped that the power company would not spray the chosen ones with herbicides. It did not, and vigorous succulent growth ensued. This verdant vegetation became the basis for our plants.

Growing the American Smoke Tree

Vegetative propagation is successful in early summer. Cuttings are taken just before the new season's growth begins to harden, and the soft fleshy tip of each cutting is pinched off. They are trimmed to 15 or 20 cm long and dipped quickly in I.B.A. in methanol or treated with Hormodin Number 3. They are then planted outdoors in ground beds covered with plastic tents and protected with 47 percent shade cloth. The cuttings are misted for 15 seconds every 15 minutes. This watering regime is critical, for if mist is maintained too long cuttings rot and quickly deteriorate. As soon as the cuttings begin to root, mist is reduced and then discontinued, and the plastic removed. The cuttings should be allowed to dry out between waterings. Rooting can take place in as little as 16 days but typically requires 4 to 6 weeks. When cuttings resume growth in early spring, successive crops can be taken for quick stock increase.

By the end of the first growing season, the rooted cuttings are 0.6 m tall. By the end of the second year, after transplanting and pruning, multiple-branched specimens can reach 1 to 1.5 m tall. If the plant is to be grown as a standard, all but the most vigorous branches must be removed.

In autumn plants should be subjected to one or two light frosts and then covered before temperatures reach the low 20s. Water and moisture in winter storage need careful attention as the plants are vulnerable to rotting. Rooted cuttings, as well as larger plants, transplant easily. Both need to be tested for container growing. These trees hold great promise for use in raised and streetside planters, as they thrive in the most harsh environments in the wild.

Seed propagation does not seem to be viable on a commercial scale, for the seed crop is usually unreliable. However, hobbyists and plant breeders should attempt crosses between *Cotinus obovatus* and *C. coggygria* in search of superior garden forms.

Peter Drummer, a propagator at Hillier Nursery in England, has hybridized *Cotinus coggygria* 'Velvet Cloak' with *C. obovatus*. Drummer plans to show superior seedlings at the Royal Horticultural Society show in London, after which the best will be named. The characteristics making Drummer's plants distinct are flowering spikes far superior to those of *C. obovatus*. Some measure 30 cm high and 28 cm wide and are deep pink in color. According to Drummer, the hybrids seem to root more freely than *C. obovatus*.

At the Arnold Arboretum we have rooted cuttings of one of Drummer's seedlings. The resultant plants exhibit a summer foliage color with a purplish cast and have exceptional vigor. Cuttings taken in May 1983 were 1.5 m tall by September and might have been taller if they had not been pinched at the top to harden stem tissue before winter set in. Drummer states that his seedlings made 1.5 to 1.8 m of growth during the 1983 season. Gardeners can look forward to the continuing development of this fine new line of garden plants.

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The Eastern Hop Hornbeam: Its Natural History and Landscape Potential

William E. Fehrenbach, Jr.

The eastern hop hornbeam, *Ostrya virginiana* (Mill.) K. Koch, is a tree with an ornamental value that has largely gone unrecognized. This ubiquitous native understory tree is one of the least-studied trees in North American forests: literature searches turn up very little reliable information on its cultural requirements or ecology. In this article I will bring together the available horticultural information and point out areas where more research is needed. Lack of publicity may be the only reason that this tree has not become more popular.

Ostrya virginiana is the most widespread species in its genus. It is hardy to USDA zone 4 and is found from Nova Scotia to Minnesota and south to eastern Texas and Florida. The genus name, *Ostrya,* is derived from the Greek word *ostrua,* designating a tree with very hard wood (Vines 1960). Many of its common names also refer to the hardness of its wood: ironwood, leverwood, hardhack, and hornbeam. Two other common names are deerwood and Indian cedar.

The genus *Ostrya* belongs to the Betulaceae, or birch family. According to T. S. Elias (1980), it is a genus of only eight species, which are quite similar to each other. All are short deciduous trees or shrubs, with simple and alternate leaves and very short petioles. All are monoecious (bearing flowers of both sexes on the same tree). Staminate catkins are borne in groups of two or three at the tips of the previous year's twigs, and the fruits are borne in clusters of bladderlike sacs. All species exhibit rough, scaly bark.

Three species are found in the United States and Canada. Of these, two are described in horticultural literature: *Ostrya virginiana* and *O. knowltonii* Coville. Unlike the widespread *O. virginiana, O. knowltonii* is a rare tree, with an extremely limited range at altitudes of 1500–2100 m in canyons of southwest Texas, New Mexico, Arizona, and southern Utah. It differs from its relative in its lesser height, nearly always under 9 m. Its limbs are slender and crooked, forming a rounded crown. Its leaves are somewhat similar to those of *O. virginiana,* but they are smaller and more broadly ovate. Both its leaves and petioles tend to be somewhat more pubescent than those of *O. virginiana,* a characteristic that is typical of some desert species. The flowers and fruits are also smaller than those of the other species but similar in structure. Bark and twigs are similar.

Elias (1980) mentions the Chisos hop hornbeam (*Ostrya chisosensis*), which he

Trunk of a mature eastern hop hornbeam (*Ostrya virginiana*) at the Arnold Arboretum.

describes as a shrub, rarely a tree, found in the same region as *O. knowltonii.* No other horticultural information is available on this obscure species.

Historically, the eastern hop hornbeam has been labeled a "weed tree" of no commercial value. Most management prescriptions for commercial forest land classify the hop hornbeam as a competitor to more profitable species and recommend its removal. In fact, one of the few published research papers available on hop hornbeam (Diller and Marshall 1937) deals exclusively with techniques of cutting the tree to reduce chances of resprouting. The authors observed that "hop hornbeam is one of the less desirable species in the farm woodlands of Ohio and Indiana. In many areas it dominates the understory so completely that the reproduction of the more valuable trees is often suppressed. . . ."

The wood of this species is light brown, tinged with red or white. The specific gravity of *Ostrya* wood is 0.83 (Young 1933), which ranks it among the hardest of our native woods. Its use is limited to such items as tool handles, golf clubs, mallets, fence posts, miscellaneous woodenware, and fuelwood. It is reported to take a very fine finish and probably would be a very valuable wood if the tree were larger.

The buds and catkins of the hop hornbeam are a preferred winter food of the ruffed grouse, especially in New York, Pennsylvania, and Wisconsin (Hamilton 1974), and the fruit is a secondary fall food. Other animals that feed on hop hornbeam are the bobwhite, ring-necked pheasant, downy woodpecker, mockingbird, purple finch, red, gray, and fox squirrels, deer, and cottontail (DeGraaf and Whitman 1979; Hamilton 1974).

Undoubtedly, the hop hornbeam's greatest assets are its ornamental qualities. At one time it was recommended for use as a street tree. Restricted root space and the fact that many city trees are planted with bare roots may have been major factors in the hop hornbeam's poor performance in the few cities where it has been tried. Because of this adverse experience, many horticultural writers unjustly removed the species from their lists of recommended trees. In cities where the tree has been located and planted properly, its performance is reported to be excellent. Nurseries in Buffalo, New York, cannot grow enough of the trees to satisfy demand (personal communication from R. Walkowiack, June 23, 1983).

The hop hornbeam is small in stature, usually attaining only 10.5 m. As such it is useful for smaller properties or locations with limited overhead space. The largest hop hornbeams are found in Arkansas and Texas, where some specimens reach 18 to 21 m high and have trunk diameters of 45–60 cm. In the Northeast 10.5 m is the average maximum height, and crown spread is usually equal to two-thirds of the height. Trunk diameters are seldom greater than 15 cm and rarely reach 30 cm. The habit of the hop hornbeam is graceful, with many horizontal or drooping branches. Few trees its size can match the hop hornbeam in fineness of texture, from the narrow shaggy strips of gray bark on its trunk to its slender reddish brown twigs.

The shape of the tree is distinctly irregular, ranging from conical to oval to irregularly rounded. Understory trees are often irregularly shaped, because of the various directions of the light penetrating the forest canopy. Its status as an understory tree also means that the hop hornbeam tolerates dense shade. It is not restricted to shady spots, however, and grows well in full sun. It is in full sun that the tree develops its most desirable rounded form.

The leaves of the hop hornbeam are alternate, egg-shaped, and 7–12 cm long and 3.8–5 cm wide. The margin of the leaf is serrate. The top surface of the leaf is glossy green in summer. The lower surface is pale green and somewhat hairy, especially along the veins and midrib. Various fall colors have been observed, from a poor yellow or yellowish brown to red and even purple. Some trees retain their leaves well into the winter, though leaf retention is not a very reliable or widespread trait within the species and may perhaps be the basis for developing a cultivar in the future.

The most notable ornamental features of this tree are its fruits and flowers. The hop hornbeam gets its name, in part, from the similarity of its fruits to the true hop fruits (*Humulus* sp.). The compound fruit is oblong. It is made up of a cluster of bladderlike sacs, each containing a single, ovoid, faintly striated nutlet about 6 mm long. Often, the smaller sacs at the bottom of the cluster are empty. The fruit clusters become conspicuous in July, when their color is an attractive pale green in contrast to the darker green of the leaves. The fruit ripens from late August to early October, and the sacs turn tan to light brown. The sacs are covered with fine, stiff hairs that are irritating to the skin when handled.

The hop hornbeam's flowers are not dramatic or showy but are interesting nonetheless. The tree is monoecious and bears its flowers in catkins much the same way as other members of the birch family. The staminate catkins are from 2.5–5 cm long and reddish brown. They begin to expand slightly in March and then more rapidly until fully open in April, when they pollinate the pistillate catkins emerging with the leaves from beneath the bud scales.

The bark of the new shoots, twigs, branches, and trunk varies considerably and is quite attractive. The newest shoots are reddish green with minute brown lenticels. Larger twigs, and branches less than 5 cm in diameter, are smooth and purplish brown to red-brown in color. On these smooth stems the lenticels are tan to gray and lengthen horizontally, so that the young bark looks much like that of birch or cherry. Stems 6 cm and greater in diameter have the characteristic gray, narrow, striped bark that sets hop hornbeam apart from other native trees with rough bark.

The hop hornbeam is a slow-growing tree, reaching, on average, 6 m in 20 years. Some speculate that this slow growth is responsible for the remarkable strength and toughness of the wood. The strong flexible twigs and excellent branching structure make the hop hornbeam almost impervious to damage by ice, wind, or heavy snow. Popular opinion also maintains that the species is extremely pest resistant; however, this cannot be substantiated until the tree is studied further, especially in stressful situations.

Growing the Hop Hornbeam

Propagating the hop hornbeam is a challenging task. The seeds exhibit a double dormancy that requires lengthy stratification in a moist medium in order to germinate. The regimen most often recommended for stratification is to place seeds in moist sand or peat for 60 days at 20°–30°C and 140 days at 5°C. An alternative regimen is 6½ months at 10°–22°C and 90 days at 5°C (Schopmeyer 1974). Despite the low percentage of germination, propagation by seed seems to be the only practical method for nursery production. Grafting hop hornbeam on rootstock of the same species, or perhaps on rootstock of another species in the birch family, may be attempted in the future at the Holden Arboretum. If the attempt proves successful, cultivars chosen for improved fall color, leaf retention, or improved growth rate may be developed. Tissue culture may also be an avenue to explore if cultivars prove to be commercially promising.

The soil and moisture requirements of the hop hornbeam are not rigid. In nature the tree is found in moist bottomland soils, near streams and rivers, and on dry, gravelly ridges, with oaks and hickories. It does not tolerate flooded or heavily compacted soils. Average garden soils will adequately support hop hornbeam, provided that drainage is good. Slightly acid soils are best but not crucial. In general, adding generous amounts of peat to average soils is the only site preparation that should be necessary when planting a hop hornbeam.

Planting sites for this tree must allow adequate space for rooting and branching. Adequate space is essential for the development of a root system that will provide necessary moisture and nutrients. Lawns less than 3 m wide, or within 5 m of a wall or building, will not provide adequate rooting space. Protection from wind is not necessary except for staking the tree during the first year or two to provide support while new roots are being formed.

Most people who know this tree agree that it is difficult to transplant successfully, especially if specimens are large. Wild trees tend to have exceptionally irregular root systems, which penetrate deeply in loose soil, so it is best to move them when they are young. Hop hornbeam should always be balled and burlapped when planted in order to improve its chances for establishment and preserve the mycorrhizal relationships the tree relies upon (Hamilton 1974).

A new approach to container growing apparently improves establishment of hop hornbeam and other species with "difficult" root systems. This approach (called the "Minnesota System") was developed by Dr. Harold Pellett (1981) and involves the use of bottomless containers arranged in trays of standing water. This prunes the strong taproot and produces a more fibrous, compact

Eastern hop hornbeam (*Ostrya virginiana*) growing in a sunny location.

root system that is better able to support the newly planted tree.

The Holden Arboretum is currently promoting the use of the hop hornbeam by providing both the grower and the buyer with reliable information about this little-used tree. It is currently in the process of locating seed sources and determining the best methods of germination. Next, soils, transplanting techniques, and planting sites will be tested and evaluated to determine optimum cultural practices for growing the tree. The staff hopes to stimulate public interest in this tree by increasing awareness of its utility, ease of maintenance, and understated charm.

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COLLECTOR'S NOTEBOOK

New Choices for the Perennial Border

Richard E. Weaver, Jr.

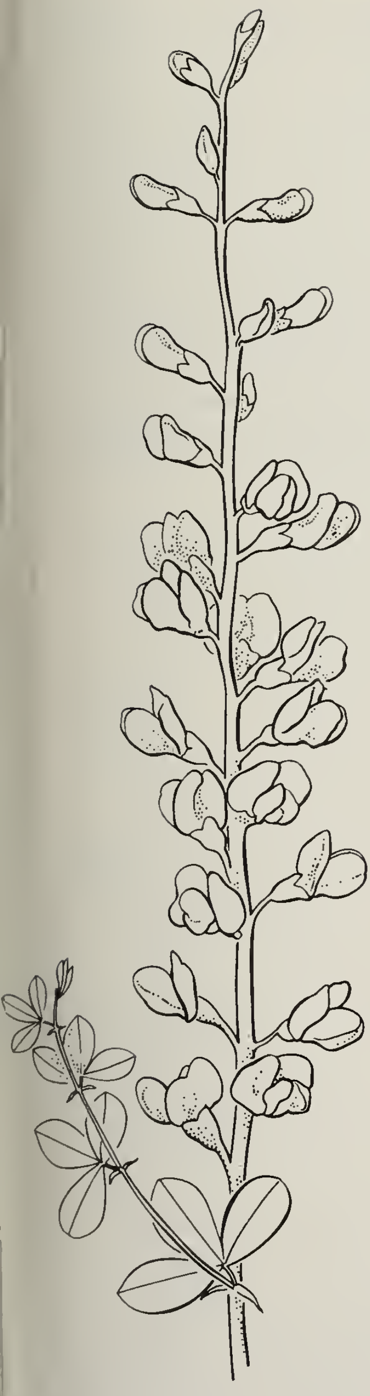
Imagine a perennial border without summer phlox (*Phlox paniculata* cvs.), Michaelmas daisies (*Aster* cvs.), gayfeathers (*Liatris* spp.), Oswego tea (*Monarda* cvs.), sundrops (*Oenothera tetragona* and *O. fruticosa*) or butterfly-weed (*Asclepias tuberosa*), and you will realize how greatly the flora of the eastern United States has contributed to horticulture. But then, take a walk through a low meadow in midsummer and count the number of spectacular plants that have not found their way into our gardens. Why have so many lovely plants been largely neglected in horticulture? Some admittedly are too vigorous or invasive, or too coarse of habit, in their wild state and must await the selection of more gardenworthy forms. But more often they are simply unavailable. Nurserymen, and most gardeners, seem unaware of the potential our native flora still offers.

I have always been a collector of rare and unusual plants, and through my writing I have tried to introduce some of them to the gardening public. Here I would like to continue in that tradition and introduce a group of native American plants that I think would make wonderful additions to the perennial border. These are not just plants for the specialist, or plants with an esoteric beauty only appreciated by a collector. Rather, they are all easily grown and beautiful enough to be appreciated by any gardener. And they are all serviceable plants rather than novelties. All should be hardy into USDA zone 5.

Unlike annual ornamentals, which have been bred for an extended blooming season, most herbaceous perennials produce flowers for only a few weeks. Therefore, those with attractive foliage in addition to their flowers are particularly desirable for use in the perennial border. One such group is the genus *Baptisia*, of the pea family (Leguminosae), with 30 or more species distributed in the eastern and central United States. False indigo, the common name of the genus, refers to the fact that many of the species yield a blue dye, similar but evidently inferior to that produced from the true indigo, *Indigofera tinctoria*. One species of false indigo, the purple-flowered *B. australis*, is a standard component of the perennial border, but the others are virtually unknown to gardeners. The white-flowered *B. alba*, native to fields, roadsides, and woodland margins from Virginia to Florida, is particularly fine. Like *B. australis*, *B. alba* is a bushy, clump-forming plant. The grayish, finely textured foliage reaches a height of 45 to 60 cm. The 3-cm-long flowers in a raceme up to 45 cm long rise dramatically above the foliage, and a plant in bloom stands 90 to 120 cm tall. The flowers appear in early June, a time when few other tall plants are blooming in the perennial border. The plants are at their best in full sun but will tolerate light shade without stretching or flopping.

The wild sennas, *Senna marilandica* and *S. hebecarpa* (formerly known as *Cassia marilandica* and *C. hebecarpa*), are members of a large, primarily tropical genus, which includes plants from delicate annuals to sizable trees. Readers who have visited the tropics may be familiar with the arborescent species with their showy, bright yellow flowers followed by long, cylindrical, black pods. However, the species considered here are herbaceous perennials native to much of the eastern United States. They are similar in most respects, but *S. hebecarpa* is the more floriferous, and therefore the better ornamental. *Senna hebecarpa* is really an excellent plant, better than many commonly grown perennials. At 1 m tall it is a substantial plant, almost shrubby in aspect. The pinnate foliage is attractive throughout the summer and turns a pleasing yellow in the fall. The 2 cm, bright yellow flowers, with thick brown anthers, are borne in clusters from the upper leaf axils in August. The plants do well in full sun or light shade and once planted should be left undisturbed, because the long, thick roots make transplanting hard work.

The sunflower family (Com-



Baptisia australis

positae) has given us many of our prized herbaceous ornamentals, both annual and perennial. In what is probably the largest of all families of flowering plants, it is not surprising that many beautiful species still await discovery by gardeners. *Aster* is a particularly neglected genus, although most gardeners are familiar with the Michaelmas daisies, which are derived from a few of our native *Aster* species. Most of the species are attractive and gardenworthy in their wild state. *Aster solidagineus* and *A. concolor* are two southeastern species: one begins the aster season and the other ends it, respectively.

Aster solidagineus and several closely related species are often called white-topped asters and based on several technical characteristics are sometimes segregated as the genus *Sericocarpus. Aster solidagineus* is a particularly neat and attractive plant. Several to many stems with narrow, 2–5 cm long leaves arise in a clump about 38 cm tall. They are topped in July with a myriad of 1 cm flower heads. The heads are unusual among *Aster* species, because the ray and disc florets are the same color and the number of rays is usually less than 10. This plant does not provide a great splash of color, but it is wonderful as a delicate accent near the front of the border. It should be grown in full sun.

Aster concolor is very different from *A. solidagineus.* When I first saw it, while driving along a country road near my new home last September, I did not immediately recognize it as an aster. As the 60–90 cm stems are long and unbranched, with narrow, erect inflorescences, I took it to be a late-blooming gayfeather (*Liatris*). The color of the flower heads — pale purplish disc florets and violet rays — added to the deception (although the uppermost heads had not opened first as they do in the gayfeathers). In the garden this plant can be used much like the gayfeathers, though it is not quite so stiff and formal as those plants are. It also blooms later than the commonly cultivated *Liatris* species. The small silky-hairy leaves make the plant attractive even when it is not in bloom. Like many asters, it is best if grown in full sun.

This is just a small sampling of the many wonderful plants that await trial by gardeners. All of those discussed above are available from a few specialty nurseries, including Woodlanders, 1128 Colleton Avenue, Aiken, SC 29801, and my own, WE-DU Nurseries, Box 724, Route 5, Marion, NC 28752. Far North Gardens, 16785 Harrison Road, Livonia, MI 48154, supplies seed for some.

Richard E. Weaver, Jr., is the former horticultural taxonomist of the Arnold Arboretum.

More on *Forsythia* 'Meadowlark'

Dale E. Herman and Norman P. Evers

With extreme flower-bud hardiness, showy flowers, quality foliage, ease of propagation, adaptability, and vigor, *Forsythia* 'Meadowlark' promises to become a popular ornamental shrub for northern landscapes. Introduced last year by the agricultural experiment stations at North Dakota and South Dakota state universities, in collaboration with the Arnold Arboretum, the selection is hardy in the northern plains, where forsythias were previously unsuccessful. Flower buds have shown hardiness at temperatures of −35°F, and the plant is therefore recommended throughout zone 3 of the USDA and Arnold Arboretum hardiness maps.

The plant originated via the breeding work of Dr. Karl Sax and Haig Derman at the Arnold Arboretum. It resulted from a cross of *Forsythia ovata* (early forsythia) and *F. europaea* (Albanian forsythia). Dr. Harrison Flint, while working at the Arnold Arboretum, observed a plant from this population in full bloom after the unusually cold 1966-67 winter, while a mass planting of *F.* × *intermedia* 'Spectabilis' surrounding the new hybrid was nearly devoid of flowers. Flint propagated and distributed the plant, which was eventually tested by the authors in North and South Dakota. It has bloomed consistently in these states for 10 years.

'Meadowlark', which begins to bloom when only three years old, bears bright yellow flowers in profusion in early spring. In size and quality they are superior to those of both parents, and their color is a deeper yellow than that of *Forsythia ovata.*

The shrub is vigorous, drought-tolerant, and rapid growing, reaching a height of 2 to 2.75 m. Its spreading form is dense and regular.

The mature leaves are ivy green and maintain their color until late fall. A purple-bronze cast is the first indication of fall color, though the leaves often change to golden yellow under favorable fall conditions. The foliage is luxuriant and virtually pest free throughout the growing season.

This plant may partially replace several pest-ridden *Cotoneaster* and *Lonicera* (honeysuckle) species. It may also be used instead of certain large *Caragana* (pea shrub) and *Philadelphus* (mock orange) species with inherently leggy growth habits.

The selection is easily propagated from softwood cuttings in a 1:1 (by volume) peat-perlite medium, with 90 to 96 percent rooting common. It can also be propagated by semihardwood cuttings, by hardwood cuttings (with bottom heat), and, in limited numbers, by layers.

Forsythia 'Meadowlark' was officially registered in January 1984 by the Arnold Arboretum, which serves as the registration authority for the genus *Forsythia.* To date, 13 wholesale nurseries have initiated commercial propagation. Distribution to retail nurseries will begin in spring 1985.

Propagation Materials Available

Anyone interested in commercial propagation of this selection may send written requests for materials to: Dr. Dale E. Herman, Department of Horticulture and Forestry, North Dakota State University, Fargo, ND 58105. Dormant, bare root liners will be available for shipment between March 10 and May 10, 1984. Hardwood cuttings can also be supplied. Potted liners will be supplied in June and July 1984 if prior arrangements are made for pickup. Softwood cuttings can be supplied during June.

Dale E. Herman is a professor of horticulture and forestry at North Dakota State University, Fargo. Norman P. Evers is an instructor in horticulture and forestry at South Dakota State University, Brookings.

BOOKS

How to Grow Tree Seedlings in Containers in Greenhouses, by Richard W. Tinus and Stephen E. McDonald.

USDA Forest Service General Technical Report RM-60. Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Fort Collins, CO 80526. 256 pp.

JOHN H. ALEXANDER III

An appropriate subtitle for this book might be "The Mass Production of Seedlings for Forestry." Not a book for the home gardener, it is a manual for the professional nurseryman or prospective nurseryman.

Intending to give as much information as possible, a system of "Confidence Levels" is used to indicate assurance in some of the research. "Level A: thought to be complete and accurate. Level B: believed to be valid, but is subject to further testing. Level C: based on observation . . . offered in the view that some knowledge is better than none."

The authors begin with the question, "should you grow your own trees?" and go on to discuss the alternatives, carefully guiding the reader through the steps necessary to determine the most appropriate size and location for a container nursery.

The first 33 pages give advice for determining size and site. A market evaluation is encouraged, and production costs are discussed, as are the availability and cost of fuels, water, and labor. Regarding the latter, the authors note that "... one laborer for each 120,000 trees and at least one technical supervisor for each 3,000,000 trees may be used as a rule of thumb."

The next three chapters describe the physical plant, including topics such as greenhouse heating, cooling, and humidity controls. These are followed by chapters on containers and media, temperature and humidity, and lighting. It is the combination of temperature control and lighting that affords the great advantage of greenhouse growing over the more traditional outdoor-production methods. Lighting systems for photosynthesis and for the prevention of dormancy are described. Three standard methods of preventing dormancy are discussed. "Photoperiod can be extended by continuous lighting 4 to 8 hours after sunset or before sunrise. Night break lighting employs 2- to 5-hour interruptions during the dark period. Cyclic lighting is brief interruptions of light repeated every 5 to 30 minutes throughout the dark period. This may require lighting only 2% to 10% of the time." Responses vary with species and within the species when growing genotypes from climatically different areas.

The longest chapter, "Mineral Nutrition and pH Control," provides suggestions for monitoring and controlling the pH and the salt concentration in the growing medium. The authors provide a table of published works on the nutrition of forest trees, which lists research on over 40 species. They also list publications that contain color photographs of known nutrient deficiencies for 19 species. Much emphasis is given here to the preparation and modification of nutrient solutions to maintain optimum growing conditions continuously.

A chapter is devoted to formulating a growing schedule, and detailed growing schedules for 14 species are provided in an appendix.

When container-growing methods are employed for large quantities of seedlings, seeds are sown in the same container that the finished seedling will occupy. In forestry practices, that seedling tree is then planted in its permanent site outdoors. Since germination is seldom 100 percent, the nurseryman must determine how many seeds to sow in the space where he wants only one finished plant. Costs of thinning and of transplanting must be weighed; thinning is always less expensive, but the cost and availability of seed must be considered. This decision should be based on a predetermined germination percentage and the probability of germination in a proportion of the container cells. Probability tables are provided in the appendix.

Record-keeping and the efficiency gained through analysis are stressed throughout. Sample forms for maintaining records are included.

Some of the technological hardware discussed here is no longer available, having been superseded by new products and techniques.

In general, the information is well documented, readable, and frequently cross-referenced. Numerous charts, line drawings, and 45 black-and-white photographs amply illustrate it. An extensive bibliography is provided also. Although this book is primarily concerned with the growing of species important to forestry, it has much information that will be helpful to any production-oriented nurseryman.

Scaly bark of the American smoke tree (*Cotinus obovatus*). Barth Hamberg photo.

The Arnold Arboretum of Harvard University, a non-profit institution, is a center for international botanical research. The living collections are maintained as part of the Boston park system. The Arboretum is supported by income from its own endowment and by its members, the Friends of the Arnold Arboretum.

Summer 1984

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The Magazine of the Arnold Arboretum

An elm (*Ulmus pumila*) having grown out of the trunk of a pine tree (*Pinus sinensis*) on the grounds of the Yao wang Temple, Malanyu, Chilihli Province, China. Frank Meyer, agricultural explorer for the U.S. Department of Agriculture, took this photograph in 1916.

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Front cover photo: 'Album', a cultivar of *Viburnum farreri,* a species Frank Meyer introduced into this country. *Back cover:* Street planting of the Bradford pear tree (*Pyrus calleryana* 'Bradford') in Cambridge, Massachusetts. Meyer collected the species in China in 1908. Gary Koller photos.

Page

Frank Meyer on his return from a collecting trip in the mountains of China in the early 1900s. Photo reproduced by permission of the U.S. Department of Agriculture.

The photographs on pages 5–12 and 16–25 were taken by Frank Meyer during his travels in China for the U.S. Department of Agriculture. Copies are in the collection of the Arnold Arboretum.

Frank Meyer, Agricultural Explorer

Isabel Shipley Cunningham

For 60 years the work of Frank N. Meyer has remained a neglected segment of America's heritage. Now, as people are becoming concerned about feeding the world's growing population and about the loss of genetic diversity of crops, Meyer's accomplishments have a special relevance. Entering China in 1905, near the dawn of the single era when explorers could travel freely there, he became the first plant hunter to represent a government and to search primarily for economically useful plants rather than ornamentals. No one before him had spent 10 years crossing the mountains, deserts, farms, and forests of Asia in search of fruits, nuts, vegetables, grains, and fodder crops; no one has done so since.

During four plant-hunting expeditions to China and Central Asia, Meyer enriched America's agricultural and horticultural resources, made important botanical discoveries, and improved the economy of his adopted country. As he fulfilled his promise to "skim the earth in search of things good for man," no hardship or danger deterred him. He sent the United States Department of Agriculture hundreds of shipments of live cuttings and thousands of packages of seeds, which resulted in more than 2,500 plant introductions. Though he published little, the 2,500 pages of his letters tell of his journeys and the plants he collected, and the USDA Inventory of Seeds and Plants Imported contains descriptions of his introductions.

Until recently little was known about the first 25 years of Meyer's life, when he lived in Amsterdam and was called Frans Meijer. Dutch sources reveal that he was born into a loving family in 1875. Frans was a quiet boy, who enjoyed taking long walks, reading about distant lands, and working in his family's small garden. By the time he had finished elementary school, he knew that he wanted to be a world traveler who studied plants; however, his parents could not afford to give him further education. When he was 14 years old, he found work as a gardener's helper at the Amsterdam Botanical Garden.

During the next eight years, Frans progressed to gardener and then head gardener in charge of the experimental garden. Hugo de Vries, director of the experimental garden, observed that Frans was intelligent, industrious, and dependable and trained him to be his assistant. He taught the boy French and English and allowed him to attend lectures on botany and plant propagation. In his leisure Frans studied languages, mathematics, and science and collected herbarium specimens of the plants of the Netherlands. When he was 20, de Vries arranged for him to study for six months at the University of Groningen.

Though he continued to work at the

Isabel Cunningham's biography of Frank Meyer, entitled *Frank Meyer: Plant Hunter in Asia,* was published in June of this year by Iowa State University Press.

Amsterdam Botanical Garden for two years thereafter, Frans felt faraway places beckoning until his desire to see the world became too strong to resist. For several months he wandered across Europe, using maps and a compass as guides. Once he almost lost his life in a blizzard when he crossed the Alps in an area where there were no roads. In 1900 he set out for England to earn money for his passage to America. A year later, in October 1901, he arrived in the United States.

When Meyer reached Washington, he presented a letter of introduction from Hugo de Vries to Dr. Erwin F. Smith, a bacteriologist at the department of agriculture, and found work in the USDA greenhouses on the Mall. For a year he was content in new surroundings. Then his desire to see what lay beyond the horizon led him to work as a gardener in southern California. There he continued to long for "farther off and unseen places." After 18 months he left California to study the flora of Mexico. He walked 1,000 miles, discovering new fruits and flowers every day, and felt that he was learning more about plants than books could have taught him in 10 years.

After returning to the United States in July 1904, Meyer found employment at the Missouri Botanical Garden, where he initiated the preparation of a list of seeds for exchange with botanical gardens in other countries. He planned to leave St. Louis as soon as he had saved enough money to explore the Andes; however, his destiny was to lead him in another direction. David Fairchild, head of the Foreign Plant Introduction Section of the USDA, for several years had been searching for an explorer to send to China. When he heard of Meyer's willingness to walk great distances and his passion for plants, Fairchild offered him this assignment and Meyer eagerly accepted. To train him for his work, Fairchild sent him on a 10-day trip to the New York Botanical Garden and the Arnold Arboretum. After examining Augustine Henry's herbarium specimens in New York, Meyer studied the tremendous collections at the Arnold Arboretum and received the advice of the director, Charles Sprague Sargent. Two days later he began his journey to China.

The First Expedition

Soon after Meyer reached Peking (Beijing) in September 1905, he hired a guide, cart, driver, and donkeys and set out into the mountains on a 10-day trip. A sweet, seedless persimmon four inches in diameter was his first major discovery. "As soon as the leaves are off," he promised Fairchild, "I'll go back to those trees and will try to send you a thousand scions." Sargent later predicted that this persimmon would add $100,000 to the American economy. In late autumn Meyer divided his collection of grape, apricot, and catalpa cuttings, pear, persimmon, and elm scions, and *Ginkgo biloba* and *Pinus bungeana* (white-barked pine) seeds. Then he mailed bundles to the USDA and the Arnold Arboretum. He never trusted anyone else to pack his cuttings and scions, for only he could judge just how much water he must wring out of the dampened sphagnum moss before wrapping each package first in oiled paper and then in burlap, which he stitched at the seams. If the moss were too wet or too dry, the material would not survive the long journey to America.

Meyer eagerly complied with the USDA policy of collecting ornamentals "when encountered." In January, when ice a foot thick formed on the canals, he returned to the Western Hills, where he had observed remnants of original vegetation around ancient temples. There he collected cuttings of the Chinese pistachio (*Pistacia chinensis*), a horse chestnut (*Aesculus chinensis*), a catalpa (*Catalpa bungei*), and a cultivar of the Peking willow (*Salix matsudana* 'Umbraculifera'). None of these trees was new to botanists, but all were virtually unknown in America. In the mountains he also found a columnar juniper (*Juniperus chinensis* 'Columnaris'), wild peach trees (*Prunus davidiana*) for use as a rootstock, the famous Peking pear (*Pyrus pyrifolia* var. *culta*), a promising maple (*Acer truncatum*), and a semidouble rose (*Rosa xanthina*) "to be shared with Professor Sargent." Sargent later wrote that this rose had been known to botanists only through Chinese paintings until Frank Meyer sent it to America.

The letters Meyer wrote during his first six months in China reflect a kaleidoscope of impressions and emotions: the miserable nights spent on brick beds in filthy inns, where he battled bedbugs, centipedes, lice, and scorpions; his joy when he "felt at peace with the whole creation" as he collected seeds of crimson oaks and flaming maples in the Ming Tombs Valley; the shock of awakening one night in Mongolia to find an assassin's knife a few inches from his throat;

Frank Meyer collected the globular-headed willow (*Salix matsudana* 'Umbraculifera'), below, in the Western Hills, Peking (Beijing) China.

his pleasure while watching his Chinese guide making his own herbarium collection; the frustration of lacking time to learn Mandarin and the many dialects of the Chinese language; and his pride in finding useful plants to send to his adopted country. He admired the Chinese people: "China is going to come to the front, for the people are a solid kind of men and they possess many sterling virtues. In agriculture, they are experts."

When authorities approved his plan to follow the Yalu and Tumer rivers to Siberia in search of hardy plants, he left Peking in late April for Newchwang (Yingkou) in Manchuria. There he mailed the USDA a collection containing the first oil-bearing soybean sent to the United States. He then set out through wild mountainous country with carts, mules, an intelligent guide, and a coolie "of doubtful character." Though he had no equipment for pressing or drying herbarium material, he frequently paused to gather specimens as he traveled. North of Mukden (Shenyang) he found a drought-resistant alfalfa, white peonies blooming in ravines, and a wilt- and bright-resistant spinach that was to save the threatened American spinach-canning industry.

When Meyer crossed to the Korean side of the Yalu at Antung (Dandong), he entered an unexplored region. For weeks he and his men followed narrow footpaths across mountain ranges and waded icy streams. He collected zoysia grass (*Zoysia japonica*) near the Yalu, and in the mountains a pyramidal cherry with bright green foliage, which Alfred Rehder of the Arnold Arboretum named *Prunus meyeri.* Farther north he and his party passed through primeval forests never before seen by Westerners. Though they lived on boiled oats during the last two weeks of the journey, they walked 20 to 35 miles every day. At last they reached Siberia.

From Vladivostok Meyer shipped his collection of 220 kinds of seeds and cuttings, as well as herbarium specimens, and then continued his journey north. At Nikolsk (Ussuriysk, formerly Voroshilov) he arranged an exchange of seeds of hardy plants with a government forester; in the countryside nearby he collected seeds of the Amur maple (*Acer ginnala*), which bore an abundance of rosy-red fruits.

He paused at Khabarowsk to mail his collection of pears, plums, nuts, wheat, barley, forage crops, and the Amur lilac *(Syringa amurensis).* He also arranged seed exchanges with the government agronomist and the head forester of the Imperial Domains there. At dusk he would watch the sun setting over the ice fields of the Amur, silhouetting the white birches against the dying purple of the western sky. One evening as he returned to his inn, three murderous ruffians attacked him, but he drew his bowie knife and defended himself so vigorously that they ran away.

Meyer spent Christmas at Kwan Tientse (Changchun) with a missionary who agreed to collect seeds for the USDA in exchange for seeds of hardy vegetables and flowers. After leaving his host, he traveled south in bitter cold but forgot the frigid air that froze his beard to his scarf as he watched the rising sun color the mountaintops rosy red. On January 21 he arrived at Mukden and prepared 20 large sacks of cereals and legumes for shipping to the USDA. Then a telegram ordering him to meet E. H. Wilson in Shanghai before February 10 abruptly canceled his plans to collect plants he had previously spotted in Manchuria.

When Meyer reached Shanghai, he learned

that Wilson had promised to send the USDA economically useful plants from the upper Yangtze and that he himself was expected to collect botanical specimens for the Arnold Arboretum in the barren Wu Tai Shan. He made no attempt to appear content with the bargain Sargent and Fairchild had made. Letters from both explorers show that their initial meeting was a disaster. Unaware that Meyer believed his own work had been undervalued, Fairchild also had chosen this time to convey Sargent's criticism of the USDA's failure to collect herbarium specimens "of the botanical species of which you have sent us seeds." Earlier Sargent had insisted that Meyer's work include the collection of herbarium material, but Fairchild had told Meyer that the department "did not place that much importance on herbarium specimens." Meyer nevertheless had collected herbarium material on his journey north and had shipped two boxes of specimens from Vladivostok. The contents of these boxes were badly damaged in a typhoon. Frustrated by this loss, Meyer replied that Sargent's criticism "is somewhat comical. It is just as if the department people were disappointed when Professor Sargent did not collect plants of economic interest on his journeys."

In April Meyer mailed 14 packages to the

Frank Meyer and his collecting party at 4,000 feet near Ying Tau Ko, China.

USDA and set out with his interpreter and guide for the Wu Tai Shan. "There goes nothing above fresh air, a blue sky above one's head, and if some mountains or lakes can be added, then life is worth living. I love exploring better than anything else," he wrote Fairchild. After reaching the mountains in a snowstorm, he studied the sparse vegetation and took photographs of the barren landscape. He then traveled south to Taiyuan. There he found quantities of *Rosa xanthina,* which bloomed early and freely and withstood cold temperatures and long periods of drought. At this point his interpreter and guide refused to endure further hardships, forcing him to return to Peking.

Sargent later complained that Meyer should have remained in the Wu Tai Shan until more vegetation appeared; Meyer replied that he could not have done so "unless I was of a barnacle nature, which God help me, I never hope to become." The following February he returned to gather seeds, staying in a room so cold that ink froze on his pen. For five days he collected seeds of several spruces, a pine, and a larch that had not been recorded previously. He also found two willows, a lilac, a rose, rhubarb, hull-less oats, and a rare hull-less barley.

A Chinese cart loaded with boxes of seeds, mostly wild peach stones and chestnuts, leaving Frank Meyer's hotel enroute to America.

After a trip to sultry Chekiang (Zhejiang) Province, where he collected edible, ornamental, and timber bamboo (including one now called *Phyllostachys meyeri*), Meyer traveled to Tsingtao (Qingtao) and began a journey across Shantung (Shandong) Province. In the Lau Shan he found a rare dwarf sorghum and a previously unknown yellow-flowered catalpa. Later he collected the Shantung plum-cot, a single yellow rose (*Rosa xanthina* f. *spontanea*) that bloomed profusely in rocky soil, and epiphytic orchids that Fairchild forwarded to the Royal Botanic Gardens at Kew.

As he and his guide searched for the celebrated pound peach of Shantung, soldiers warned them of robbers nearby. Meyer's party did encounter a band of outlaws the next day, but he held his pistol "glistening in their eyes" and saw the leader signal his men not to attack. The risks of the journey proved worthwhile near the village of Feicheng, where Meyer found the sweet and juicy peaches that sometimes weighed more than a pound. *Juniperus chinensis* and *Pinus bungeana* trees at least 1500 years old made this trip memorable. He also saw Chinese cabbages (*Brassica pekinensis*) weighing up to 40 pounds each, hawthorns (*Crataegus pinnatifida*) bred to produce fruit that made delicious preserves, a rare yellow-fruited hawthorn, and a dogwood loaded with dark green berries that the natives used as a source of oil for lamps. After four months he returned to Peking.

Meyer disliked the confining task of labeling, describing, and packing seeds and cuttings of the hundreds of plants he collected. To assist him in determining the correct Chinese names of the plants, he employed Chow-hai Ting, who continued to work with him during his later expeditions. While he labored indoors, he yearned for "the burning sun and the smell of the mountains." Sargent criticized him for covering too much territory, but he argued that he must travel widely in order to find plants that would make America "wealthier and better." He firmly believed that "any ordinary botanist" could stay in one place and collect specimens of shrubs and trees; identifying grains and fruits that might benefit humanity seemed to him infinitely more challenging.

To give his expedition "a fitting end," Meyer planned a series of journeys. In November a trip north to Jehol (Chengde) yielded acorns of oaks that looked like chestnut trees (*Quercus variabilis*) and 73 bundles of fruits, nuts, forage crops, and hardy ornamentals. But he despaired as he watched farmers cutting down trees. "I see with sad eyes the last vestiges of a once grand vegetation," he mourned. Late in January he worked in deep snow in the mountains beyond Peking, collecting the white-barked pine, a rare pyramidal white poplar (*Populus tomentosa*), persimmons, apricots, yellow plums, a free-flowering pink rose (*Rosa odorata*), and pods of a spiny locust (*Gleditsia heterophylla*). Since this tree seemed to be in a state of mutation, he asked Fairchild to send sets of pods to Sargent and to de Vries. He also assembled a large quantity of scions of the dry-land elm (*Ulmus pumila*), a dwarf lemon (*Citrus* × *meyeri*), a silver-blue juniper of dense habit (*Juniperus squamata* 'Meyeri'), and a dwarf lilac (*Syringa meyeri*). Published accounts state incorrectly that Meyer found this lilac (PI 23032) in the Wu Tai Shan. He bought *Syringa meyeri* at Fengtai near Peking on March 31, 1908. He previously had collected *Syringa villosa* (PI 22675) in the Wu Tai Shan.

After transporting his collection to Shanghai in May 1908, Meyer supervised the packing of 20 tons of plant material, including 2 zelkovas, a Chinese holly, 18 lilacs, 4 viburnums, 2 spireas, a rhododendron, a daphne, 30 kinds of bamboo, and 4 lilies. Throughout the four-week voyage to America, he exposed his plants to sun and air whenever the weather was mild and cared for a pair of rare northern monkeys that he was bringing to the National Zoological Park.

During a year in the United States, Meyer visited many agricultural experiment stations, forming a list of their needs to guide him on his coming expedition to Central Asia. Long before the discovery of germplasm, he wrote, "In the future we will create unheard-of strains of fruits and shrubs and trees and flowering plants. All we need now is to build up collections so as to have the material at hand." He eagerly returned to the Arnold Arboretum to study the extensive living collections and herbarium specimens there. When Sargent reprimanded him for his failure to collect a large number of the latter, Meyer responded that the USDA had sent him to China to collect plants of economic value; privately, he told Fairchild that he agreed with Sargent about the need for authentic material in herbariums. In response to Sargent's request for specimens of all the arboreal species that he might find in the future, he asked the USDA to authorize him to fulfill that request.

Frank Meyer's caravan crossing the Mussart Glacier in Chinese Turkestan (Yinjang Autonomous Region).

Meyer spent most of the spring and summer of 1909 "cooped up in that little office in hot and humid Washington." He sorted his hundreds of negatives and photographs and studied the 1,664 inventory cards that had accompanied his introductions. Of these, 1,297 had survived, and over 50 percent of the 497 varieties that he had sent as scions or plants were growing in America. He also completed his bulletin, *Agricultural Exploration in the Fruit and Nut Orchards of China,* before he received his appropriation and set out on a three-year journey to Central Asia.

The Second Expedition

Aware that he had begun his first trip to China without adequate preparation, Meyer prepared for his second by visiting European nurseries and botanical gardens. In England he spent a week studying the "wonderfully rich" herbarium at the Royal Botanic Garden. "If I had known that Kew is after all rather poor in northern Chinese material . . . I most certainly would have collected more," he wrote Fairchild. "It really hurts me now to find out how much more useful I could have been to mankind." He was impressed by the Chinese plant introductions that E. H. Wilson "kindly pointed out" at Veitch and Sons and at Kew. As he studied collections at the Jardin des Plantes and Vilmorin Nurseries in France and "other centers of accumulated knowledge" in Belgium, Germany, and Russia, he arranged plant and seed exchanges for the USDA.

When his itinerary took him to Antwerp, he acted as host to members of his family, whom he had been longing to see. "We are a crowd of eight people," he wrote Fairchild. "I am, of course, the most popular member, and they want me to talk for hours and hours about all my experiences." Four days together were not enough. He took his entire family with him for three additional days when he traveled to Brussels. Then he moved on to botanical gardens in Germany and Russia.

After a series of frustrating delays in St. Petersburg (Leningrad), Meyer received the necessary permits and journeyed to the Crimea. On a rocky cliff there he found the common privet (*Ligustrum vulgare*), which proved to withstand cold winters and drought in the upper midwestern United States. In addition to roots and seeds, he mailed to the USDA olive cuttings; herbarium specimens, to be divided with the Arnold Arboretum; and algae and fungi, for the New York Botanical Garden. Then, accompanied by an assistant and an interpreter, he boarded a steamer and crossed the Black Sea.

Meyer assembled a large collection and arranged several seed exchanges during four months in the Caucasus. An early shipment contained seeds of apples, cherries, almonds, and an evergreen hawthorn (*Crataegus meyeri*); several kinds of wheat; soil samples; and herbarium specimens to be "shared liberally with Professor Sargent." From his base at Tiflis (Tbilisi), he explored not only Georgia but also Azerbaidzhan and Armenia, sending the USDA grapes, plums, apricots, black barley, coffee made from soybeans, a new peony, and cuttings of the Paradise apple (*Malus pumila* var. *paradisiaca*) from its native habitat. In late April he and his interpreter left Tiflis on foot for the northern Caucasus. Despite snowstorms in the mountains, Meyer collected alfalfa, clover, and herbarium specimens of other plants. When he reached Baku, he sent the USDA fruit, grain, legumes, and alfalfa, as well as fossils and ancient pottery for the Smithsonian Institution. On May 30, 1910, he crossed the Caspian Sea to Russian Turkestan.

Vegetation in Russian Turkestan lacked variety, and the police there harassed Meyer continually. Nevertheless, before venturing into the Hissar Mountains south of Samarkand, he found the drought-resistant

A crowded street on market day in Tching to Tchun, Shensi, September 1914.

Kashgar elm (*Ulmus carpinifolia* var. *umbraculifera*) for settlers in the arid southwestern United States. No roads existed in the steep mountains and food was scarce; however, he collected the Siberian bush cherry (*Prunus prostrata*) and herbarium specimens of pistachio, almond, maple, and juniper. After stopping at cholera-infested Tashkent, where he hired a German interpreter of Russian, Meyer and his small party plodded across the desert through ankle-deep sand with 1,200 pounds of baggage.

When they reached Chinese Turkestan (Xinjiang Autonomous Region), Chow-hai Ting joined the party. From Kashgar (Kashi) they traveled to Yarkand (Shache) and continued south across "dreary expanses of sand and grit," relieved occasionally by oases sheltered by Russian olive shrubs (*Elaeagnus angustifolia*). Near Khotan (Hotan) Meyer collected a drought-resistant ash (*Fraxinus potamophila*), which later proved to be use-

The north side of a mountain densely grown with forests of the Thian Shan spruce (*Picea shrenckiana*), near Idin-Kul, Chinese Turkestan.

ful in Nevada, and two wheat cultivars (*Triticum aestivum* 'Ak-Mecca Boogdai' and *T. aestivum* 'Kizil Boogdai') that are still maintained in the USDA germplasm collection at Beltsville, Maryland. Returning to Kashgar on trails used only by natives, he and his men climbed barren mountains where food was scarce and then trudged across snow-covered deserts until they lost track of time. The tents of the fierce Kirghiz sometimes offered shelter from icy winds that froze their hot tea before they could drink it. On the mountainsides Meyer found a spruce species (*Picea schrenkiana*), several kinds of hardy wheat, hull-less barley, and alfalfa and cut scions of fruit trees, elms, willows, and rare poplars. He returned exhausted to Kashgar on January 1, 1911, after an absence of two months. There he packed and mailed seeds of peaches, nectarines, plums, and pomegranates; 11 varieties of sweet apricot kernels (*Prunus armeniaca*), pistachio nuts, and grains, as well as herbarium specimens of other plants.

Meyer and his party then set out across the desert to Aksu (Aqsu), where Chow-hai Ting took the main road east to China and the others followed a rough trail north. In a valley in the towering Tian Shan, Meyer collected two types of wheat (*Triticum aestivum* 'Kara Boogdai' and *T. turgidum*) that are stored in the USDA germplasm collection today. As his small party approached the Mussart Glacier, which formed a pass through the Tian Shan, they prepared for the awesome climb along shifting trails beside gaping chasms. They reached solid ground after six hours on moving ice and then scaled a steep ascent to 13,000 feet. Descending in deep snow at dusk, they camped in bitter cold. Though snow, rain, and hail fell during the next several days, Meyer "grubbed out" roots of climbing asparagus and a rare alfalfa (*Medicago platycarpa*), and cut scions of apples, apricots, and willows. From Kuldja (Guldja or Ining) he mailed 52 packages of roots and cuttings, including a hawthorn for the Arnold Arboretum. North of Kuldja he had difficulty finding a guide because he and his party were entering a "robber district." Though robbers "prowling around" disturbed their rest on four nights, they continued north across an alkaline plain where only artemisia and tamarisk grew. Finally they arrived at Chuguchak (Qoqek or Dacheng) in Mongolia.

After pausing at Chuguchak, Meyer and his interpreter trekked through barren and monotonous country until they reached the Altai Mountains in Siberia. Siberian irises (*Iris sibirica*), globe flowers (*Trollius asiaticus*), and daphne (*Daphne altaica*) covered the slopes and perfumed the air. Among patches of snow in alpine meadows, Meyer noticed primroses, gentians, anemones, and dense masses of pansies, buttercups, and violets. Near Lake Markakol he and his companions were forced to balance on fir logs as they carried hundreds of pounds of baggage across a rushing mountain stream. Even on a limited diet of bread, wurst, and tea, he enjoyed climbing range after range of snow-capped mountains. Camping under a majestic pine near a swift and icy stream, he rejoiced because "fear and wrong disappear in such surroundings." After descending at last to the lowlands, he and his interpreter reached Omsk on July 2, 1911, having walked about 1,000 miles from Kuldja. The journey along the border of Mongolia and Siberia had yielded extremely hardy apples, apricots, currants, and alfalfa, as well as two new pasture plants, *Lathyrus pisiformis* and *Vicia megalotropis*.

Mail from three continents awaited Meyer at Omsk, but a letter from Augustine Henry pleased him most. Dr. Henry, a former British consular official in China, had sent many herbarium specimens to the Royal Botanic Gardens at Kew. His letter complimented Meyer on his bulletin about fruit and nut culture in China. A USDA request for 500 pounds of seeds of wild *Medicago falcata* anchored Meyer in Siberia until fall. After his German interpreter of Russian returned to Tashkent, he traveled to Tomsk and spent 10 days studying herbarium material and conferring with professors at the university there. He then searched the area around Semipalatinsk where the yellow-flowered wild alfalfa grew in scattered locations. When he returned to Omsk, he mailed the USDA alfalfa, legumes, vetches, clovers, and two promising forage crops (*Astragalus sp.* and *Hedysarum sp.*), as well as conifer cones, samples of wheat, and herbarium specimens of other plants for Sargent. Though he had intended to go on to China, news of the revolution there forced him to turn westward.

Frank Meyer at 23 years old. Photo courtesy of *De Arde en haar Volken,* Amsterdam, Holland. From the Library of Congress collections, Washington, D.C.

As Meyer traveled along the Volga, he visited agricultural stations, nurseries, and universities, collecting seeds and scions of hardy fruits and 15 cultivars of the variable *Medicago falcata.* He also arranged exchanges of seeds and wheat samples. In a ravine near Saratov, he found a creeping vine (*Coronilla varia*), from which propagators developed Emerald crown vetch, a groundcover that now controls soils erosion on the banks of interstate highways. Though he had developed typhus malaria, he spent two days at Koslov (Michurinsk) with Gregori Mijurin, called the Luther Burbank of Russia, and mailed the USDA scions of some of the hardiest cherries, apricots, plums, and quinces in existence. He also arranged seed exchanges at the Kharkov Botanical Garden, the Moscow Agricultural Institute, and the St. Petersburg Bureau of Applied Botany. When his illness became severe, he stayed indoors long enough to complete a 38-page report on wild alfalfa and to pack wheat, barley, flax, herbarium material, and cones of a hybrid pine for Sargent.

In March 1912, he left Russia and visited his family and Hugo de Vries in Holland before going to England. At Cambridge he conferred with Augustine Henry and conveyed an offer from Fairchild to Kingdon-Ward. He also studied rare ornamentals at Veitch and

Sons and the Royal Botanic Gardens, where officials asked permission to publish some of his photographs. His assignments completed, he crossed the Atlantic on the *Mauretania*, passing through dense low fog just one day behind the *Titanic.*

Confined to an office in Washington once more, Meyer wrote reports and identified his photographs. Though Fairchild often urged him to record his botanical observations, Meyer found formal composition uncongenial. He prepared to return to China after only six months in America. Before departing, he spent two weeks at the Arnold Arboretum, studying the herbarium collections, taking notes in the library, and conferring frequently with Sargent, Wilson, and Jackson Dawson, superintendent of plantings. They welcomed him cordially, and he enjoyed discussing plant exploration in the interior of China. Sargent suggested that he send all rare woody plants directly to the Arnold Arboretum; however, Meyer could promise only to label all rare arboreal plants to be forwarded to the Arboretum. The relationship between Wilson and Meyer had changed since their first meeting. Wilson took time to show Meyer his own collection of *Prunus* and the newly introduced Chinese plants at Farquhar's Nursery. From Boston Meyer traveled to New York, where he visited botanists at the New York Botanical Garden and shared his knowledge of unexplored northern Korea with Roy Chapmen Andrews at the Museum of Natural History. Then he set out on a three-year expedition that would encircle the globe.

The Third Expedition

Meyer stopped briefly in England to consult William Purdom, the only Western collector except Potanin who had worked in Kansu (Gansu) Province in China. In January he crossed Russia and Siberia by train, stopping occasionally to visit potential USDA correspondents or to arrange seed collections and exchanges. Once in Peking he hired Chow-hai Ting as his interpreter and Johannis de Leuw, "a young Hollander," as his assistant. He soon mailed seeds of Swiss stone pine (*Pinus cembra* var. *sibirica*), Japanese larch (*Larix leptolepis*), Japanese fir (*Abies firma*), *Cryptomeria japonica, Zelkova acuminata,* and the Hinoki cypress (*Chamaecyparis obtusa*). After a brief trip to Shantung and a severe attack of malarial fever, he packed and mailed seeds of fine local varieties of vegetables and scions of the seedless Chinese jujube (*Zizyphus jujuba*), the English walnut (*Juglans regia*), and the Chinese walnut (*Juglans cathayensis*) for Sargent.

Because the Office of Forest Pathology needed to know whether the chestnut blight (*Endothia parasitica*) that was killing American chestnut trees was of foreign origin, the USDA asked Meyer to look for the fungus in China. Meyer searched the mountains beyond Peking and soon mailed specimens of the fungus to America; however, he observed healed wounds on the Chinese chestnut trees (*Castanea mollissima*) and reported that they appeared resistant to blight. After pathologists had grown cultures that proved the American chestnut blight had come from the Orient, they told Meyer that he had accomplished the most important work done in plant pathology in 10 years. Meyer was amused and wrote Fairchild, "Haven't you any more such problems to solve in China? They do not involve so much trouble as, for instance, bamboo culture or jujube problems."

Meyer delayed his expedition to Kansu for months because bands of outlaws were terrorizing the inhabitants of the interior. While he waited for conditions to improve, he shipped the USDA grains, legumes, a dwarf cherry (*Prunus humilis*), 150,000 stones of the promising bush cherry (*Prunus tomentosa*), 20,000 persimmon (*Diospyros kaki*) seeds, 1,500 pounds of *Prunus davidiana* stones, 250 pounds of chestnuts (*Castanea mollissima*), entomological and pathological material, and a wooden case containing several sets of 500 labeled herbarium specimens. He also sent scions and cuttings including *Viburnum farreri*. Sargent later declared that such a handsome shrub had not been introduced into America for a long while.

Meyer, de Leuw, and Ting finally left Peking by train in mid-December. At the end of the railroad they began a challenging journey across Shensi (Shaanxi) Province. In the rugged Ta hua Shan, where trails were too steep even for donkeys, Ting fell and sustained an injury. When they reached Sian (Xi'an), a doctor informed Ting that he could not con-

A field of Chinese cabbages (*Brassica chinensis*), near Huai-jau, in 1905.

tinue the journey to Kansu. While he rested, Meyer spent several weeks in the countryside near Sian. There he found heavenly bamboo (*Nandina domestica*), jasmine (*Jasminum nudiflorum*), the pagoda tree (*Sophora japonica*), the Chinese honey locust (*Gleditsia sinensis*), and the princess tree (*Paulownia fortunei*). He collected nine named persimmons, four named jujubes, chestnuts that appeared unusually resistant to blight, and a slow-growing privet (*Ligustrum quihoui*) bearing masses of black berries. In the southern United States this handsome privet now produces panicles of creamy white flowers and remains evergreen all winter. Meyer, de Leuw, and Ting left Sian on February 1 and crossed Shansi (Shanxi) and Honan (Henan) provinces, despite wind, sleet, and snow. Moving on to Shantung, Meyer collected scions.
of pears, apples, peaches, haw, quinces, and jujubes; 12 tree peonies (*Paeonia suffruticosa*) and 5 herbaceous peonies (*P. lactiflora*); and root cuttings of *Paulownia for-*

A row of watermelon plants (*Citrullus vulgaris*) in northern China, "where the duststorms blow so fiercely in spring and early summer that the plants would be blown to pieces if not shielded by windbreaks of reed stems."

tunei, Albizia chinensis, and *Populus tomentosa.* Then he and his men boarded a train for Peking.

Though he intended to explore Kansu, the difficulty of replacing Ting and the activities of a murderous band of outlaws called White Wolves delayed Meyer's departure. While he searched for an interpreter, he mailed the USDA 15 cases of seeds of the bush cherry, rooted rice plants, roasted soybeans, vegetables, and ornamentals. In desperation, he finally employed an interpreter who lacked experience in the field. Accompanied by de Leuw, Chi-nian Tien (the interpreter), and a coolie, he left Peking with 30 bulky pieces of baggage.

As they crossed the mountains of Honan and Shansi provinces, high temperatures and heavy rainfall spoiled their food and made drying specimens nearly impossible. Meyer nevertheless continued his journey with relays of pack animals, despite a band of outlaws nearby and several attacks of "this accursed fever." East of Pingyang (Linfen) he noticed a small green peach the size of a marble and recognized it as the original wild peach (*Prunus davidiana* var. *potaninii*). He found it repeatedly as he traversed Shansi, Shensi, Kansu, and the Tibetan borderland. Potanin had collected herbarium specimens of this peach in Kansu, but Meyer sent the USDA dried fruits, samples of the wood, scions, and 700 peach stones. Tired, dirty, and hungry, he and his men reached Sian on August 19, 1914, only to hear upsetting news of the outbreak of war in Europe. Despite official warnings that the roads ahead were unsafe, they continued their journey.

Between Sian and southwestern Kansu (Gansu) Meyer and his party climbed steep and slippery mountain trails and shared shelters with their mules or slept among idols in ancient temples. As they traveled, Meyer collected a large amount of herbarium material and dried it over charcoal fires. Though botanists then believed that *Pinus bungeana* grew only in Hupeh (Hubei) Province, Meyer found it in Shansi, Shensi, and Kansu as well. Approaching the Tibetan borderland, Chi-nian Tien and the coolie refused to continue the journey because they feared certain death at the hands of the Tibetans. When Meyer reached Siku (Zhugqu), he had spent three days trying to persuade Tien to abide by his contract.

By coincidence, a British plant-hunting expedition led by Reginald Farrer and his assistant, William Purdom, happened to be in the remote town of Siku at this time. Farrer, who had been sending the *Gardeners' Chronicle* a series of articles describing his "state of perfect isolation," heard of Meyer's arrival "in a tempest of surprise, by no means wholly pleasurable." Farrer and Purdom called on Meyer and then left Siku for several days. While they were gone, Meyer experienced "great difficulty with the interpreter and coolie. They left the inn and hid themselves." Farrer also described these events, although they took place in his absence: "Words flew until the interpreter descended the stairs with more precipitation than he would have chosen, followed by the coolie." He then added that Meyer's conduct so antagonized the townspeople in Siku that his life was in danger there. Though Farrer avoided saying that Meyer shoved Tien, recent versions based on Farrer's account state that Meyer threw Tien and the coolie down a flight of stairs.

When Meyer returned Farrer's visit, he explained that he had asked the magistrate to enforce Tien's contract. Since Farrer spoke Chinese, he accompanied Meyer to a hearing and helped to present his claims. "Had it not been for our presence indeed," Farrer wrote, "it is not easy to imagine how the American party could have extricated themselves from the present predicament." Farrer wrote that he assisted Mr. Meyer and "[sent] him on his way rejoicing." Actually, Meyer did not go on his way. Farrer and Purdom left for winter quarters, but Meyer used Siku as a base for two weeks. He first journeyed to the mountains south of Siku and across the Siku River into what was then Tibet (Xizang). After he had found the bush almond (*Prunus tangutica*), Potanin's peach, and other fruits, he returned to Siku. Then he followed the Siku River west, collecting scions of fruit trees and a hazelnut (*Corylus tibetica*) at altitudes up to 10,000 feet. Returning to Siku once more, he dried his herbarium material and negotiated with muleteers for the journey north to Lanchow (Lanzhou).

"A large bush of the Tangutian almond (*Prunus tangutica*) lodging in the crevices of a mighty rock. Such a situation proves the remarkable drouth-resistant qualities this almond seems to possess."

On November 19, 1914, Meyer and de Leuw began a challenging trip over snow-covered mountains without an interpreter or a guide. They crossed four mountain passes at elevations above 11,000 feet in a single day. Magnificent spruce trees 150 feet tall, splendid red-barked birches nearly 100 feet high, and groves of *Sinarundinaria nitida* (a type of bamboo) repaid Meyer for the hardships he endured. At Taochow (Lintan) American missionaries received him cordially and agreed to ship the USDA seeds of barley, oats, flax, and spring wheat in return for winter wheat, vegetable seeds, and flower seeds. He and de Leuw and their muleteers then climbed a chain of high mountains. Food was scarce and the White Wolves had left the few inns along their route in ruins. Nevertheless, Meyer enjoyed the rugged scenery and collected nuts, scions of fruit trees, herbarium specimens, and *Daphne tangutica*, "a first-class decorative." When he and de Leuw reached Lanchow, they had walked a thousand miles from Sian. Able to relax at last, Meyer spent the night reading 120 letters that awaited him.

During his stay in Lanchow, Meyer was disturbed by news of the war in Europe and by his failure to find an interpreter. Unsanitary conditions there also troubled him. All water used in the city came from the Yellow River (Huang He) in wooden buckets, and, "horrible to say, in these same buckets, all the waste water [was] carried to the river and thrown out." Despite these problems, Meyer set a record by successfully shipping live plant material from Lanchow to Washington. After a prolonged search, he abandoned hope of finding an interpreter to accompany him as he returned to Peking. He and de Leuw therefore prepared to make the difficult and dangerous journey alone.

Early in January 1915, Meyer and de Leuw left Lanchow with two muleteers, three mules, and a cart containing rare herbarium specimens. Setting out at daybreak each morning, they climbed windswept mountains and endured dust storms and bitter cold. When they reached the Kansu border, they encountered soldiers who suspected Meyer and de Leuw of carrying contraband poppy seeds and forced them to stand against a wall in preparation for immediate execution. Fortunately the soldiers changed their minds and escorted the two men to a nearby town for consultation with a superior officer. After a customs inspector in the town examined their baggage, he released them. For several weeks they trekked through Shensi (Shaanxi) and into Honan (Henan), crossing deep ravines and climbing steep mountain trails, despite fierce dust storms, icy winds, sleet, and snow. They finally reached the railroad, having walked 40 miles in 15 hours that day. When they arrived at Peking, they heard further news of the war in Europe and of Japanese aggression in China. "A dark cloud hangs over all humanity," Meyer wrote Fairchild. "If only we are not at the threshold of another dark age." Despite his concern, he labeled and packed a collection that included grains, alfalfas, soybeans, fruits, nuts, ornamental trees and shrubs, lichens and mosses, and cones for Sargent. Before leaving Peking for Chekiang (Zhejiang) Province, he tried to fill Fairchild's requests for seeds: 50 pounds of *Prunus davidiana,* a bushel of *Pistacia chinensis,* several bushels of *Pinus bungeana,* 75 pounds of *Ulmus pumila,* and a 1,000 pounds of *Zizyphus jujuba.* He also received a plea from the USDA: "We have been carrying out your suggestion and sending Professor Sargent one-fourth to one-half of all the seeds you are sending. Couldn't we propagate first and then share?"

Meyer and de Leuw traveled south in May 1915, stopping at Nanking (Nanjing) to arrange a shipment of seeds of the Chinese elm (*Ulmus parvifolia*) and *Albizia chinensis.* They reached Hangchow (Hangzhou) during the rainy season, but Meyer forgot the sultry weather when he saw hickory nuts in the

Floating rafts of bamboo poles, *Cryptomeria japonica* and *Cunninghamia lanceolata.*

markets. Knowing that the hickory never had been reported in China, Meyer questioned missionaries and learned that the nuts probably came from Yuhang (Linping) in the Pan Shan, south of Hangchow. At Yuhang he found that he must travel west several days. At last he discovered groves of hickories (*Carya cathayensis*) in sheltered valleys in the mountains and also observed *Ginkgo biloba* growing semiwild. Sargent later wrote Meyer that finding the hickory was by far his most interesting accomplishment from a botanical point of view. After parting from de Leuw at Shanghai, Meyer went to Japan. There he found the chestnut blight unrecognized but well established. His assignments completed, he left Japan for the United States.

At the USDA's plant introduction station, in Chico, California, Meyer inspected his thriving Tangsi cherries, jujubes, dwarf lemons, almonds from Turkestan, Chinese chestnuts, olives from Central Asia, and tung-tree seedlings. Best of all, he saw orchards of fruit trees growing on his *Prunus davidiana* stock in alkaline soil that had previously been considered useless, even for alfalfa. In contrast, the news of the loss of his shipment from China in a cyclone at Galveston was difficult to accept. He hoped that the rare herbarium specimens that he had collected in the interior of China might be salvaged, but all were lost.

Once more Meyer devoted much of his time in America to paperwork. He also visited agricultural experiment stations, gave lectures, and wrote the article "China, A Fruitful Field for Plant Exploration." In March he spent pleasant days with E. H. Wilson, Camillo Schneider, and Jackson Dawson at the Arnold Arboretum. Late in May he attended Wilson's lecture at the New York Botanical Garden before moving on to Boston. He stayed there three weeks, conferring frequently with Sargent and Wilson about his next expedition. He also enjoyed discussing plant propagation with Jackson Dawson and visiting him and his family. Before returning to China, he visited experiment stations in western states.

The Fourth Expedition

In Oregon Meyer studied the fire blight (*Bacillus amylovarus*) that was destroying American pear orchards. F. C. Reimer of the Southern Oregon Experiment Station, who had tested all available varieties of pears, told him that only the wild pears he had sent from China (the Chinese sand pear, *Pyrus ussuriensis*, and *P. calleryana*) resisted fire blight. He therefore planned to collect great quantities of wild pear seeds for use in developing a congenial immune stock for pears.

Three weeks after Meyer reached China, he and Chow-hai Ting set out to collect the Chinese sand pear in the Shingling Shan, northeast of Peking. Published accounts have confused this pear (*Pyrus ussuriensis*) with the Peking pear (*Pyrus pyrifolia* var. *culta*), which Meyer collected in the same region 10 years earlier. Thereafter he sent to the USDA not only seeds and roots of the wild pear but also a spruce (*Picea meyeri*), the Manchurian walnut (*Juglans mandshurica*), 15 cases of stones of *Prunus davidiana*, several hundred pounds of dried *Zizyphus jujuba*, 75 pounds of *Juniperus chinensis* berries, seeds of the huge *Brassica pekinensis*, lichens and fungi for the New York Botanical Garden, and acorns for Sargent. As he left for the Yangtze Valley, he admitted to Fairchild that he did not feel quite well, blaming "this never-ending, horrible war" for "making me feel like a ship adrift."

Meyer and Chow-hai Ting traveled up the Yangtze River (Chang Jiang) to Ichang (Yichang). "I am now on *Terra Sancta*," he wrote Fairchild. "Mr. Wilson and Dr. Henry had Ichang for headquarters for many years. I feel like a Christian in Palestine or a Mohammedan in Mecca." He soon began an extensive search for the Callery pear (*Pyrus calleryana*) and found the trees widely scattered on sterile slopes, sunny ledges, and in standing water in low areas. When he returned to Ichang, he was pleased to learn that the USDA had distributed 17,234 of his *Ulmus pumila* to settlers on the northern plains.

In a letter written during his stay in Ichang, Meyer said that America's entry into World War I caused him to feel so depressed that he could not eat or sleep. His doctor warned him that continued overwork, loneliness, and worry about the war, especially in the debilitating climate of the Yangtze Valley, could cause further attacks of "nervous prostration."

A few weeks later Meyer and Chow-hai Ting went to Hankow (Hangou), where Meyer looked forward to a visit from Liberty Hyde Bailey. "At last I will again meet somebody who is my superior in knowledge of plants," he commented. When Bailey arrived, he and Meyer visited markets and gardens and enjoyed "solid talks." In June Bailey returned to confer with Meyer for several more days. Meyer stayed in hot and humid Hankow throughout the summer, but Chow-hai Ting returned to the cooler climate of Peking in July. Before leaving Hankow, without any competent assistance, Meyer shipped the USDA a 260-pound crate containing citrus specimens, nuts, early rice, late soybeans, soil for nematode analysis, cones for Sargent, and entomological and pathological specimens.

After a 16-day journey through the mountains of Hupeh (Hubei), Meyer settled at Kingmen (Jingmen) where he had observed the greatest concentration of *Pyrus calleryana*. His frustration mounted as weeks passed, for the pears were ripening very slowly. He was forced to wait in order to extract the seeds and was unable to collect in the mountains north of Ichang as he had planned. By mid-October, he had accumulated 5,000 pounds of pears the size of marbles. Eventually he and his helpers cleaned and dried about 100 pounds of seeds. In addition, he harvested a large quantity of seeds of *Pistacia chinensis* and *Eremochloa ophiuroides*, afterward named centipede grass.

His solitude ended when F. C. Reimer arrived to study the wild pears in their native habitat. Meyer shared with Reimer "unreservedly" the information he had gleaned and showed him "special trees that it tooks weeks to spot." They then spent five days exploring the Chikang Shan west of Ichang. After Reimer departed, Meyer began a 17-day trip north of the Yangtze that took him almost to the border of Szechwan (Sichuan) Province. Along the way he found *Ginkgo biloba* growing "undoubtedly wild" for the first time. He also collected the Ichang lemon (*Citrus ichangensis*) and the kiwifruit (*Actinidia chinensis*) before returning to Ichang by rowboat. Though civil war had spread to Hupeh, he nevertheless explored for another week south of the Yangtze.

When Meyer reached Ichang again, he was trapped there by government and revolutionary troops that were fighting in the surrounding countryside. He filled the winter days by helping Westerners with their horticultural problems, arranging his herbarium specimens, and serving with other foreign residents on a defense committee. Despite rifle fire a mile from the city and stories of looting and atrocities, he occasionally took long walks in the country. All commerce stopped and food became scarce. In March he wrote Fairchild that "fighting occurs almost hourly and everyone feels depressed from this long-drawn state of suspension."

Meyer's Death

Meyer and his guide, Yao-feng Ting, slipped through the battle lines on May 2 and walked 80 miles past looted and burned villages. Though soldiers occasionally stopped them, Meyer was able to reach Kingmen and reclaim his baggage and collection. Then he walked 60 miles to the Yangtze, where he found a boat bound for Hankow. He planned to go to Shanghai to mail his collection and then to move to the cooler coast of Shantung to label and mail his herbarium material; however, he delayed leaving Hankow because he had contracted a severe digestive disturbance. On June 1, 1918, he and Yao-feng Ting boarded a steamer for Shanghai. The next day Meyer talked at length to a British passenger and felt well enough to have dinner for the first time since his illness began. Just before midnight the cabin boy reported that he could not find Mr. Meyer. The captain ordered a search of the riverboat, but Frank Meyer was not on board.

As soon as the American consul at Shanghai heard of Meyer's disappearance, he launched an investigation. Meyer's body was recovered from the Yangtze and brought to Shanghai for burial in the Bubbling Well Cemetery. *Horticulture* reported that Meyer fell overboard and was drowned, while the *American Nurseryman* called his death "one of those mysteries of the white man in the Orient." Sargent commented in a letter to Wilson, who was in Korea. "He may have committed suicide or some of the Chinamen may have thrown him overboard. This is certainly bad news, for he was getting to be a useful collector."

People on three continents mourned the death of Meyer. The supervisor of parks in Shanghai wrote that he "undoubtedly knew more about the economic vegetation of China than any other man." Liberty Hyde Bailey said, "I shall never cease to regret his untimely end; and I am more than ever glad that I had the two opportunities to be with him last summer, not only because I liked him personally, but also because he gave me so very many points of view and so much interesting information about China. . . . He was worthy of anything we can do to perpetuate his memory." From the Chosen Hotel in Korea, Wilson wrote to Fairchild. "I am much distressed over the sad end of Meyer and also deeply puzzled. By his untimely death plant exploration has lost one of the most energetic and enthusiastic servants it ever had." In a letter to Meyer's father, Fairchild said that the thousands of plants that Meyer had introduced had been increased to hundreds of thousands by propagation and had been scattered throughout America; however, he deeply regretted that Meyer's "remarkable fund" of knowledge had not been recorded and published.

Meyer's Contribution

Frank Meyer introduced plants that are still treasured because they are useful, beautiful, or new to botanical science. His efforts to find in remote regions "the rudimentary and long-forgotten parent stock or as yet unused wild plant that might be adapted to man's profit" furnished new germplasm for the development of improved varieties of fruits, nuts, grains, fodder crops, shrubs, and flowers. He opened the field of agricultural exploration in Asia. He also investigated methods of dry-land farming that the Chinese had perfected; developed the earliest USDA seed exchanges; established a group of USDA correspondents and missionary-collectors abroad; perfected techniques for shipping live material over great distances; and collected thousands of herbarium specimens. The National Arboretum in Washington holds a set of his documented specimens; other specimens are preserved at the Arnold Arboretum, the New York Botanical Garden, and elsewhere.

Drought-resistant trees and ornamentals previously unknown to botanists are among Meyer's significant introductions. His *Ulmus pumila* thrives from Canada to Texas and breaks the searing winds on formerly treeless prairies, while his *Pistacia chinensis* is used for street plantings in the Southwest. His new trees and shrubs include *Carya cathayensis, Citrus × meyeri, Crataegus meyeri, Juniperus chinensis* 'Columnaris', *Juniperus squamata 'Meyeri', Picea meyeri, Prunus × meyeri,* and *Syringa meyeri.* He was the first to send to America *Ligustrum quihoui, L. vulgare,* and *Viburnum farreri.* No other plant hunter in modern times found *Ginkgo biloba* in the wild or sent living plant material of *Prunus davidiana* 'Potaninii' and *P. tangutica* to the Western world.

Ornamental plants that have Meyer's introductions as their source include all hardy yellow roses that grow in New England or the northern prairie states, greenhouse roses that had as grafting stock his *Rosa odorata,* lilies propagated from his scarlet Korean *Lilium* species, and ornamental trees bred from his hawthorn, bush almond, Feicheng peach, and Callery pear. An outstanding example is the 'Bradford' pear, which Dr. John L. Creech of the USDA developed and called a living memorial to Frank Meyer. Other cultivars from *Pyrus calleryana* are 'Aristocrat', 'Chanticleer', 'Whitehouse', and 'Capital'.

The USDA still holds many of Meyer's trees and shrubs, including *Acer buergeranum* (USDA Plant Introduction No. 19411), *Acer truncatum* (PI 18578), *Diospyros sinensis* (PI 23013), *Malus halliana* (PI 38231), *Myrica rubra* (PI 22905), *Syringa meyeri* (PI 23032), and *Viburnum macrocephalum* (PI 22978). The Glenn Dale Plant Introduction Station in Maryland maintains a 100-foot-long *Ligustrum quihoui* hedge (PI 38807), while *Juniperus chinensis* 'Columnaris' (PI 18577) forms handsome hedges at Glenn Dale and at the National Arboretum. *Rosa xanthina* (PI 21620) apparently now grows only at the Arnold Arboretum.

Among the fruits that Meyer collected, *Prunus davidiana* not only proved to be a good rootstock for peaches but also enabled orchardists to grow apricots and plums on dry, alkaline soil. In addition, it has been used to develop a leading rootstock that is resistant to nematodes. His Tangsi cherry (distributed as *Prunus pseudocerasus*) continues to be a factor in breeding early cherries. Persimmons grown commercially in America, despite their Japanese names, are a direct result of Meyer's work in China. His *Prunus calleryana* remains the rootstock most resistant to fire blight and pear decline. The Meyer lemon (*Citrus × meyeri*) is an important source of frozen lemon juice in Florida and is also grown commercially in Texas, South Africa, and New Zealand.

The contributions made to American agriculture by Meyer's grains, fodder and forage crops, grasses, and vegetables were largely unrecorded. The USDA Small Grains Collection at Beltsville, Maryland, holds 10 of Meyer's wheats, while the National Seed Storage Laboratory at Fort Collins, Colorado, stores one of his soybeans and two of his sorghums. His centipede grass is used as a lawn grass in the Gulf States. Though his celery-cabbage, bean sprouts, alfalfa sprouts, and bean curd failed to interest his contemporaries, his *Spinacia oleracea* collected in Manchuria is in the breeding lines of most multidisease-resistant cultivars of spinach grown in the United States today.

Meyer acknowledged the pioneering nature of his work when he wrote, "We are only cutting out a few steps in the mountain of knowledge and others have to mount by our steps." Though he collected 42 varieties of soybeans and contributed careful studies of soybean products, especially as a protein substitute, this represented only a beginning. He laid the groundwork for future accomplishment when he found blight-resistant chestnut trees in China and when he collected zoysia grass in Korea. Others went to Asia later to collect soybeans, chestnuts, zoysia, peaches, and pears, but Meyer first pinpointed their location and revealed their value. Meyer's introductions often entered the mainstream of American agriculture unrecognized when propagators used them as unrecorded breeding parents. Though it is impossible to identify each use of a specific introduction, what is significant is that all uses were made possible by his initiative and discrimination.

"A large grove of Chinese pistachios (*Pistacia chinensis*) planted as a burial ground to the neighboring village. In the foreground are carefully planted beds of garlic."

Conclusion

E.H.M. Cox, who accompanied Farrer on his second expedition, wrote, "It is unfortunate that much of Meyer's work has been forgotten in comparison to the more showy introductions of other collectors who specialized more in ornamentals than in economic plants . . . . To most gardeners he is not even a name, but he has done more toward helping the economic life of a country than most plant collectors and his name should be a household word among American farmers."

Despite physical hardships and an increasing sense of isolation, Meyer pursued his goals courageously. He could have no more fitting epitaph than the words Fairchild wrote soon after his death: "Meyer's field work is done. Whether his body rests near the great river of China or under some of the trees he loved and brought to this country matters little to him. He will know that throughout his adopted land there will always be his plants, hundreds of them, in fields, in the backyards and orchards of little cottages, on street corners, and in the arboreta of wealthy lovers of plants. And wherever they are, they will all be his."

China remained fully open to foreign plant collectors for less than half a century, the Grand Age of plant exploration. Frank Meyer emerges from the shadows that have surrounded his life and work to take his rightful place beside E. H. Wilson, George Forrest, and Frank Kingdon-Ward, the giants of that memorable era.

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Biotechnology at the Arnold Arboretum

John Einset

Biology has made enormous progress during the last 30 years in understanding the chemical reactions that characterize living things. This burst of scientific discovery largely has resulted from two fundamental findings: (1) the identification of deoxyribonucleic acid (DNA) as the genetic material and (2) the elucidation of its detailed molecular structure. Because of these discoveries and the perfection of powerful chemical techniques for altering DNA molecules, biology has reached a stage at which it is now theoretically possible to manipulate the genetic makeup of organisms in specific ways. The term *biotechnology* is used to describe practical applications of this capability in medicine, agriculture, and forestry.

Although most discussions of biotechnology focus on the essential role of DNA biochemistry, biotechnology actually requires input from virtually every field of biology. The full realization of the potential of plant biotechnology, for example, will undoubtedly depend on a multidisciplinary effort, combining knowledge from biochemistry, physiology, morphology, anatomy, genetics, ecology, and systematics.

With the conversion of facilities at the Dana Greenhouses into scientific laboratories, the Arnold Arboretum has begun a new program of research in the use of tissue culture to gain further knowledge of the physiology of woody plants. The program is also expected to provide valuable information pertinent to the development of biotechnology for woody species.

Tissue Culture

Tissue culture involves the control of development in isolated parts of an organism placed under defined conditions of nutrient supply and physical environment. It was first employed as a basic research tool to identify chemicals that normally nourish and regulate development in plants. The ultimate objective of our research is to obtain a better understanding of plant hormones (phytohormones) and other factors that control plant growth generally.

As far as propagation is concerned, tissue culture is a relatively new technique, having been used extensively only during the last 15 years. To date, it is estimated that tissue-culture methods have been devised for over 300 plant species, although the technique is used commercially for only about 30 species. That is not to say that the impact of tissue culture has been minor. As a matter of fact, tissue culture is already an extremely valuable process for propagating plants with superior characteristics rapidly and for producing plants (via meristem-culturing) that are free of virus and fungal infections. Undoubtedly, these applications will continue to be important to agriculture and forestry in the future. Indeed, if the true potential of tissue culture in combination with DNA biochemistry can be realized, tissue culture may very well lead to revolutionary advances in applied plant biology.

Our program of tissue-culture research involves comparative studies of woody species in about 35 different families that represent a considerable degree of the diversity in the plant kingdom. The table below summarizes the families, orders, and superorders under study. Experimentally, we will investigate several of the physiological characteristics of these woody plants in tissue cultures. In this manner, we will be able to assess each species for its suitability for tissue-culture propagation and to study the factors that regulate growth and development in plants generally.

The families, orders, and superorders of plants under study at the Arboretum to determine their suitability for propagation by tissue culture.

- Superorder Magnoliidae
  - Order Magnoliales
    - Family Magnoliaceae (Magnolia)
    - Family Annonaceae (Annona)
  - Order Laurales
    - Family Calycanthaceae (Calycanthus)
    - Family Lauraceae (Laurel)
  - Order Ranunculales
    - Family Ranunculaceae (Buttercup)
- Superorder Caryophyllidae
  - Order Polygonales
    - Family Polygonaceae (Buckwheat)
- Superorder Dilleniidae
  - Order Theales
    - Family Theaceae (Tea)
    - Family Guttiferae (Garcinia)
  - Order Malvales
    - Family Tiliaceae (Linden)
    - Family Sterculiaceae (Sterculia)
  - Order Urticales
    - Family Ulmaceae (Elm)
    - Family Moraceae (Mulberry)
  - Order Ericales
    - Family Actinidiaceae (Actinidia)
    - Family Ericaceae (Heath)
    - Family Clethraceae (White Alder)
- Superorder Rosidae
  - Order Rosales
    - Family Rosaceae (Rose)
  - Order Fabales
    - Family Leguminosae (Pea)
  - Order Cornales
    - Family Cornaceae (Dogwood)
  - Order Myrtales
    - Family Melastomataceae (Melastoma)
  - Order Proteales
    - Family Proteaceae (Protea)
  - Order Euphorbiales
    - Family Euphorbiaceae (Spurge)
  - Order Sapindales
    - Family Aceraceae (Maple)
    - Family Staphylaceae (Bladdernut)
    - Family Sapindaceae (Soapberry)
    - Family Anacardiaceae (Cashew)
    - Family Rutaceae (Rue)
    - Family Meliaceae (Meliaceae)
- Superorder Asteridae
  - Order Gentiales
    - Family Oleaceae (Olive)
  - Order Polemoniales
    - Family Boraginaceae (Borage)
  - Order Lamiales
    - Family Verbenaceae (Vervain)
  - Order Scrophulariales
    - Family Bignoniaceae (Bignonia)
  - Order Rubiales
    - Family Rubiaceae (Madder)

The Importance of Comparative Physiology

Understandably, most current efforts worldwide to propagate woody plants in tissue cultures have concentrated on economically important plants, primarily in two families, the Rosaceae (which includes the roses, apples, and blackberries) and the Ericaceae (which includes the rhododendrons and mountain laurels). As a result, only a limited number of systematic groupings have been studied. It is because of this that we believe that the Arboretum can play a unique role in physiological research by conducting fundamental comparative studies on a broad range of woody species. This research will increase knowledge of growth regulation in plants and will also result in new technology for propagation, conservation, and improvement of these species.

From the perspective of basic plant physiology, comparative studies are particularly important now. Although much is known about the metabolism and physiological effects of the five major classes of phytohormones, most of the research on these subjects is based on experiments with just a few types of plants. The obvious question is whether concepts based on a limited number of species can be extrapolated to all plants. For example, our understanding of the apical-dominance phenomenon (the tendency of a single shoot to inhibit the growth of others) is based on extensive research with beans, peas, and tobacco. Comparative studies in tissue cultures will determine whether the same controls are operating in other species. Another subject of interest is cellular proliferation and the factors in plants that regulate it.

Studies on comparative physiology will also broaden the understanding of growth regulation and its evolution. It is already evident that plants vary in the ways they control their growth, and this variability can be documented and characterized through comparative physiology. This is an essential first step in understanding the evolution of growth regulation in plants.

Professor G. L. Stebbins, an evolutionary biologist with the University of California, has pointed out that different characteristics in plants evolve at different rates and that characteristics associated with essential aspects of plant life are the most slowly evolving. Because growth regulation is central to plant development, one would expect that it would evolve slowly. One would also expect that it would distinguish large systematic groupings rather than individual species within a genus. In this sense, comparative physiology potentially could become a complement to systematics, especially in addressing questions of the relationships of families and orders to each other.

The practical implications of comparative physiology, of course, are also significant. In a general sense these studies will define a framework of knowledge that relates propagation technology to systematic botany. Therefore, it will help to make propagation by means of tissue culture a predictable rather than a hit-or-miss procedure. Beyond this, the research will lead directly to new technology as illustrated by the examples in this article. It could also result in the identification of germ-plasm resources within important plant groups that could be valuable to biotechnology. In the family Leguminosae, for example, if species that are particularly amenable can be identified, then the characteristics that render them amenable potentially could be transferred by plant breeding into soybeans or other important legumes. For agricultural technology, the implications of this research are far-reaching.

Botanical Interpretation of Growth and Development

Knowledge of some botanical terms and principles is necessary in order to understand tissue-culture propagation.

The term *monopodial* refers to the condi-

Lilacs (*Syringa vulagaris* × *hyacinthiflora* 'Excel') being propagated in four different tissue-culture mediums. The medium in the second test tube from the left contains a high concentration of cytokinin, a hormone that is found in all plants and stimulates the most vigorous growth.

tion in which a single growing tip produces an unbranched stem from year to year. Extreme examples of monopodial growth can be seen in several palms in which a single stem constitutes the entire above-ground part of the plant. The contrasting condition is *sympodial* growth, which involves stem growth resulting from different growing tips. Sympodial growth is exhibited by elms, in which the terminal shoot tips abort from branches at the end of each growing season. As a result, shoot growth during the subsequent year always begins from a lateral bud. The sympodial growth condition is also evident in many tropical tree species in which both main stems and branches from lateral buds grow simultaneously.

Growth of lateral branches concurrent with growth of the main stem is also referred to as an example of *weak apical dominance* in contrast to *strong apical dominance*, a condition in which a growing shoot tip effectively inhibits growth of lateral buds in the axils of leaves below it. Physiologically, apical dominance is believed to involve two phytohormones: *auxin*, produced in the growing tip and transported to lateral buds, where it inhibits growth; and *cytokinin*, which stimulates shoot growth. According to the major scientific hypothesis on apical dominance, the relative levels of auxin and cytokinin in lateral buds determine whether the buds will or will not grow out. If auxin is in excess, the lateral buds will not grow, and a monopodial shoot will emerge. On the other hand, if cytokinin is predominant the lateral buds will grow, and a sympodial shoot will emerge. (An article by Michael Donoghue in *Arnoldia* [January/February 1981, volume 41, number 1] contains further information on terminology.)

Multiplying Plants in Tissue Culture

The most common procedure for multiplying woody plants in tissue culture is to add a high concentration of cytokinin to a complex nutrient medium. This environment stimulates shoot growth and overcomes apical dominance. The sympodial shoots that result are then subdivided into individual branches, and these are either recultured on the same medium, to increase the number of shoots, or treated with auxin to stimulate rooting. Rooted plants can then be transplanted to soil.

If the objective is rapid, clonal propagation, each branch can be excised and subcultured on the same medium. For example, at a multiplication rate of five shoots produced from one every month, this procedure theoretically would generate well over a million plants within nine months.

At the Arboretum rapidly expanding shoots of *Syringa vulgaris* × *hyacinthiflora* 'Excel' are taken from the plants in spring and disinfested with detergent and bleach. When these shoot tips are transferred to a medium with the cytokinin thidiazuron, within six weeks monopodial shoots develop and inhibit lateral buds at three to five nodes. A surprising characteristic of *Syringa*, which is shared by other genera in the Oleaceae, such as *Ligustrum* and *Forsythia*, is that shoots in tissue culture exhibit strong apical dominance that cannot be overcome by cytokinin. Shoot multiplication with these plants therefore requires a different strategy.

The procedure we devised is as follows: we cut each monopodial shoot into sections consisting of a node with two lateral buds and a piece of stem. We then culture individual sections on the cytokinin medium, where they each, in turn, produce a monopodial shoot that also can be separated into sections for the next tissue-culture passage. This procedure, when used repeatedly, can produce a million shoots from a single bud within one year. These can be treated with indole butyric acid and rooted in vermiculite.

A third method of tissue-culture multiplication is used with an uncommon amaryllis (*Hippeastrum striatum* 'Fulgidum'). This plant (see photo on page 33), a native of the tropical rain forests of Brazil, exhibits several characteristics that make it an excellent house plant. It blooms at least twice a year, producing many umbels of showy orange flowers. (Most commercially available *Hippeastrum* cultivars produce only one umbel with four flowers.) Its evergreen foliage remains vigorous and healthy throughout the year. Tolerant of low light and low humidity, the plant requires little care.

In using tissue culture to multiply this desirable *Hippeastrum* clonally, we adapted methods that had been used successfully for *Narcissus,* a member of the same family as the *Hippeastrum,* the Amaryllidaceae. We first cut the bulb of the plant into sections, each containing a piece of stem and the bases of at least two leaves. (A bulb is a compact shoot system with a short stem and several scalelike leaves.) Next each section is placed with its stem side down on a medium supplemented with powdered charcoal but lacking phytohormone. The charcoal apparently absorbs chemicals produced in response to the wound made in cutting the bulb. After about four weeks of incubation in the dark, each section forms a new bulblet in the axil of the two leaves. At this stage the bulblets are removed and cut longitudinally into two equal parts, each containing a piece of stem and at least two leaves. Within another four weeks each of these explants in turn will regenerate a new bulblet, which also can be cut in two and recultured as often as needed. Depending on the number of bulbs required, the tissue-culture method can be scaled up. We estimate, for example, that 1,000 *Hippeastrum* plants can be produced from a single bulb in six months.

Goals and Prospects

In all probability the variation among strategies of growth regulation in plants is a product of evolution just as any other plant characteristic is. Our rationale is that the mechanisms of growth regulation can be characterized, and their evolution can be described, by a systematic, comparative study of physiological expression in tissue cultures. We believe that over time this experimental approach will improve the understanding of developmental regulation in plants generally and will also point the way for new methods in biotechnology.

A second and equally important aspect of our research at the Arboretum is the direct analysis of the physiology and biochemistry of two phytohormones, cytokinin and ethylene, which are crucial to tissue-culture manipulations. By obtaining a better understanding of these substances, we hope to gain further knowledge of comparative physiology.

At present rapid progress also is being made in several areas related to plant biotechnology. In the last few years, for example, two completely new methods for hybridizing plants have been discovered. The first of these involves *protoplast fusion,* a process in which cells from two different plants are treated with enzymes to dissolve their cell walls, and the protoplasts then are mixed together under special conditions that stimulate them to fuse and produce a hybrid cell. Once this has been accomplished, tissue-culture techniques are used to produce a whole plant from that cell. Protoplast fusion was first achieved with species of tobacco, but it has since been used with potato and tomato plants and two species in the Brassicaceae (cabbages).

A second technique for genetically altering plants is one of the most elegant procedures in DNA biochemistry, involving the injection of bacterial DNA into plant cells. In the most sophisticated versions of this technique, a gene conferring resistance to a poison is isolated from bacteria and introduced via a bacterium into protoplasts from

The evergreen amaryllis (*Hippeastrum striatum* 'Fulgidum') produces many flowers, in contrast to the usual four of most commercially available amaryllis cultivars. By means of tissue-culture techniques, 1,000 of these plants could be produced from a single bulb in only six months. Peter del Tredici photo.

cells of petunia, tobacco, and carrot plants. Tissue-culture techniques are then used to produce poison-resistant plants.

The most desirable woody species for genetic modification at this time are those that permit the regeneration of whole individuals from single hybrid cells. Although few species are amenable to this type of manipulation at present, it is expected that more will become so as the factors that regulate development become better understood. In our research on woody species from the Arboretum's collection, we are especially interested in identifying such species. Not only are these of interest from the point of view of comparative physiology, but they also may represent valuable genetic resources for the biotechnology of plants. With the advent of biotechnology, the consolidating work of the Arnold Arboretum in botany and horticulture will have a profound impact.

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COLLECTOR'S NOTEBOOK

The Sweetleaf

Richard E. Weaver, Jr.

Many of our fine native shrubs are seldom seen in American gardens, either because they are unfamiliar to the gardening public or because they are difficult to propagate or transplant. *Symplocos tinctoria* is one of these plants. This interesting southeastern native is known by several common names: sweetleaf or horse sugar, because the sweet-tasting leaves are attractive to browsing mammals, and dye-bush, because the bark and leaves yield a yellow dye.

The sweetleaf is a shrub or small tree, occasionally to 9 m tall; it usually forms loose colonies from root sprouts, much in the manner of *Sassafras albidum*. The handsome leaves, 13–15 cm long and 3–5 cm wide, are thick and lustrous. They are clustered at the ends of the twigs and resemble those of *Rhododendron carolinianum* or the mountain laurel (*Kalmia latifolia*) except for the few, inconspicuous teeth along their margins. They often persist until November or December in the south. The delightfully fragrant, creamy white flowers are crowded into nearly stemless, very dense clusters, and they appear in April or May, before the leaves. A plant in flower somewhat resembles the various wild plums. The berries are yellowish and unspectacular.

Several varieties have been recognized by botanists. *Symplocos tinctoria* var. *tinctoria* occurs in hummocks and at the edges of swamps on the coastal plain from Delaware to Texas. *Symplocos tinctoria* var. *ashei* is a plant of the Southern Appalachians from North Carolina to Georgia. It is most common on dry ridges, but it also occurs in moist lowland forests. *Ashei* can be distinguished from *tinctoria* by its hairy twigs and earlier deciduous leaves. It certainly should prove to be the most cold-hardy of the varieties. A third variety, *S. tinctoria* var. *pygmaea*, a dwarf plant with small leaves and few flowers, occurs in sandy soil in a restricted area of southeastern Virginia.

Symplocos is a rather large genus of trees and shrubs widely distributed in the warmer areas of Australia, Asia, and the Americas. The sweetleaf is the only species native to the United States and is therefore the northernmost representative of the group in the New World. Several of the species are used on a small scale as dye plants, but few are cultivated for ornament. Only the sapphire-berry (*Symplocos paniculata*), a wide-ranging Asiatic species, is used for such purposes in the United States, and then only rarely. The sapphire-berry is a fine ornamental. With its open clusters of white flowers appearing after the leaves have partially expanded, and its beautiful blue berries, it is very different in appearance from the sweetleaf.

Very little information is available concerning methods of propagation of *Symplocos* species. Jack Alexander, propagator at the Arnold Arboretum, uses an alternative warm/cold stratification for the seeds of *S. paniculata*, but germination is poor. He said that softwood cuttings of the sapphire berry, taken in early July, had rooted well by September, when they were transferred to pots. Surprisingly though, not a single plant grew out the following spring. Alexander had no data on the propagation of *S. tinctoria*.

Several years ago I tried to collect plants of the sweetleaf in Burke County, North Carolina, for the Arnold Arboretum. I found that the plants in the colonies I sampled were mostly suckers from very thick, sparsely branching roots, with very few fibrous roots attached. Plants that reproduce in this manner are

Flowers of *Symplocos tinctoria* var. *tinctoria*. Robert L. Taylor photo. Reprinted by permission of the American Horticultural Society.

usually very difficult to transplant, and none of the ones I collected survived. Such plants usually can be propagated from pieces of their roots, however, and *Symplocos tinctoria* is no exception.

One- to two-inch pieces of root taken in December and January produced shoots within one month and roots within two months. Root growth has been slow, and the cuttings probably should not be disturbed until their second spring. I have not tried to germinate the seeds, as I have not been able to acquire any. They are seldom produced in the foothills of North Carolina.

Since the sweetleaf can now be propagated and transplanted easily, container plants should become available, and this interesting shrub will make its debut in American gardens.

Richard E. Weaver, Jr., the former horticultural taxonomist at the Arnold Arboretum, now operates WE-DU Nurseries in Marion, North Carolina.

Introducing *Betula platyphylla* 'Whitespire'

Edward Hasselkus

A narrow, pyramidal white-barked birch that is tolerant of high temperatures and resistant to the bronze birch borer was registered and introduced last year by the author at the University of Wisconsin–Madison.

Betula platyphylla var. *japonica* 'Whitespire' has a wide range of adaptability, from USDA hardiness zones 5a through 7a and possibly farther. The parent tree has been uninjured following exposure to winter temperatures as low as −30°F at Madison. Its seedlings have been undamaged by summer temperatures as high as 120°F in Oklahoma, where other white-barked birches defoliated at these temperatures. Seedlings in commercial nurseries have thrived under a wide range of soil conditions. Poor drainage, however, caused stunting and the development of chlorotic foliage.

The original 'Whitespire' birch is located in the Longenecker Horticultural Gardens of the University of Wisconsin–Madison Arboretum. Now 27 years old, this tree measures 10 m in height and 4.5 m in spread and has a distinctive spirelike form. Fine-textured in twig and foliage, the glossy leaves turn yellow in autumn. The chalky white bark is marked with black triangles at the bases of lateral branches and does not exfoliate.

In October 1956, seed of *Betula platyphylla* var. *japonica* (plant introduction number 235128) was collected from a single tree in Nagano Prefecture in southern Japan by John L. Creech of the United States Plant Introduction Station (Creech 1957). The collection site was an open field above Shibuyu Onsen at 1,530 m in the Yatsugatake Mountains. *Betula p.* var. *japonica* occurs in two distinct distribution regions, a massive northern distribution that connects eventually with the Siberian distribution and a separate distribution in central Honshu. A distinct band where the tree does not occur exists between these two regions (personal communication from John L. Creech, March 7, 1983). Creech's seed came from the southernmost part of the Central Honshu distribution and may represent the only introduction of the tree to this country from the southern disjunct population. This may account for its tolerance of high temperatures and consequent borer resistance.

Plants from Creech's seed were distributed by the U.S. Plant Introduction Station to the University of Wisconsin–Madison Arboretum and 33 other cooperators in the spring of 1957. In the spring of 1961, five trees were planted in a newly established birch collection on a droughty site in the arboretum. Three 27-year-old trees have remained free of the bronze birch borer, whereas plants of *Betula pendula, populifolia, pubescens,* and *utilis* and other

Opposite: *Betula platyphylla* 'Whitespire'.

seed strains of *B. platyphylla* var. *japonica* have become infested with borers.

The trees from Creech's seed are isolated on the site from other white-barked birches. The one with the most striking spirelike form has been named 'Whitespire'. Seed from this tree has been distributed annually to several nurseries around the country during the past eight years. Liners have been widely distributed as the "University of Wisconsin strain" of the Japanese white birch. No assurance exists that the seedling progeny is not hybrid; the relative isolation of the parent tree makes that possibility unlikely, however. Seven-year-old seedlings of 'Whitespire' birch have attained a height of 6 m and a spread of 2.7 m. They are extremely uniform, with well-developed white bark and the slender pyramidal form of the parent tree.

Vegetative propagation of this birch from cuttings has been unsuccessful. However, propagation through microculture has just been accomplished at a commercial micropropagation laboratory, providing the potential for clonal propagation of 'Whitespire' by the nursery industry.

Reference

Creech, John L. 1957. Plant Explorations: Ornamentals in Southern Japan. ARS 34-1. Agricultural Research Service, USDA, in cooperation with Longwood Gardens of the Longwood Foundation, Inc. Washington: U.S. Government Printing Office.

Edward R. Hasselkus is a professor of horticulture at the University of Wisconsin in Madison.

Books

Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation, and Uses, by Michael A. Dirr. Third edition. Champaign, Illinois: Stipes. 826 pp.

DONALD WYMAN

Michael Dirr's *Manual of Woody Landscape Plants,* now in its third edition, is a truly excellent selection for the plantsman's library. It is clear that the author has studied the plants and has spent many hours with them, noting their characteristics and discovering the various methods of propagating them. He has visited collections in this country and Europe, made detailed notes about each species, researched what others have to say, and especially has recorded his own observations.

The book describes 1,100 species, 300 of which are new to this edition, and over 1,500 cultivars. Mr. Dirr acknowledges the existence of hundreds of others too numerous to treat. For example, approximately 700 named species and cultivars of *Malus* exist, and may be growing somewhere in the United States, but it would take a lifetime to distinguish them. The author mentions those that he has seen and tells what he knows of them. Mr. Dirr wisely excludes most genera with large numbers of cultivars, such as *Camellia* and *Syringa,* which are unwieldy for a book like this, and instead lists other sources of information. He does list 40 cultivars of *Potentilla fruticosa,* however, an indication of his interest in these plants.

The list format of the text means that details of size, hardiness, habit, rate of growth, texture, bark and leaf color, flower and fruit characteristics, culture, propagation, cultivars, vulnerability to disease and insects, native habitat, related species, and landscape values are readily accessible. Such an arrangement can often mean dull reading, but the author saves us from that fate by his occasional digressions to relate little-known facts and personal observations, like the following. The literature recognizes 18 clones of the well-known native balsam fir, but none of these has proved worthy of commercial development to any significant degree.

The amateur gardener, especially, will find this book valuable, as it amasses a great deal of information that otherwise would be difficult and time-consuming to obtain. The entry for *Cotoneaster apiculatus* is an excellent instance of how much the reader can glean about a plant he or she may not know but may observe in a nursery catalogue. A section or morphology of leaves, stems, buds, flowers, and fruits and accompanying sketches is helpful in making the technical information understandable. The simple discussion of nomenclature will also be helpful to the amateur, as will the glossary of botanical terms. Pen and ink sketches used liberally throughout the text aid in identifying and comparing species.

The bibliography of 266 titles includes most of the available modern sources needed for a complete study of woody landscape plants. Anyone interested in creating a personal library would do well to begin with a selection of these. This is a fine book for any gardener's library, written by a man who knows his subject thoroughly.

Donald Wyman is horticulturist emeritus at the Arnold Arboretum of Harvard University.

Gertrude Jekyll on Gardening. Edited, with a Commentary, by Penelope Hobhouse. Boston: David R. Godine. 336 pp. $20.00.

AUGUSTUS M. KELLEY

Several of Gertrude Jekyll's books have been reprinted in recent years, testifying to a revival of interest in this great figure in the history of garden design. Now a handsome, well-produced volume, *Gertrude Jekyll on Gardening,* undertakes to give a comprehensive exposition of Miss Jekyll's philosophy of design. Composed of selections from Miss Jekyll's articles and books (especially her first, *Wood and Garden*), it makes available material that otherwise would be difficult to track down.

Miss Jekyll designed English gardens from the mid-1890s until the time of her death in 1932. She was one of three leaders of the so-called natural movement in garden design, with William Robinson, who is mentioned several times in this book, and Reginald Farrer. An essential characteristic of Miss Jekyll's work was the use of flowers in great drifts of carefully coordinated colors, backed by generous plantings of shrubs, climbing vines, and trees, and often massive walls or woods. Penelope Hobhouse, the editor of this book, maintains that it is feasible to apply Miss Jekyll's principles to smaller gardens, but I must demur on this point: I believe that scale is a crucial element in Miss Jekyll's work. We can enjoy reading about grand projects though and can profit from Miss Jekyll's encyclopedic knowledge of plants and gardens and her carefully worked-out color schemes. I might add that Miss Hobhouse's knowledge of these subjects also is considerable.

I have never seen a border as large or as beautiful as those designed by Gertrude Jekyll. The one at Wisley is large (approximately 46 m) but composed chiefly of specimen perennials. This book tells of great borders (60 m × 6 m) at Clivden, planted by Graham Thomas, who Miss Hobhouse believes to have been influenced by Gertrude Jekyll.

The major part of this book is organized according to the months of the year, with sections entitled "Color," "Water," and "Pergolas" at the end. That system must have been difficult to adhere to, as the editor often resorts to such connective phrases as, "But to return to May."

The editor's comments in general seem to me to interrupt the flow of Miss Jekyll's prose. I often found myself having to look back to see if I were reading Miss Jekyll or Miss Hobhouse. It might have been better to keep Miss Hobhouse's contributions separate, in footnotes perhaps.

Each monthly section is prefaced by a quotation from Miss Jekyll. I want to quote in full the one that introduces December, because it reveals so much of her basic philosophy.

> It is just in the way it is done that lies the whole difference between commonplace gardening and gardening that might rightly claim to rank as a fine art. Given the same space of ground and the same material, they may either be fashioned into a dream of beauty, a place of perfect rest and refreshment of mind and body — a series of soul-satisfying pictures — a treasure of well-set jewels; or they may be so misused that everything is jarring and displeasing. To learn how to perceive the difference and how to do right is to apprehend gardening as a fine art. In practice it is to place every plant or group of plants with such thoughtful care and definite intention that they shall form a part of a harmonious whole, and that successive portions, or in some cases even single details, shall show a series of pictures. It is to regulate the trees and undergrowth of the wood that their lines and masses come into beautiful form and harmonious proportion; it is to be always watching, noting and doing, and putting oneself meanwhile into closest acquaintance and sympathy with growing things. In this spirit the garden and woodland, such as they are, have been formed. There have been many failures, but, every now and then, I am encouraged and rewarded by a certain measure of success. Yet, as the critical faculty becomes keener, so does the standard of aim rise higher; and year by year, the desired point seems always to elude attainment. (*Colour Schemes* [1908] p. viii).

It is clear that natural gardening requires a lot of artifice.

Miss Jekyll's love of cottage gardens is evident throughout this book. For her, cottage gardens were a source of plants in particularly good forms (she differentiated between plants that do well on the show bench and those that do well in the garden), and their caretakers were a source of knowledge about growing techniques. Her familiarity with old country crafts and implements was extensive. There is an account here of her annual winter trip into the woods, with knife and sharpener, to cut hooked pegs from her beloved bracken for nailing down plants. Her description of a woodchopper splitting into four a big oak trunk with axe and wedge is profoundly moving.

I usually like to read the complete book or the complete article; with excerpts I have the nagging suspicion that I may be missing something. Yet I must admit that the material the editor brings together in this book is a powerful and true record of Gertrude Jekyll and her central ideas on garden design.

Augustus M. Kelley is the publisher of Theophrastus Books, Little Compton, Rhode Island.

Bark of *Betula platyphylla* 'Whitespire', a recently introduced birch species that is tolerant of high temperatures and resistant to the bronze birch borer. See page 38 for details.

The Arnold Arboretum of Harvard University, a non-profit institution, is a center for international botanical research. The living collections are maintained as part of the Boston park system. The Arboretum is supported by income from its own endowment and by its members, the Friends of the Arnold Arboretum.

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URBAN ISLANDS

Trees and Shrubs for the Inner City

This urban island in Newport, Rhode Island, includes *Ginkgo biloba* and a species of *Juniperus*. Photograph by Gary Koller.

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Front cover: Angell Memorial Plaza, Post Office Square, Boston. Small-leaved European lindens (*Tilia cordata*), box-leaved hollies (*Ilex crenata*), beds of annuals, and a small expanse of lawn adorn this well-maintained island of green in the heart of Boston's financial district. Photograph by Peter Del Tredici. *Back cover:* A cluster planting of Austrian pines (*Pinus nigra*) at the Ford Museum in Dearborn, Michigan. Photograph by Gary L. Koller.

Page


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Urban Islands: Who Will Maintain Them?

Charlotte Kahn

Camels can live in zoos; dolphins can live in aquariums; human beings can walk on the moon; trees can live in urban islands. What is at issue is not technical feasibility but extraordinary care. The question is this: in an era of diminishing will on the part of taxpayers to pay for improvements to the public sector, can we justify creating high-maintenance streetscapes that have more in common with exhibits in a zoo than with natural and self-sustaining ecosystems? And if so, how?

On a clear summer day in June 1984, Robert McCoy, parks commissioner for the city of Boston, and William Geary, head of the state's Metropolitan District Commission, met to celebrate the opening of the newly renovated Franklin Park Zoo. Standing together during the ceremonies, they noted with pleasure a distant view of yews being installed by a contractor in the median strip of Blue Hill Avenue. Their pleasure turned to chagrin when they realized that no funds had been appropriated to either agency to maintain the new median strip, nor had either of them been informed of the installation.

The improvements to the median strip were themselves the culmination of years of community pressure to refurbish a once flourishing commercial district: the plantings were meant to symbolize the city's commitment to sustained economic development and a brighter future for the neighborhood. Without an appropriation to one of the two agencies in question, or an organized effort to transfer stewardship responsibility to neighborhood residents or businesses, the two parks commissioners feared that the federally funded project would become instead another testament to the unmet needs of the community.

Like hundreds of trees and shrubs before them, these plants were being placed in their "urban island" habitats with a final squirt of water and perhaps a prayer. Few city and state tree-planting contracts specify the first (and most important) year's maintenance program, although most contracts guarantee replacement in six months or a year in the case of death. The plants struggle through their first year, their sparse green leaves barely acknowledging life, only to fail or become overgrown by weeds thereafter, beyond the reach of contract commitments.

Statistically, the life of a large plant in a small hole — whether planter or pit — is relatively short. The average life expectancy for a shade tree planted in a small urban island is but a fraction of its potential life span. Ac-

A five-year-old cherry that has not grown since it was planted. Photographs with this article by the author.

cording to Professor Clifford Chater of the University of Massachusetts' Shade Tree Laboratory in Waltham, such trees may live in their islands for "twenty years at most, and it may be down to ten on a practical basis."

Despite his own finding that 87 percent of the trees planted in Boston under contract within the past five years are alive, Professor Chater is not sanguine about the future prospects of these island inhabitants: "Don't expect them to grow normally. What you've got is essentially potted plants. Their roots are restricted, and roots can't grow without air. They're going to grow slower and die sooner. The roots of potted trees freeze earlier and harder, whereas those of most other trees in the Northeast keep growing until December. They struggle along but they don't look like much."

The huge old maples and oaks that we see in our mind's eye as we watch new street trees being installed were in all likelihood planted before cars or electricity were invented and before streets and sidewalks were paved with impermeable materials. Long past the early vulnerable years, their roots by now have had time to locate nourishment scores of feet from their stout trunks, to find pockets of water and air to sustain them. Plantings in urban islands, on the other hand, require extra attention: more design, more construction, more water, more care in watering, and more pruning because of winter dieback or vandalism. A tree or shrub whose roots cannot self-reliantly search for nutrients and water in a park, yard, expansive tree lawn, or generous 2 × 4 m tree pit is dependent for its survival on people.

The source of the problem is not a lack of technical know-how. Studies of plants in the urban environment usually contain charts detailing various tolerances and intolerances of plant species to a grim list of urban environmental woes: salt from streets and sidewalks, air pollution, compacted soil, constrained roots, night lighting, drought, and flooding. Urban islands of the usual sort subject their inhabitants to most of these. No tree (except the ubiquitous ailanthus, which literally seems to have found its ecological niche in a crack in the pavement) is adapted to all of the adverse conditions of most American cities. Plants in artificial environments require artificial life-support systems.

The people nominally responsible for their care in all likelihood work for a public agency — usually a parks department already staggering under budget cuts in the wake of recent taxpayers' revolts and cuts in federal funds. It cannot realistically be expected to provide the care required.

A newly transplanted tree requires about 40 liters of water per week during the growing season, preferably for two years. Alternatively, it needs a thorough soaking eight to ten times annually while in active growth. Even in a very wet year, nature will not provide enough water at regular intervals for a transplanted tree to thrive.

No matter how well planted or mulched, plants in urban islands will eventually be sharing their space with vigorous weeds. No matter how well loved by their human neighbors, they will occasionally require an expert's attention to prune a broken limb, examine a trunk for signs of insect infestation, or repair damage from a collision with a bicycle, tricycle, or truck.

Isolated trees and shrubs in urban islands, unlike those in parks or groves, often bear the marks of human aggression, frustration, or need. Plants already showing signs of stress are often the first victims of vandalism. On the other hand, plantings that are well-maintained often escape injury, even in the most heavily trafficked parts of a town or city.

A good example of these extremes can be found on the Boston Common at Tremont Street. There rows of flowers in rectangular brick planters at sitting level grow in undisturbed splendor day after day as pedestrians pass by or rest at their edge. Next to them, single trees in well-maintained, well-mulched round planters provide a neat visual counterbalance. Several of the trees in the round planters, however, are less vigorous and not so well maintained, for some reason, as the others. Weeds have come up through the mulch and several branches have died. These are the planters that attract bottles, trash, and sometimes sleeping persons. And why not? While the flower planters are clearly someone's pride and joy, the weedy tree planters just as clearly are not. It is unusual to see violence perpetrated on a space that succeeds in being a cheerful, thoughtful, well-maintained amenity for the people of a city. In this sense maintenance is not merely necessary to satisfy the horticultural requirements of urban island plantings but is essential in order to protect them from attack.

As a background to the question of maintenance, let us observe two recent trends: first, the environmental movement, which gained prominence on Earth Day 1970. As Richard Nixon's fledgling administration responded by setting up the Environmental Protection Agency, it also began to dismantle Lyndon Johnson's armaments for the war on poverty. Social programs, such as that created by the Comprehensive Employment and Training Act (CETA) (which for years enabled the Boston Parks and Recreation Department to hire provisional maintenance workers), were cut back. In Boston the number of parks department employees, including CETA and other workers not in the civil service, has decreased from a high of 2,042 in 1977 to about 350 today. The budget is dwindling, down to $7 million from $9.3 million in 1980 (when then Parks Commissioner Alan Austin characterized his budget as "grossly underfunded"). Despite the cuts in the parks department's funds, the number of urban islands in its care is rising. By the early 1980s auxiliary maintenance crews were gone. "Bricks and mortar" capital-improvement programs, on the other hand, were increasingly viewed as permanent investments in the urban fabric and continued to receive support. Although federal capital-improvement funds continued to flow, maintenance funds did not.

The environmental movement had set up expectations for human habitations: lace curtains came down; potted ferns and spider plants went up. A new generation of city dwellers began to expect plantings at the intersection of downtown streets. Landscape architects, urban designers, and federal administrators were only too glad to oblige. Urban islands were seen as a permissible green frill on the bricks-and-mortar investment: they made the brutalist architecture look better; people liked them; and they were relatively inexpensive. Maintenance funds, however, were out of the question. That was a job for local government.

Unfortunately for local government, a second societal trend paralyzed its ability to handle its new high-maintenance greenery. By the 1980s, taxpayers were enacting laws with names like Proposition 13 and Proposition 2½, designed to limit the power of state and local governments to raise revenues. Many middle-class families with children had moved to the suburbs, and older urbanites were experiencing the effects of mounting inflation. Faced with diminishing tax bases and a taxpayers' revolt, cities began to cut back, and parks departments' budgets (almost always among the first to go) were slashed.

After the passage of Proposition 2½ in Massachusetts, the Boston Parks and Recreation Department budget was cut 60 percent. In a report published by the Massachusetts Recreation and Parks Association, Boston was cited as "getting out of the recreation aspect and concentrating just on maintenance of physical facilities." The report went on to declare that "bathhouses and pools will be closed. No more water in park fountains or in the Public Garden pond. No more Christmas lights. Close all gymnasiums. Cut off all lighting of athletic fields. Closing of all city golf courses at Franklin Field and Hyde Park. Soccer, baseball, basketball, and other leagues sponsored by the Department will now have to find own coaches, referees, and equipment." Funds to maintain urban islands slid to the bottom of and finally off the charts. In Boston, they had never really been on the charts in the first place.

In 1979, for instance, at a time when urban islands were already looking perilously more like graves than groves, Mayor Kevin White, in a preelection city-improvement project, spent between $300,000 and $400,000 on cement planters for downtown streets. He had them filled with cherry, linden, and honey-locust trees. Nine months after the election, most were

An urban-island planting maintained by adjacent businesses.

in decline for lack of maintenance.

According to Michael Conners, chief horticulturist for the Boston Department of Parks and Recreation, all plants in the city 20 or 30 years ago were installed by or in careful coordination with the parks department. The locations of new plantings were based on a list of priority areas derived from requests from residents, and the parks department knew where the new plantings were. In Boston today, after almost a quarter century of one new initiative after another — urban renewal projects undertaken in the 1960s and early 1970s, Federal Highway Administration street improvements in the 1970s and 1980s, neighborhood revitalization with Federal Community Development Block Grant funds in the 1980s — the parks department has already given up trying to keep pace with new plans and plantings. Proposition 2½ was simply the last hole in an already leaking vessel.

Nevertheless, Boston's Department of Parks and Recreation is held responsible for almost half of the publicly owned green space in the city, the newer parts of which tend to be high-maintenance playgrounds, islands, and plantings of street trees. According to a recent *Boston Globe* article, the total area is 2,500 acres, including 50 parks, 90 playgrounds (with 168 ballfields), two golf courses, 82 squares and malls, 16 historic cemeteries, three active cemeteries, 125,000 trees, seven recreation centers, and two indoor and two outdoor pools. The department's horticulturists, however, only select plant materials for the replanting of city parks. All other planting — for new parks, islands, or street trees — is done by agencies or individuals who are not going to be responsible for the care of the plants over time.

A well maintained public planting on Boston Common that seems to inhibit vandalism.

Despite the complete inability of the parks department to take on any new responsibilities without an increase in funds, more new plantings are turned over to the city every year.

According to Valerie Burns, director of planning for the parks department: "Boston has no capacity to support new landscaping in the city. Nevertheless, new parks, urban islands, and street trees continue to be passed on to the department for maintenance after completion of the construction contracts. When another agency is planning to build a new park or streetscape, they talk to our engineers but not to our horticulturists." Burns says that some of the new plantings are "beautiful in design and execution but very difficult to maintain. Many of the new areas are very heavily planted and not very practical in terms of conception or execution. Not many landscape architects can see a project with a city department's eye. Trees and shrubs simply shouldn't be planted without a maintenance plan."

"Since Proposition 2½ we've only had two inspectors working on trees," says John Ruk, executive secretary of Boston's parks department. "Counting all the street and park trees, that's two men for more than 125,000 trees. In terms of tree planting, we can only respond to 5–10 percent of the requests. We subcontract out pruning and tree removal, and then only after we've had a complaint. It's impossible to fertilize — and water, forget it! We considered getting a water wagon once, but we realized that there was no way we'd have enough people to water the trees." Ruk remembers when the parks department had a budget that enabled the city to have a tree division with annual spring and fall plantings. Even then, he re-

Poorly maintained planters that have become receptacles for trash.

calls a parks commissioner in the early 1970s saying, "My God, the city's going bald!" He estimates that in the forties, fifties, and sixties, perhaps three times as many trees were planted in the city annually as are planted today. He sees the city's older, larger trees dying, mostly from old age or disease. Unless the city maintains its older plantings and replaces them as they die with young trees destined to have a better shot at their normal life expectancies than those now being planted in urban islands, Boston will indeed be bald.

Valerie Burns and Boston's parks commissioner Robert McCoy are trying to affect the way that public-improvement projects are funded. Says Burns: "I have never seen a project — ever — that had maintenance money attached to it. Some percentage of the federal capital-improvement monies has to be allocated for maintenance."

Money for maintenance — or the lack of it — is at the heart of the survival issue for urban planting projects and is especially critical for urban island designs, which by definition require extraordinary care. Like other elements of the public realm that our culture used to value and pay for, such as education and clean streets, city trees in islands or in parks now no longer seem affordable to a society that prides itself on being the richest nation on earth. Building the wealth of the public realm requires patience, commitment, stewardship. Trees and shrubs are planted in inappropriate places or without appropriate care and expected to produce benefits regardless: shade, flowers, cleaner air, and seasonal interest. All too often, they are destined to be stunted, leafless, with trunks gashed or limbs broken. While we know full well that few urban islands will

The lindens in this picture, installed in an urban island in 1979, were dead in July 1984.

produce their own version of a climax forest, we plant them nevertheless, taking advantage of this or that federal or state or city capital-improvement program without taking into account the long-term needs of the trees.

Boston's case is perhaps extreme. While most major cities incorporate many of their outlying suburbs within their limits (and thus are able to raise adequate funds through their property taxes), Boston is a relatively poor city surrounded by wealthier neighbors that do not contribute to its operation. As a result, Boston property owners and residents must pay for the maintenance of areas trampled daily by tourists, commuters, and visiting businesspeople. Taxes on meals, hotel rooms, and other sales go directly to the state: only a portion returns to the city as local aid.

To make matters worse, more than half of the property within Boston's city limits is tax-exempt — owned by large nonprofit cultural, religious, and educational institutions. In 1984 it is estimated that Boston lacks $50 million required for already trimmed basic city services. San Francisco, a city of equivalent population and parkland acreage, spends $55 per capita annually on its parks; Boston spends $12. Next year it may be less.

Money, however, is only part of the solution. Even cities with adequate financial resources do not necessarily allocate them to the maintenance of street planting. In Dallas, Texas, that city renowned for its oil and associated wealth, the same issues regarding maintenance recently arose. Trees for the Town, Inc., a nonprofit organization in Dallas, begins a pamphlet thus:

A failed planting in downtown Boston.

No municipal government that we know of maintains what are known as "street trees" (trees that grow in your parkway). In one sense these trees grow on municipal property. Traditionally, municipalities that maintain parks departments have their hands full maintaining municipal parks. Most city governments feel that they would have to maintain a larger labor force and buy more equipment to service these trees and thus leave the ordinary maintenance of the trees to the citizens. Many citizens still harbor the idea that their municipality maintains the street trees. This is not true here or elsewhere.

The solution arrived at by the founder of Dallas's Trees for the Town, Inc., Mary Robertson, is to organize neighborhoods block by block to hire arborists to maintain the plantings. "In our block there were five hackberry trees and twenty-three smaller red oaks. The arborist that we have selected to do the job charged $140.00 each for the four hackberry trees and $15.00 each for the red oaks, a total of $900.00 for the entire block. There are 18 houses on our block so we decided the costs of the project should be borne at $50.00 a house." For this price the trees were pruned and generally cared for, disease and injuries were treated, and girding roots removed. While Trees for the Town, Inc., is residential and upscale, it is nevertheless a practical approach to maintaining urban-island plantings in upper-income or business districts.

The state of California's Department of Forestry in 1979 produced a handbook entitled *The Hip-Pocket Urban Tree Planter.* It stated that "the limited city budgets allocated for trees frequently must be spent largely to remove dead or damaged wood, which presents a public safety hazard. Very little money is left for routine maintenance or for tree planting. With cutbacks in government spending, this problem seems bound to increase. Just as government can help people plant trees by providing professional advice and a streamlined permit process, people can help government by shouldering greater responsibility for planting and caring for trees. Through citizen Tree Boards, people can even take on some of the administrative, regulatory, and planning functions needed for a fully viable urban forest."

The handbook advocated forming a citizen's task force on trees, officially sanctioned by the city, to assess the city's tree-related problems and opportunities and work in partnership with government to solve them. This group, it states, "could evolve into a permanent tree board, working on a volunteer basis within government on behalf of trees."

Finally, the handbook recommends that arrangements be made for long-term maintenance. "Only plant what you can care for. Make sure that each neighbor understands his or her responsibility. . . . If the city is to help with maintenance, be sure this is clearly understood and that long-term maintenance funds are available."

Boston has had and still has its own version of this kind of program. In a project recently organized on Beacon Hill, one of the city's wealthiest neighborhoods, residents donate half of the funds needed to purchase the plants. The Beacon Hill Civic Association donates the other half, and the Boston Parks Department excavates and helps to plant the trees. Resident purchasers are then expected to care for their new greenery.

In the South End of Boston, for more than a decade the largest urban-renewal district in the nation, potted trees and urban islands have been planted as part of a variety of federal, state, and city programs. At one point in the early 1970s, the Boston Redevelopment Authority was encouraged to communicate with residents on several side streets being planted with trees. A beautifully printed green and blue card was attached to doors up and down the block: "Have you noticed the new trees in your neighborhood?" it asked. "These trees were planted by the Boston Redevelopment Authority as part of the public improvement program for your neighborhood. A tree provides oxygen, humidifies and circulates the air and most importantly, it humanizes and beautifies the city. However, there are some things you must do to keep it alive and well:

"1. Water the tree regularly during the growing season. About 10 gallons a week is sufficient.

"2. Keep the base neat and weeded, and keep pets away.

"3. Keep salt away in winter.

"These trees are yours to enjoy and care for."

Roger Erikson, landscape architect with the Boston Redevelopment Authority, credits this personal approach with the success of the trees planted 12 years ago. Also, Fred Smith, then a professor of landscape architecture at Harvard, insisted that the trees be surrounded by bricks in sand to permit the passage of water and air to the trees' roots.

A visit to a contemporary tree-planting project in the South End today, however, reveals that the bricks are being set in concrete, not sand, and that the trees are confined to 1-square-meter pits. It seems the Federal Highway Administration refuses to approve the use of bricks in sand in plantings, despite the obvious better health of trees planted in porous materials. No cards accompany these recent immigrants to the South End streets, despite the obvious "better chance" such communication would afford them. In an institutional context, it is as if each administration had begun its new term with a profound case of amnesia. Despite the advances of modern science, with regard to urban islands we seem to have forgotten more than we have learned.

In 1910 the Boston Parks and Recreation Department's landscape architect Arthur A. Shurtleff wrote to the Metropolitan Improvement League concerning

> an examination of Beacon Street, Boston, between Arlington Street and Massachusetts Avenue, to consider the feasibility of planting street trees upon its borders and to secure actual bids for planting such trees carefully in adequate pits and maintaining them for a period of two years after planting. . . . The attached specifications require the installation of irrigation pipes in each tree-pit and stipulate that the trees shall be properly watered by means of them during a period of two years. At the end of this period it is assumed that the care of the trees would lapse into the hands of authorities especially entrusted with the future maintenance of these trees. To permit the trees at this period to shift for themselves or to be cared for by the individuals upon whose sidewalks they might be growing would be to repeat the general history of Boston street-tree planting: while a few trees might thrive, the majority would decline through ill-advised care or the want of the most ordinary attention. To entrust them to the city would be to condemn them to a demise almost as certain, unless the authorities were bound by agreement to provide care which in the past they have not afforded to the city street trees at large. The residents of Beacon Street should assure the success of the tree-planting project, and realize a proper businesslike return for the money invested in the trees by taking perpetual care (or long-term care) of the trees through the same organization which carries out the plantings. In no other way can hoped-for results be assured.

Such assured but conservative advice may seem unduly pessimistic and expensive to admirers of urban greenery. And yet it is probably true. John Ruk of today's Boston Parks and Recreation Department agrees that to maintain urban islands and street trees properly, "I would have to have an army doing nothing but watering, weeding, fertilizing, and pruning."

> There are many excellent trees which grow well in the suburbs, but selecting trees for the built-up urban areas is most difficult. The absolute minimum of an open soil area about the trunk at the base of the tree is a square 8 feet on a side and 12 feet would be much better. . . . The size of the tree at planting time is important and, in general, one should keep in mind that the smaller the tree, the easier it is to transplant and the quicker it will start into vigorous growth. Trees that are 12–15 feet tall and 3–4 inches in trunk diameter are frequently used in planting a street, but it is a well-known fact that those which are planted 7–8 feet tall get off to a quicker start and within a few years will overtake the taller trees in growth. Also, when smaller trees are used at the start, it is possible to spend more money on obtaining the right kind of soil or mulching material for each plant and also to spend the time necessary to water the trees well after they have been planted. No street tree planting should be started without complete plans for watering the trees the first few years. A recent street tree planting in a large city started off with much fanfare in the local newspapers and over $50,000 was spent buying and planting trees. However, heavy droughts came during the first year, no money was available for watering the trees, and as a result, the program was a complete failure. No planting program should be initiated unless full care in mulching, fertilizing and watering can be given the trees in the first few years.
>
> Donald Wyman
> *Wyman's Gardening Encyclopedia*
> (Macmillan, 1971)

Says Professor Chater, "It's going to take money, that's all. You want trees, you've got to pay for them. You want parks, you've got to pay for them. But also, some money ought to be spent educating people, to make people more tree-conscious."

Unfortunately for Boston, which is certifiably broke, urban islands and perhaps even street trees may be a luxury. In a city facing high rates of unemployment among teenagers and young adults, it is not for lack of workers or need that its urban islands are not maintained by John Ruk's "army," but lack of funds. A Youth Conservation Corps or summer work program is all that would be needed to repair, replace, and maintain Boston's green heritage and future wealth, but funds are not available.

The only real solution to the problem is a change in funding priorities. Especially in areas where traffic is heavy, urban greenery must have a maintenance budget attached before it is planted. Federal and state officials must recognize that living amenities are not equivalent to bricks and mortar, and the public must begin to understand that you get what you pay for (unless you are prepared to volunteer to take up the slack, in which case you get what you work for). The public realm is our common wealth: we will never individually own and maintain what we could communally create and enjoy. Urban islands, like others aspects of the public realm, will be what we make them: symbols of our stewardship or proof of our indifference.

Charlotte Kahn is executive director of Boston Urban Gardeners, a nonprofit organization dedicated to improving the quality of life in Boston's low-income neighborhoods.

Island and Median-Strip Planting

William Flemer III

A generation ago the use of plantings to divide highways or regulate the flow of traffic on roads was rare, confined to wealthy residential areas in such cities as Philadelphia, Richmond, and Boston, to cite a few well-known examples. The parkways of Westchester County, New York, and Connecticut, as well as the Shirley Parkway along the Potomac River, were among the first divided roadways with planted strips between them. The plantings were meant to create restful driving conditions and to screen out headlight glare at night. After World War II, highway planting began on a nationwide scale when the huge network of the so-called national defense highway system was installed. Almost all of the superhighways had separated roadways for opposing lanes of traffic, and in all but the most congested urban areas the strips between the roadways were planted with trees and shrubs. Carefully kept accident-rate statistics for old-fashioned and divided-lane highways proved beyond a doubt that the benefits for median-strip planting far exceeded the costs of installation and maintenance.

Now the use of island plantings has begun to spread to other sites. Among these are the parking areas surrounding modern suburban shopping centers. These expanses of pavement become unbearably hot in the summer months, and locked cars quickly reach oven temperatures during the daylight hours. More and more local planning boards therefore are requiring islands of trees to provide shade and add visual appeal to these otherwise unsightly spaces. Merchants, too, find that although the islands reduce parking space somewhat, they are more effective than painted lines on the pavement in keeping automobiles aligned. Thus, improved utilization of space compensates for the loss.

In selecting trees and shrubs for islands or median strips, one must be aware of the special difficulties that such sites impose. Narrow median strips are especially difficult for trees and shrubs because of wind whip from speeding traffic. On highways especially, with cars and trucks speeding by at 60 miles per hour, the wind damage to foliage can be severe, both in the spring when the leaves are soft and tender and in the summer when weather is hot and dry. For this reason plants with tough, thick leaves are most successful.

In the colder parts of the United States and Canada (zone 6 and below), road salting in winter presents additional difficulties. Speeding traffic can create a salt spray as concentrated as ocean spray. The salt settles on plants and soil, and prevailing winds deposit large concentrations on the downwind side of roadways. It is essential, therefore, that trees and shrubs chosen for these areas are salt tolerant. It is no coincidence that tree species that thrive at the seashore are also successful in island plantings. Thus sugar maple, which is one of the choice species for residential surburban planting in its native range, is a poor choice for island or median-strip planting, while sycamore maple does well. Canada hemlock, which is also exceptionally susceptible to salt spray, should be avoided, while green ash and Japanese black pine (where it is winter hardy) are sound choices. Indeed the sugar maple decline in New England, about which so much was written 20 years ago, has since been attributed to salt kill. Maintenance crews tend to use salt with a lavish hand, a practice that ought to be vigorously curbed. Meanwhile, salt-sensitive species must be avoided in island plantings for cold areas.

Salt injury to trees in island plantings in parking lots can be very serious even though traffic is too slow to create salt spray. Here salt is spread on the pavement, and often before the snow is melted the salt and snow mixture is scooped up by front-end loaders and disposed of "out of the way" on the islands, to the detriment of the vegetation planted on them.

Ecological Requirements

The forested areas of the north temperate zone contain a wide variety of tree and shrub species. The greatest number occurs in areas where the old Tertiary forest was not extirpated during the last Ice Age, particularly the eastern United States, Japan, and parts of China. When cleared land is abandoned in naturally forested areas, a gradual process of forest regeneration begins. The first trees are "pioneer" species that can stand exposure to full sun and drying winds. After these have colonized the open field and matured, they are slowly replaced by so-called climax species, which are long-lived and shade tolerant when young. Climax species ultimately comprise the entire forest except on very exposed sites.

The ecological conditions of island plantings on highways are extremely harsh for tree growth, and only pioneer species or species from dry, inhospitable climates can be expected to grow well. Island sites are exposed to full sun and wind, as well as the turbulence caused by vehicular traffic. They are also narrow, so that natural penetration of rain to the root zone is inhibited. It is essential therefore to plant only those species that are tolerant of dry soil. Among the many species of small maples, the Japanese maple (*Acer palmatum* Thunb.), which is strictly an understory tree in the woodlands of Japan, quickly succumbs in island plantings. The Amur maple (*Acer ginnala* Maxim.), in contrast, thrives under conditions that are lethal to the Japanese tree. Not surprisingly, the Amur maple comes from the harsh climate of the Amur river valley of China, which is bitter cold in winter and hot and dry in summer. Our native eastern flowering dogwood (*Cornus florida* L.) grows poorly and is subject to drought stress and severe borer infestations in island plantings, whereas the native species of hawthorns are excellent for such locations. The cornelian cherry (*Cornus mas* L.), which grows out to the edge of the steppes of Russia, is another tree of choice.

Island plantings of shade trees are particularly exposed to wind damage. Although the Bradford callery pear (*Pyrus calleryana* Decne.) is otherwise suitable for islands, it is susceptible to breakage when it matures. It has been dropped by many state highway departments because of this but is still a favorite for sheltered locations in the downtown areas of cities. The tough-wooded bur oak (*Quercus macrocarpa* Michx.) can serve as an alternative to Bradford pear. This tree comes from the Plains States, where violent thunderstorms routinely occur each summer.

Trees and Shrubs Recommended for Island Planting

The following is a list of trees and shrubs that have proved adaptable over a wide range of soils and climates in the East and Midwest. For the subtropical climate of Florida and the desert conditions of the Southwest, of course, entirely different lists are needed.

Trees

Acer ginnala Maxim. Height 5–6 m. Hardy to −50°F. Amur maple.

This small tree has the unique characteristic of tolerance of extremes of heat, cold, and drought. It can be grown with several trunks or pruned to a single stem. The Amur maple's beauty lies in its leaves, scarlet in fall and a glossy dark green in summer. A similar species, *Acer tataricum,* merely turns yellow in fall and is much less cold hardy. The Amur maple is very tolerant of salts and alkaline soil and can substitute well for the Japanese maple (*A. palmatum*) in the Midwest, where the latter is not winter hardy.

Acer platanoides L. Height 15–18 m. Hardy to −30°F. Norway maple.

The common Norway maple has been much maligned in recent years because trees of seedling origin vary greatly, and many are distinctly inferior in growth habit, growth rate, and quality of foliage. The best grafted clones are much improved, however, and should rate high on the list of trees for difficult sites. The Norway maple will grow well in island plantings and in polluted conditions in cities, where the sugar maple and red maple will not thrive. It is one of the few species with attractive flowers, which are a clear chartreuse color and abundantly borne. The fall color is a fine yellow.

Acer pseudoplatanus L. Height 15–18 m. Hardy to −30°F. Sycamore maple.

Although it is not a particularly distinguished tree, the sycamore maple ranks high wherever salt spray or deicing salts are a problem. After the hurricane in the summer of 1948, it was the only deciduous tree with green leaves (no browning whatsoever) along the coasts of Rhode Island and Massachusetts. Trees from seeds are often mediocre, but the best clones of the variety *purpureum* are vigorous and shapely, and the purple undersurface of the leaves is particularly attractive. The tree tolerates dry soil, pavement glare, and alkaline or saline soils.

Celtis occidentalis L. Height 12–15 m. Hardy to −50°F. Hackberry.

The hackberry is one of the last trees to disappear from the landscape as one journeys west across the prairies. It also grows in the thin soil on basalt and granite hills in New England. It is not surprising therefore that it endures the stressful environments of island plantings. Plants from seedlings are variable, and many are subject to unsightly twig and foliar diseases. Grafted clones are available, however, which are both shapely and disease free. Clones and seedling trees are very tolerant of dry, alkaline soil and exposure.

The hackberry tree (*Celtis occidentalis*). Photographs with this article from the Archives of the Arnold Arboretum.

Cornus mas L. Height 5–6 m. Hardy to −30°F. Cornelian cherry.

The toughest of the tree-sized dogwoods, the cornelian cherry grows wild on the bleak steppes of Russia. It is not as showy as the large-flowered species (*Cornus florida*), but it becomes a haze of yellow in early April. The dark green leaves are thick and leathery and do not scorch in summer droughts. It is difficult to grow *Cornus mas* in tree form; it is best grown as a large clump. This tree is

Cornelian cherry (*Cornus mas*).

free of the borers or diseases that plague *Cornus florida.*

Crataegus crus-galli L. var. *inermis.* Height 6–8 m. Hardy to −30°F. Thornless cockspur hawthorn.

The common cockspur hawthorn is one of our toughest small trees, but because of its long, needle-sharp thorns, it constitutes a danger in areas where pedestrian traffic is present. The thornless form has the favorable qualities of the species without the dangers: tolerance of drought and exposure, fine glossy foliage, and long-lasting red fruits.

Crataegus phaenopyrum (L.f.) Medic. Height 6–9 m. Hardy to −30°F. Washington hawthorn.

One of the finest small-flowered trees for island planting. In the mini parks of downtown New York City, it thrives under the most adverse conditions. It is attractive, although not spectacular, in bloom. The glossy foliage turns red in the fall, and the brilliant red berries hang on until the following spring. Unfortunately, no thornless clone of this species is available, but its thorns are much shorter and less dangerous than those of *C. crus-galli.*

Fraxinus pennsylvanica Marsh. Height 15–18 m. Hardy to −40°F. Green ash.

While the white ash (*Fraxinus americana* L.) is preferable for its superior autumn color, it is not as suitable for stressful environments as the green ash, which will tolerate drought, heat, cold, and saline and alkaline soils with impunity. Seedling trees are variable, and many female trees set large crops of seed and defoliate very early in the fall. As is common to trees with a broad latitudinal range, green ash has a number of geographical races. Trees grown from Florida seed are as hardy as orange trees in North Dakota, while trees from North Dakota provenance grow as well as balsam fir would in Florida! Several fine male clones are available, all from the North Central States, where green ash is an important shade tree. 'Marshall's Seedless' is unsuitable, however, because nurserymen have found that it has begun to seed overabundantly.

Gleditsia triacanthos L. var. *inermis* Willd. Height 15–18 m. Hardy to −30°F. Thornless honeylocust.

The selection and introduction of a number of thornless clones with shapely crowns have transformed the honeylocust from an unattractive weed tree into an important street tree. The thornless honeylocust is rapid growing, easy to transplant, and tolerant of very difficult urban environments. Like green ash, it is among the trees that persist longest as one crosses the northern prairie states with their harsh extremes of climate and alkaline soil. Such tolerance for adversity is an indication of the honey-locust's suitability for island planting. It is particularly desirable for parking lots because its tiny leaflets blow away after dropping and do not have to be removed. Though cold hardy, it does not thrive in the very acid soils of parts of Maine and Nova Scotia.

Malus baccata (L.) Borkh. Height 9–12 m. Hardy to −50°F. Siberian crab apple.

A native of one of the world's harshest climates, the Siberian crab apple is a first choice among flowering trees for island plantings. It survives drought and a wide range of soil conditions. The flowers are red to pink in bud and pale pink to pure white on opening. Bloom is heavy on alternate years. The tree is virtually immune to apple scab disease and mildew and resistant to fire blight. In fact, in the Pennsylvania crab-apple trials, which have been conducted for many years, the only clones to receive recommendations have been *Malus baccata* seedlings or hybrids derived primarily from *baccata.* A very desirable feature of this species is its disease-free foliage, a trait that is shared by *M.* ×*atrosanguinea* (F.L. Späth) C. K. Schneid. and *M. floribunda* Siebold ex Van Houtte. Crab-apple trees chosen for island planting where pedestrian traffic is present should be trees that bear tiny fruits or few fruits.

Phellodendron amurense Rupr. Height 9–12 m. Hardy to −40°F. Amur cork tree.

Having originated in the fierce climatic extremes of the Amur River valley, this small, spreading tree easily endures poor, dry soil, reflected heat, and atmospheric pollution. Its lower branches must be pruned when the tree is young to prevent interference with passing traffic. The thick, corky bark of mature trees is an attractive feature. The foliage, which is free of pests and diseases, turns a clear yellow in the fall. Staminate (male) trees are preferable for urban settings, as pistillate (female) trees produce large crops of fruits.

Platanus × *acerifolia* (Ait.) Willd. Height 21–27 m. Hardy to −30°F. London plane tree.

This vigorous hybrid is the city tree par excellence, a standard against which others must be judged. Tolerant of drought, poor soil, reflected heat, and atmospheric pollution, it is easy to transplant and grows rapidly. The original clone, now often called the "Bloodgood strain" is resistant to anthracnose leaf disease, which defoliates our native sycamores during wet springs. The London plane tree has gone through several cycles of popularity and disapproval. Many years ago a few nurserymen grew the trees from seed that produced great variation in habit of growth and disease resistance, and this may be one cause for the disapproval. Another may be the plane tree's vulnerability to canker stain disease, a serious condition spread by pruning tools or other mechanical means. The severity of the disease once led the city of Philadelphia to enact ordinances that prohibited planting the tree. Still, where a large tree is needed for island planting, it is a first choice.

Pyrus calleryana Decne. Height 12–15 m. Hardy to −30°F. Callery pear.

The cultivation of the vigorous, thornless 'Bradford' pear by the U.S. Department of

Agriculture Plant Introduction Station at Beltsville, Maryland, transformed an unknown, thorny scrub tree into one of the most popular street trees. This tree has everything to recommend it: rapid growth, beautiful pure white flowers, and richly colored fall foliage. Like all pears, it grows well in compacted, poorly oxygenated soil. Brittle wood is its only weakness, and mature trees can literally collapse in a violent summer wind storm, as the parent tree did at Beltsville. The Pennsylvania highway department and others have removed it from their planting lists for that reason. However, for street or island plantings in more sheltered urban locations it is still an excellent choice. Several cultivars that are more wind firm and/or more cold hardy than 'Bradford' are now available in the nursery trade.

Quercus macrocarpa Michx. Height 18–24 m. Hardy to −50°F. Bur oak.

Many species of oaks make excellent shade trees under ordinary street conditions, but few thrive in constricted island plantings, especially where soil pH is high. Members of the black oak division of the family (pin, red, scarlet, willow, and black oaks) turn yellow from chlorosis under these circumstances and gradually die out. The bur oak is unique in that it grows well in alkaline soils, stands drought, heat, and cold and is tolerant of deicing salts. It is not so easy to transplant as the pin oak but is comparable in this regard to red and scarlet oaks. It grows slowly but becomes a tough, long-lived tree. Its native range extends farther west than that of any of the other eastern oaks, which means that it is naturally adapted to ecological conditions similar to those of island plantings.

Sophora japonica L. Height 15–18 m. Hardy to −30°F. Japanese pagoda tree.

This unusual summer-flowering tree has been in the nursery trade since the 19th century but only recently has become a popular street tree. It is one of the most variable of all species; a single seedlot can produce both dwarf weepers and tall, full-headed trees. Now improved clones with first-rate shade tree form are readily available. This species tolerates compacted soils (including the "brick yard" soils of Washington, D.C.), high pH, salt, drought, and polluted air. It is a conspicuous bloomer in August and retains its dark green leaves later in the fall than other deciduous trees. Like honeylocust it will not grow in highly acidic soils, however.

Syringa reticulata (Blume) Hara. Height 6–9 m. Hardy to −30°F. Japanese tree lilac.

This tough, hardy small tree is covered with huge panicles of white flowers in June, after the blooming season of most other flowering trees has passed. It withstands exposure and alkaline soils and is not troubled by mildew on the leaves or stem borers as are other lilacs. The lower branches must be pruned when young so that they will not interfere with pedestrian traffic. Several clones are now available, including one from Canada. These have been selected for their superior foliage, growth habit, and larger blossoms.

Tilia cordata Mill. Height 15–20 m. Hardy to −30°F. Small-leaved European linden.

Lindens in general grow well under city conditions, and the best clones of this species are especially reliable. Like those of the pagoda tree (*Sophora japonica*), populations of small-leaved lindens grown from seed are

Flowers of the Japanese tree lilac (*Syringa reticulata*).

The small-leaved European linden (*Tilia cordata*).

extremely variable. Growth may be either rapid or slow; wood is sometimes weak; and leaves may be small and leathery or large and easily scorched. Grafted trees do not exhibit graft incompatibility and reproduce exactly the very best forms. Easy to transplant, fairly rapid in growth, and tolerant of many soils and climatic conditions, they are excellent subjects for urban islands. The flowers are not conspicuous, but their rich fragrance is a great rarity among shade trees.

Tilia × *euchlora* C. Koch 'Redmond'. Height 12–15 m. Hardy to −30°F. 'Redmond' linden.

Much controversy exists as to whether this tree is a Crimean or an American linden cultivar. It has the large leaves and resistance to spider-mite attacks characteristic of American lindens. A compact, upright tree that is native to Nebraska, it is inured to climatic extremes of heat, cold, and drought and thrives in urban locations.

Ulmus × *hollandica* Mill. hybrids. Height 15–18 m. Hardy to −30°F. Dutch elm.

The Dutch elm disease, which was first identified in Holland, has destroyed a major portion of the splendid elm populations of Europe and North America during this century. In response to the crisis, the Dutch government selected and bred elms to produce forms that would be immune to the disease. Seven clones were distributed, some of which have demonstrated remarkable resistance to even the most virulent strains of the fungus. These have the upright, rectangular crowns of European elms rather than the wine-glass shape of American elms. Although vulnerable to elm-leaf beetle, they are exceptionally well adapted to urban street conditions and grow well in narrow planting pits and poorly oxygenated soil.

Zelkova serrata (Thunb.) Mak. Height 15–18 m. Hardy to −20°F. Japanese zelkova.

Not many decades ago this species was rarely encountered outside arboreta and botanical gardens. Seedling trees are very variable, and most have irregular, zig-zag habits of growth and small yellowish foliage. The original introductions came from the warmer regions of Japan and were not too cold hardy. It was not until the Dutch elm disease destroyed the American elm and the search began for replacement species, that zelkova began to receive serious attention. Hardier clones with excellent shade-tree shapes are now available and are being widely used on city streets. Tolerant of pollution, drought, and heat, they have shown remarkable vigor in downtown locations in Washington, D.C., and Baltimore, Maryland. They are not as cold hardy as most important shade trees but otherwise are excellent choices for island planting. Any tree with such a wide native distribution as zelkova must have hardy races in the colder parts of its range, and a serious attempt to find them would increase the uses of this excellent tree. Although artifical innoculations of *Zelkova serrata* with the Dutch elm fungus have demonstrated that this species is vulnerable to the disease, this factor can be ignored because the insect vectors of the disease do not feed on this tree.

Shrubs

Shrubs for urban islands should share the same characteristics as trees chosen for these sites. They must be tolerant of poor soil, drought, and exposure to wind and heat. Salt spray is just as damaging to shrubs as to trees in island plantings, and it is not surprising that several of the species listed below are also first choices for seashore planting. In addition, shrubs, like trees, are vulnerable to the problem of vandalism. The New York City Public Housing Authority has found that it is best to avoid shrubs with conspicuous flowers except for extremely vigorous growers such as forsythia. All of the shrubs listed below are on the approved list for the authority and have withstood the severest tests of time in very unfavorable inner-city conditions. They are relatively free from diseases and insect pests and can truly be termed low-maintenance shrubs.

Shrubs that grow to be too tall for their location can be safely cut down to the ground and will resprout and grow more densely than ever. On level sites a well-sharpened brush mower can be used at a great savings in labor costs. Cutting back is best done in November or December so that the cut surfaces can dry out and seal themselves before the sap begins to run in the spring. Also, cutting off at this time will result in the most vigorous regrowth.

Acanthopanax sieboldianus Mak. Height 2–3 m. Hardy to −30°F. Five-leaf aralia.

This dense, many-stemmed shrub is especially tolerant of poor, dry soil and atmospheric pollution. It is thorny and makes an excellent barrier planting. Other than its abundant disease-free foliage, it has no special beauty but is most useful for its vigor under adverse conditions.

Berberis thunbergii DC. Height 2 m. Hardy to −20°F. Japanese barberry.

Japanese barberry plants were once sold by the millions for low-growing hedges, but their use has declined as formal clipped hedges have lost popularity in home gardens. It is still useful as a barrier and tall ground cover, however, and will grow well in conditions of poor soil and neglect. The numerous, small thorns are needle sharp, a real deterrent to trespassers without being dangerous. The brilliant shades of scarlet foliage in the fall and the persistent red berries are very attractive. The redleaf form is colorful throughout the growing season.

Chaenomeles lagenaria (Loisel.) Koidz. Height 1–2 m. Hardy to −30°F. Flowering quince.

One of the most colorful early-flowering shrubs, the flowering quince resists vandalism because of its numerous prickly thorns. It is a popular substitute for the Kurume azaleas in cold areas where the latter are not winter hardy. There are numerous named clones with flowers ranging in color from pure white through various shades of pink and orange to deep crimson red. They vary in height and density, and the low, bushy forms are excellent for ground cover.

Deutzia gracilis Siebold & Zucc. Height 1 m. Hardy to −30°F. Slender deutzia.

This low, twiggy shrub has greatly increased in popularity in recent years for the purpose of mass plantings. It is covered with pure white flowers in May and has abundant pest-free foliage. It is also useful as a hedge but, being thornless, it should not be planted where it can be trampled by pedestrians. Several forms that are lower and more spreading are grown in Japan, but unfortunately these are not available in this country.

Elaeagnus umbellata Thunb. Height 3–4 m. Hardy to −40°F. Autumn olive.

The foliage of this species is not so showy as the pale silvery leaves of the Russian olive (*Elaeagnus angustifolia*). Yet is has the advantage of being better adapted to the Eastern States and other areas where summer humidity is normal. The extensive highway plantings of Russian olive in the East in the 1950s all have gradually succumbed to twig blight, while the disease-free autumn olive has become extensively naturalized in the same areas. Autumn olive is a superb tall shrub for roadway or seashore planting, withstanding salt, poor soil, and drought without setback. The silvery green foliage and pretty bronze-to-red fruits are decidedly ornamental. The U.S. Soil Conservation Service has introduced a strain grown from seed called 'Cardinal' with fruits that are a brighter red.

Forsythia × intermedia Zab. Height 2 m. Hardy to −20°F. Showy border forsythia.

Wherever it is winter hardy, this is one of the best shrubs for screening purposes. It is vigorous, pest free, tolerant of city conditions, and unaffected by deicing salts. Vandals do break off branches in the blooming season (April), but the plant quickly recovers from the injury.

Three excellent new clones of the much hardier *Forsythia ovata* have been bred for the northern Plains States and Canada, where border forsythias will survive.

Ligustrum obtusifolium var. *regelianum* (Koehne) Rehd. Height 2 m. Hardy to −40°F. Regel privet.

This is the only hardy privet that is low growing, dense, and spreading, and exceptionally useful for mass planting. One of the toughest shrubs for city use, it is a mainstay for adverse sites. Almost 100 years of extensive planting in New York City and elsewhere have shown that it is one of the most reliable shrubs for city landscaping.

Lonicera fragrantissima Lindl. & Paxt. Height 2 m. Hardy to −10°F. Winter honeysuckle.

This handsome semievergreen shrub is often listed as hardy to −20°F, but it is better grown at minimum winter temperatures of −10°F and above. It has leathery foliage and deliciously fragrant flowers, which open in March in the south and in April further north. It withstands poor soil and polluted air and is free of pests and diseases. Young plants are sparsely branched but fill out with age to form an impenetrable screen.

Myrica pensylvanica Loisel. Height 2 m. Hardy to −40°F. Bayberry.

One of the three most appropriate shrubs for the seashore, bayberry has proved to be equally indispensable for roadways. It grows wild in the poorest, most sterile soils and withstands salt spray, heat, drought, and polluted air. It is semievergreen in the southern part of its range, and the foliage is pleasantly aromatic. The gray-white berries of female plants last far into the winter. This is a dense shrub, spreading gradually by underground runners.

Potentilla fruticosa L. Height 1 m. Hardy to −50°F. Bush cinquefoil.

This hardy, drought-resistant shrub is suitable for mass planting in full sun but does not thrive in shade. It is not spectacular in bloom, but the pretty yellow flowers are borne over a long period during the summer. It is especially useful where summers are dry, with low humidity. Many cultivars are available, varying in flower color, habit of growth, and tolerance for adverse conditions. 'Katherine Dykes' is among the best for ground-cover use.

Prunus maritima Marsh. 1–2 m. Hardy to −40°F. Beach plum.

This was once a rarely grown native shrub chosen by knowledgeable landscape architects for mass plantings in seashore gardens. It is now extensively used, not only for the traditional seaside uses, but also for roadway planting, because it is so tolerant of salt spray and poor, sterile soil. The white flowers are attractive in the spring, and the fall foliage is more colorful than that of many other plums. The dense branching habit renders it useful for barrier planting.

Rosa rugosa Thunb. Height 1 m. Hardy to −50°F. Rugosa rose.

Generally regarded as the most beautiful of all the wild rose species, this splendid shrub is unsurpassed for mass planting. It is a seashore plant in its native Japan and has become widely naturalized in this country on the East Coast. The red, pink, or white flowers are deliciously fragrant, and the

Arrowwood (*Viburnum dentatum*) in flower.

handsome disease-free foliage turns orange and red in the fall. It thrives along the seashore and in adverse urban locations. Like other shrub roses, it benefits from being periodically pruned to ground level and grows best in full sun. Rugosa rose has the advantage of blooming throughout the summer, unlike most other wild roses.

Rosa virginiana Mill. Height 1 m. Hardy to −40°F. Virginia rose.

This species, the shining rose (*Rosa nitida*), and several other native species comprise a confusing group of very similar wild roses of doubtful identity. Whatever their taxonomic status, these plants are an exceptional group of shrubs for mass plantings in adverse locations. They are covered with fragrant pink flowers in June, and their glossy foliage turns scarlet in the fall. The red new stems and abundant red fruits are colorful throughout the winter. Easily transplanted, they withstand drought, salt spray, and exposure and are free from pests and foliar diseases.

Symphoricarpos ×*chenaultii* Rehd. 'Hancock'. Height 45–60 cm. Hardy to −20°F. 'Hancock' coralberry.

This low, rapidly spreading shrub from Canada is an excellent ground cover in full or partial sun. It has tiny, neat foliage and spreading branches that root wherever they touch the ground, forming a dense mat. Coralberry grows well in poor soil and is free of pests and diseases.

Viburnum dentatum L. Height 3–4 m. Hardy to −50°F. Arrowwood.

This splendid shrub is one of another cluster of species whose identity is doubtful. Although it inhabits wet, lowland areas in the wild, it is also drought tolerant and withstands salt spray and exposure. The foliage and stems are immune to the stem cankers and leaf spots that disfigure other hardy viburnums. The berries are an inconspicuous blue-black color, but the yellow and red fall color of the foliage is first rate.

Viburnum prunifolium L. Height 4–5 m. Hardy to −40°F. Black haw.

One of the tallest native viburnums, the black haw makes an excellent screening plant and can also be sheared to create a formal hedge. This is an upland species, inured to poor soil and drought. In autumn the smooth oval leaves initially turn pink, then red, and finally purple. The berries also change from green to pink and finally blue-black in the fall.

Island Tree Planting

Island beds for tree planting should be raised well above the level of the surrounding pavement. The runoff from the impermeable pavement can so concentrate rain and snow melt in a sunken island that death from root rot can occur. Although raised above grade level, the surface of the island also should be somewhat dished to retain rainwater (see figure 1). Plantings often fail when the soil is graded to an even crown so that water runs off instead of being absorbed. As noted earlier, the surface area for rainwater infiltration is very limited in island plantings, and because islands are surrounded by pavement, which carries off precipitation, the subsoil beneath is usually deficient in moisture. Thus, little capillary replenishment to the root zone can occur.

Because islands are small and their soil is often poor, too much peat or humus is frequently added to the beds. Many old backfill specifications called for up to a third or a half of the mix to be well-rotted manure or other forms of humus. Trees initially grow vigorously in such high-humus soils, but when the surrounding soil is clay, they begin to slow down and stagnate in a couple of growing seasons. Organic matter of any kind is gradually decomposed by soil bacteria and eventually disappears into the atmosphere as carbon dioxide. As the volume of humus in the backfill disappears, the tree settles deeper in the soil and roots become situated too deeply for proper growth. Arborists and landscape architects are now re-examining the old specifications for soil amendment. Unless the soil on the site is entirely unsuitable — a mixture of brickbats and rubble for example — they recommend adding fertilizer and enriching the existing soil with a minimum of humus, not more than 10 percent. Such minimal treatment avoids the interface problems that can occur when the backfill mix is very different in texture from the soil in which the planting pits were excavated. Since trees for island plantings have to be large enough in caliper to withstand vandalism, they are usually balled and burlapped rather than container-grown. These transplant with little difficulty and do not

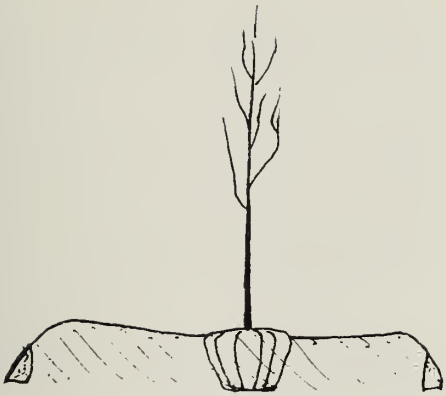
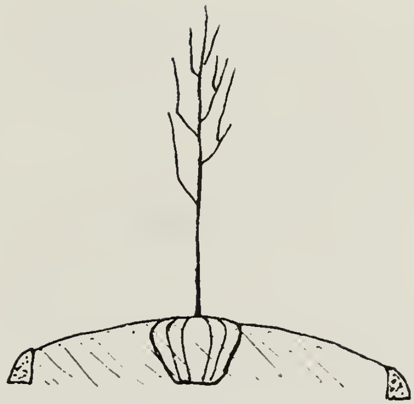


Figure 1. Dished island surface



crowned surface

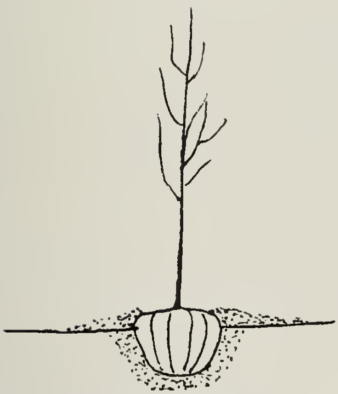
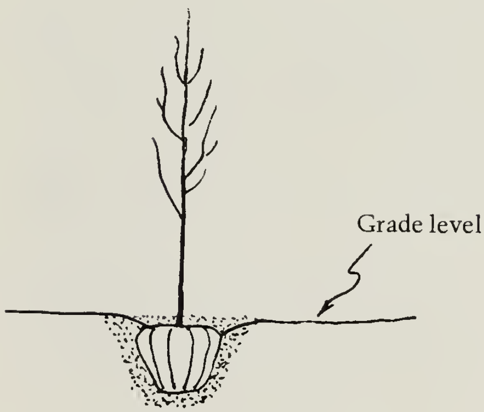


Figure 2. Planted high



Planted too deep

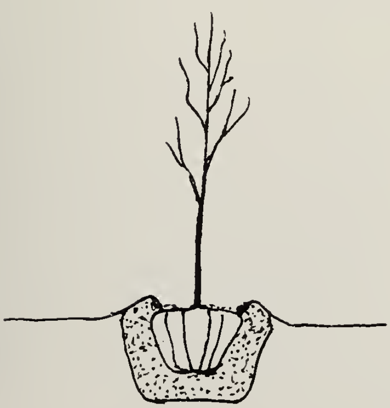
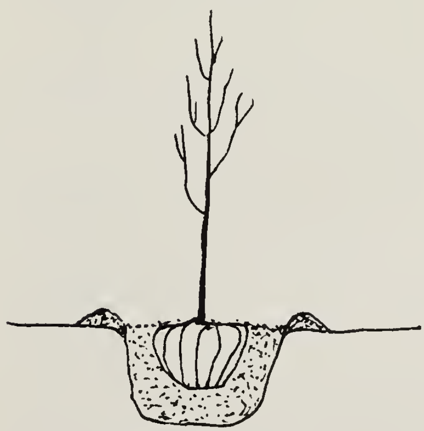


Figure 3. Improved method
Edges of basin placed over edges of ball



Traditional method

need high-humus backfills. If the existing soil is a heavy clay and requires lightening for proper air penetration, coarse sand, calcined clay particles, or similar nonorganic materials should be used.

Whenever trees are planted in newly worked or loosened soil, they should be set "high" in relation to the final grade level (see figure 2). The ideal system is to place the ball on an unbroken column or pedestal of undisturbed soil so that it cannot settle, though such extra care is impractical in all but a few planting situations. An alternative solution is high planting, 5 cm above grade for the top of a 60 cm ball, 8 cm for a 90 cm ball. It is far better to err on the side of too shallow rather than too deep planting. A famous example was the red oak avenue leading to the Rutgers University stadium in New Jersey. The land on the site was a very poor red-clay soil, so generous amounts of rotted manure were incorporated in the backfill. The trees all lived and grew well for the first two growing seasons, only to stagnate later on. Eventually all the trees were dug up again and reset with the tops of the balls above grade, and thereafter they grew beautifully. High planting is the best way to avoid these difficulties.

Most planting specifications for shade trees recommend forming a shallow berm around the edge of the planting pit to facilitate watering. Experience in California, where water is scarce and expensive, has shown that the basin is much more effective if the edges are placed over the edge of the ball (see figure 3). Particularly in sandy locations, this assures that the ball itself is well watered during irrigation and that the moisture does not slip down the side of the pit.

One detail that is often overlooked in island planting, especially in parking lots, is to ensure that trees and shrubs are planted far enough from the perimeter of the island so that the bumpers of cars will not debark the trunks or flatten the stems. The large automobiles of the 1960s are no longer common, but even small cars have substantial overhangs. In far too many island plantings, trees become will established initially but eventually succumb to repeated debarking by careless drivers.

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Design for Survival

Anne Whiston Spirn

The term "urban island" refers to a patch of plants and soil embedded in a matrix of pavement and buildings. Urban islands may be as small as a pit or pot for a single tree or as large as the center of a traffic rotary. They may be round or square, regular or irregular in shape, a compact patch or a linear strip. They may be part of a considered design or merely leftover space landscaped as an afterthought or colonized by weeds.

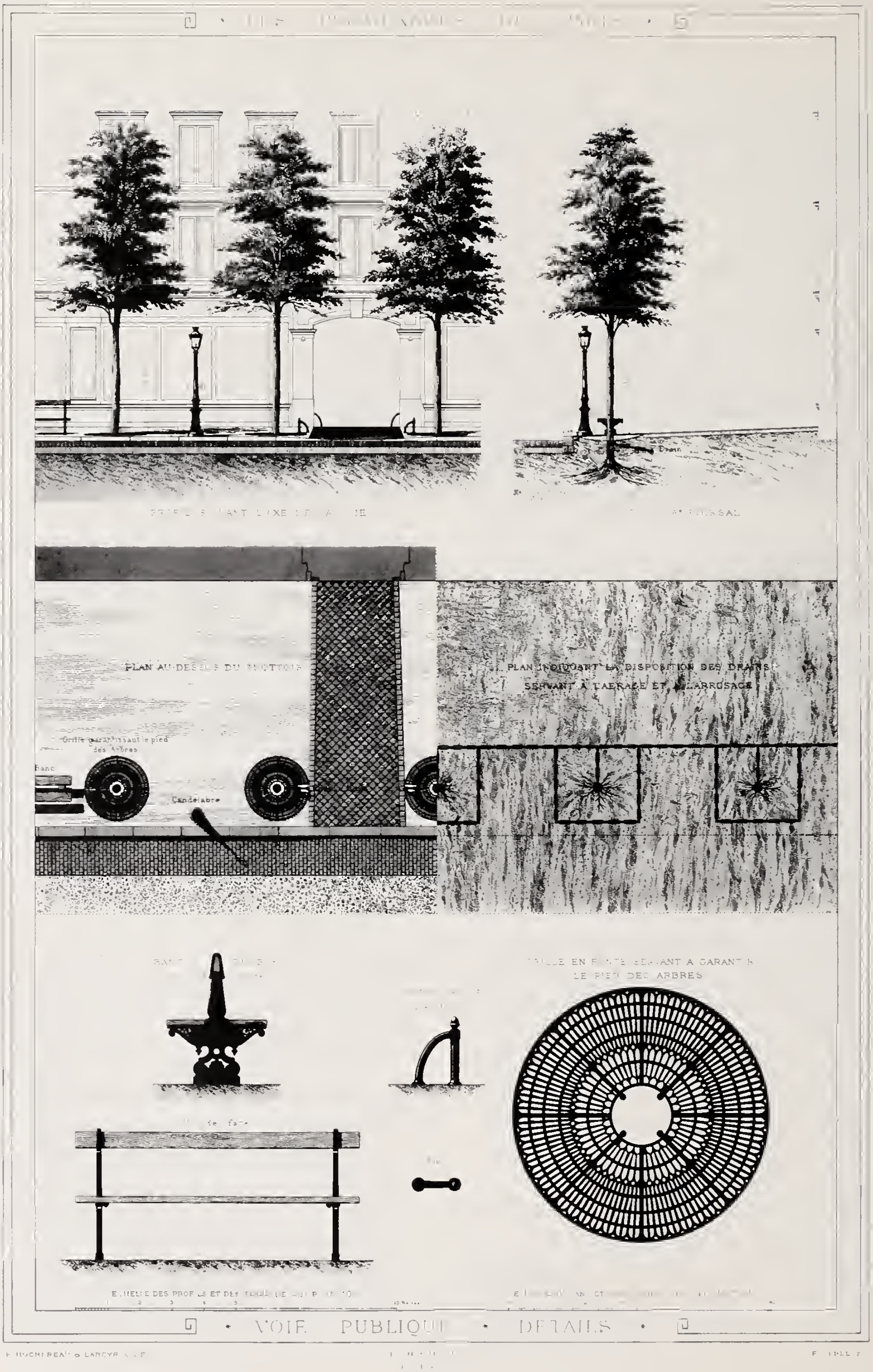
Urban islands are ubiquitous in American cities. They are to be found along streets and highways, in parking lots and plazas. They are highly visible to all who move into and through the city every day, and thus have a major effect upon how the city is perceived. At their best they can enhance a place or even represent a neighborhood, as Bloomsbury's tree-filled squares characterize that district of London, for example, or as the Commonwealth Avenue Mall symbolizes Boston's Back Bay. Unfortunately, in most American cities urban islands are sorry affairs. The empty tree pits and planters that litter sidewalks and plazas, the weed-filled traffic islands and median strips, and the dead and dying trees that lie along our streets are testaments to our failure to provide a viable habitat in these islands and, in a broader sense, are symbolic of our failure to sustain vital cities. If only urban islands were designed to enhance their surroundings and to thrive under the harsh conditions to which they are subjected, they could contribute to a more vital urban public realm.

Urban Islands: Stressful Habitats

City plants must contend with tremendous biological, physical, and chemical stresses: too much water or too little; temperatures too low or too high; polluted air, water, and soil; pests and diseases. All these urban stresses are exaggerated in islands. Many plants cannot survive at all; others survive in a dwarfed, distressed condition. But all urban islands are not equivalent in the stresses they pose; small pits and pots, for example, are far more hostile environments for most plants than larger strips or plots.

Pits and Pots

Most street trees eke out a marginal existence, their roots cramped between building and street foundations, threaded among water, gas, electric, and telephone lines, and encased in soil as dense and infertile as concrete. Their trunks are gouged by car fenders, bicycle chains, and even the stakes installed to protect them. Their branches are broken by passing buses. Leaves and bark are baked in the reflected heat from pavement and walls or condemned to perpetual shade cast by adjacent buildings. Roots may be parched or drowned; in either case their ability to de-


PLAN INDIQUANT LA DISPOSITION DES DRAINS
SERVANT À L'AÉRAGE ET À L'ARROSAGE
Grille garantissant le pied
des Arbres
Banc
Candélabre
LE PIED DES ARBRES
DÉTAILS

liver essential nutrients to the tree is drastically reduced.

The street trees that survive maintain a precarious balance between life and death. Incremental insult can spell the difference. Gusty winds on a street corner or at the base of a tall building increase the loss of precious water by evaporation. Salts from deicing compounds and dog urine alter the osmotic pressure of water in the surrounding soil so that water is sucked out of the tree roots. Leaks from gas mains poison plant roots, while air fouled by automobile exhaust and industrial emissions and heavily laden with dust can poison and suffocate the leaves of sensitive species. It is more surprising that street trees and plants in urban islands survive at all than that their life span is so short. The demise of the average street tree is due to a daily struggle for survival in which the tree weakens progressively year by year and finally succumbs to a blight or a drought that a healthy tree could easily survive.

Trees or shrubs in pots on a plaza may face even worse conditions than those in pits on the street. Many plazas are not built over soil but are actually roofs of basements or subways, and plaza trees are therefore often planted in pots, either sunken or raised. The depth of soil they are planted in is limited by the strength and size of the structure beneath the plaza. Rarely is sufficient soil provided to sustain large trees over a natural life span. A raised planter that is large enough for only a single tree is one of the worst environments for a plant, a fact attested to by the many empty concrete planters that line urban plazas. When the sides of a planter are exposed to air, the soil freezes and heats up rapidly, and tender roots are alternately burned and frozen in climates with pronounced seasonal changes. Plazas are also often located at the bases of tall buildings, where gusty winds dehydrate both tree and soil.

The problems posed by such hostile environments are often compounded by the installation of plant species that are poorly adapted to such conditions. Transplant a forest tree, for example, to a city street or plaza, and it must contend with conditions different in every respect from those in which it evolved: individual trees spaced far apart, with bark and the underside of leaves exposed to sun and reflected heat; paved surface; dense, infertile oxygen-deficient soil; and an uncertain water supply.

Strips and Plots

Strips of land along roads and highways, and plots large enough for several trees afford more hospitable conditions than isolated pits or pots. A small plaza in Philadelphia provides a dramatic demonstration of this point. Half of the plaza is at street level, with trees planted in tiny holes within impervious pavement. The other half contains a large, raised, concrete planter filled with many trees. Within a few years of installation, the trees planted in pavement were dead or dying, while trees planted at the same time in the open soil of the large planter were thriving. When planted in a group, trees protect one another from extremes of sun and wind. In addition, planters that are sufficiently large to accommodate many trees do not have the severe problems

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Illustration from *Les Promenades de Paris* showing the infrastructure installed to support street trees in nineteenth century Paris. The pipes were for drainage, aeration, and irrigation.

of temperature fluctuation and desiccation that plague smaller pots.

Designing Urban Islands

The stressful conditions of urban islands could be overcome or at least ameliorated by regular maintenance: irrigation, fertilization, mulching, and pruning. Unfortunately, unless owned or adopted by an individual or located in a highly symbolic public place, urban islands seldom receive the maintenance they are designed to require for survival. The combination of stressful conditions and lack of maintenance in these environments makes careful design imperative. In the absence of maintenance, the most effective way to enhance the survival of plants in urban islands, and to improve their appearance, is careful attention to the design of landscaping, to the way it is installed, and to the selection and arrangement of plants. The following are guidelines for the design of urban islands.

Principle 1: The more the conditions of an urban island depart from a natural ecosystem, the more energy (maintenance) is required to sustain the plants.

Urban islands are miniecosystems. Ideally, they should be designed and managed as relatively "closed" systems, requiring minimal input of energy in the form of irrigation, fertilization, reseeding and replanting, and plant removal. The following recommendations will increase the likelihood that an urban island will function in this manner:

- Provide as large an area as possible. The larger the urban island, the more likely that it will be able to function as a relatively closed system that can sustain normal plant growth. A 1–2 m² planting hole, for example, may support a mature tree of only 6–8 m in height (Kozel et al. 1978). Healthy, mature growth can be achieved in urban islands if trees are planted in clusters, rather than spaced out along the sidewalk in pits. The plantings in Bloomsbury and Russell Squares in London and in Louisburg Square in Boston are excellent examples of this strategy. The aesthetic effect of a single cluster of large trees may also be greater than a larger number of much smaller trees lining the street. This strategy is especially well-suited to plazas built over basements, where planters must be used in order to provide sufficient soil depth for trees or shrubs. Pits for street trees can also be enlarged by replacing the strip of sidewalk between the trees with stone dust or permeable pavement, thereby connecting what would otherwise be tiny, isolated spaces.

- Provide as deep a soil as possible. A deep permeable, relatively homogeneous soil will provide a growing medium that promotes water drainage and storage and nutrient exchange.

- Maintain a ground surface that is permeable to air and water. The air and water exchange permitted by a permeable ground surface is essential to healthy plant growth. Ideally, the surface of the island should be unpaved and planted with shrubs or ground cover that will shade the soil surface, protecting it from water loss and buffering it from extremes of heat and cold. If a paved surface is absolutely necessary, it should be composed of a permeable material like stone dust, pea gravel, or bricks set in sand.

The deline of an urban island. Taken over 12 years, this series of photographs documents the fate of an award-winning landscape design whose impact relied on uniformity of plant species and arrangement, and which failed to take into account different soil and drainage conditions. Widespread disregard of urban soils accounts for poor survival rates of urban street trees and landscaping. Photographs by James C. Patterson; courtesy National Capital Region, National Park Service.

Three types of urban island on Pennsylvania Avenue in Washington, D.C.: raised pot, sunken pot, and grassy strip. The two rows of street trees were the same size when planted four years earlier. Sidewalk trees are now noticeably smaller than those in open soil, despite an elaborate system constructed to support them. Photographs by James C. Patterson; courtesy National Capital Region, National Park Service.

- Permit natural soil fertilization to occur. If leaves are allowed to remain on the soil surface, they will decompose and form a natural mulch and fertilizer.

Principle 2: The more closely the urban-island habitat matches the natural habitat of the plants growing within it, the less energy is required to sustain the plants.

Having adapted to the environment in which they evolved, plants have different needs for water, air, light, and nutrients. Two approaches are open to the designer of an urban island: to create a habitat that approximates the natural habitat of a desired species or to select species whose native environments are similar to that of the urban island.

- Approximate the native habitat of the plant species selected. Many trees planted in the city evolved in a forest environment: a humid, temperate climate where each tree is surrounded by other trees, protected from sun and wind. The surface of the forest's soil is soft and spongy, as a result of the long-term accumulation of decomposed leaves. Tiny rootlets pack the upper few inches of the soil, the major feeding zone of the forest tree. To enhance the survival rate of forest trees in urban islands, they should be planted in clumps in an open soil with a soft, permeable surface and adequate water.

- Select plants whose native environment is similar to that of the urban island. It may not always be possible to amend the habitat to suit a forest tree, but not all trees are native to forests. Trees, shrubs, and other plants native to stressful environments, such as floodplains, old fields, and seacoasts, may survive with far less care in urban islands than forest trees. The repeated floods that floodplain trees must contend with prevent the accumulation of leaf mold and topsoil and saturate the earth, rendering it just as deficient in oxygen as compacted urban soil. It is therefore not surprising that floodplain trees like *Ailanthus altissima* flourish in the city. Old field trees, such as sumac and *Fraxinus* species, and seacoast species, such as *Rosa rugosa*, will thrive in urban islands. Matching the urban island habitat with analogs in "wilder" settings will yield plants that are likely to survive with minimal care.

Principle 3: Careful preparation of the planting area during installation will increase growth and survival rates, improve the appearance of the plants, and minimize maintenance problems.

"Plant a one-dollar tree in a ten-dollar hole" is an old maxim whose validity has been proved again and again. On major streets, or those with symbolic value, many cities are now spending close to ten times the value of the tree on preparation of the pit and the pavement around it. An elaborate system was devised, for example, for street trees on Pennsylvania Avenue in Washington, D.C. Existing soil was excavated to a depth of 81 cm in a circle of 5 m in diameter around each tree, amended with compost, and replaced. An irrigation ring 4 m in diameter was positioned under concrete sidewalks to promote irrigation, fertilization, and aeration. An underground drain connecting the trees carries away excess water, and a grate around the base of each tree helps to keep the soil from becoming compacted. The cost of the new pavement, soil, and drain around each tree exceeded $5,000 (Jewell 1981). Despite this elaborate system, the trees have not fared as well as those planted on an adjacent grassy strip.

A city can afford such expensive solutions only in a few streets. There are other, less expensive alternatives. The design of the pit, the composition of the soil, and the preparation of the soil surface are all important.

- Grade the bottom of tree pits to protect tree roots from water-logged soils. Although this can be accomplished in single-tree pits, the larger and deeper the hole the more efficiently and economically it can be drained.

- Amend the existing soil, rather than replace it. The contrast between compacted subsoil and new topsoil in a tree pit is a primary cause of the "tea-cup" effect, in which tree roots become flooded as a result of inadequate water drainage. Amending the excavated urban soil with organic matter and a coarse material, such as cinders or expanded shale, reduces the contrast between the soil of the tree pit and the adjacent soil, enhancing drainage and root growth.

- Cover the soil surface with several inches of mulch. A thick mulch will retard weed growth, prevent water loss from evaporation, and reduce soil compaction. Where an organic mulch is not feasible, an inorganic material, such as porous stone dust, will provide a walking surface under trees and still permit the access of air and water to tree roots.

Principle 4: No matter how carefully the foregoing principles are employed, individual plants in urban islands will vary in growth and survival rate.

Designs that rely on uniformity either of plant form or arrangement are especially vulnerable to such irregular growth. The following strategies address this problem:

- Overplant an urban island, so that if some plants die enough will remain to achieve the desired effect. Overplanting will also yield a greater aesthetic effect immediately after installation. Nature will eventually cull the weakest plants.

- Design the plant arrangement so that the loss of certain plants will not undermine the overall effect. This does not mean that one should not plant a uniform grid of trees, for example, but a bosque may be converted to a grove if several trees succumb.

These are general principles. The design of a specific urban island will depend upon such considerations as the location, size, and shape of the island, the degree of maintenance it will receive, and the agent who will maintain it. A design appropriate for a planter in front of city hall, for example, may not be appropriate for all islands in the city that must be maintained at public expense. Urban islands are too important a resource for a community in terms of esthetics, image, and quality of life for their design to be left to chance.

Acknowledgments

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New Choices for Urban Islands

Gary L. Koller

Urban islands are meant to be oases of natural greenery that contrast with and visually soften the hard surfaces of urban landscapes. One wonders if the plants we now utilize are tough enough to survive benign neglect, harsh environmental conditions, and vandalism. Some plants are, but one sees many urban islands in which the plants are dead or dying. A plant that would flourish in one location might fail miserably in another, and it would be incautious therefore to recommend a plant for all situations. In any planting it is most important to observe the conditions of the site and choose plants that most readily adapt to that habitat.

It is my opinion that plants are often chosen because of ornamental criteria, such as showy flowers, brilliant autumn foliage colors, or evergreen foliage. What is ultimately more important is to select plants that are capable of thriving under existing site conditions. If the plant does nothing more than provide a green, leafy presence in the city, then it has performed well. The importance of flowers, fruit, and autumn color should be secondary, for what good is the most gorgeous flowering tree or shrub if it is barely surviving? I also believe that we should revive the use of tough plants with minor ornamental attributes that have been abandoned in favor of prettier plants that are often more exacting in their habitat requirements.

William Flemer III has identified and discussed many tough plants in his article in this issue. These plants have proved themselves through repeated successful applications in urban sites, and they should continue to be used. At the same time we must continue to seek little-known new plants that adapt to island habitats. What is needed is the widest possible array of plants to select from, so that we have species fitting every specialized habitat.

The plants listed below have been selected for toughness, longevity, and adaptability to a wide range of environments. All present the primary attribute of attractive foliage throughout the growing season. Most are little known and little used, and few are commercially available at present. All are hardy at the Arnold Arboretum and can be observed there. The list that follows is for nursery growers and landscape architects who wish to, dare to, and can afford to experiment with something different. Why not select one or two for evaluation and help extend knowledge about plants for urban islands?

Trees

Asimina triloba (L.) Dunal. Height 5–8 m. Hardy to −10°F. Pawpaw.

Plantings on many large islands in cities are often visually monotonous because of regularly spaced specimen trees. Thickets or col-

onies would increase interest and create the effect of an urban woodland.

The pawpaw is a native colonizing tree that spreads outwardly via rootsuckers. Because shoots arise next to and in the middle of nearby plantings, the pawpaw is best used alone in a mass planting, with a simple ground cover such as *Rhus aromatica* Ait. 'Gro-Low', *Symphoricarpos × chenaultii* Rehd. 'Hancock', *Arundinaria viridistriata* (Siebold ex André) Mak., *Aruncus dioicus* Walt., or *Xanthorhiza simplicissima* Marsh.

The pawpaw has a round-topped shape, and good specimens bear branches directly to the ground. The leaves are 15–30 cm long, light to medium green, and visually distinctive because of their pendent or drooping character. Autumn foliage is an attractive amber yellow. The fruit, which is edible, resembles a short, fat banana. It ripens to a purplish brown color and possesses a distinctive flavor and texture.

Although *Asimina* has few other habitat requirements, it prefers a soil that retains adequate moisture. It is somewhat difficult to transplant, and nursery-grown specimens dug for transplanting are slow to recover vigor and normal shoot elongation. Container-grown plants may respond more quickly. Once established, the plant is undemanding and long-lived.

Pawpaw has many potential uses. It would look handsome running along a ridge or on both sides of a path. It would also be effective as a leafy camouflage for the concrete slabs that serve as noise-reduction barriers along highways.

The Sawara cypress (*Chamaecyparis pisifera*), foreground.

Chamaecyparis pisifera (Siebold & Zucc.) Endl. Height 12–21 m. Hardy to −30°F. Sawara cypress.

Chamaecyparis pisifera is capable of remarkable growth under the most difficult conditions, surviving where many other plants fail. In many locations the common evergreens, such as white pine (*Pinus strobus* L.), Canada hemlock (*Tsuga canadensis* [L.] Carrière), Austrian pine (*Pinus nigra* Arnold), and Japanese black pine (*Pinus thunbergiana* Franco), are failing miserably. Their decline can be attributed to intolerance to drought, air pollution, environmental salts, construction damage, and insects or diseases.

Mature specimens of *Chamaecyparis pisifera* appear in many long-established inner-city landscapes. The trunks are tall and majestic, with a cinnamon brown to gray-brown bark. The trees have an openness of habit that permits a view through them, and their yellow-green foliage is attractive in the winter landscape. Frequently, mature plants possess a layered fullness of form that is absent in many pines, spruces, and firs.

Sawara cypresses are best planted in groves. In one such planting at the Arnold Arboretum, individual plants are spaced 6–8 m. apart. Today the outer branches touch, enclosing the space beneath the canopy.

Dwarf cultivars of *Chamaecyparis pisifera* have become more popular than the tree types, which are now infrequently grown in the nursery industry. Perhaps this is because the tree types were used inappropriately in the past. They were often planted beneath windows, next to doorways, and along driveways, where their quick, full growth overwhelmed the space. As a result, they were ineptly pruned, creating an ugly effect.

Chamaecyparis pisifera is a plant of robust, vigorous growth. It is extremely tolerant of dry, nutritionally poor soils, as well as the sandy soils of coastal areas. It must be grown in full sun, as shade kills leaves and branches. Sawara cypress is exceptionally tolerant of winds and ocean spray. Long-established plantings are present on the islands of Martha's Vineyard and Nantucket.

The cultivars of *Chamaecyparis pisifera* are numerous, and most are dwarf or compact evergreens. However, several significant tree forms are available, including 'Plumosa', which is dense and conical with ascending branches. Mature trees at the Arnold Arboretum planted in 1891 now stand 9–12 m tall. Winter foliage color is a brown-green, which some consider unattractive. This cultivar could be improved by the selection of individuals with shiny, dark green foliage that remains attractive year-round. 'Squarrosa' is one of the most distinctive evergreens for soft blue-grey foliage and rapid growth. Although the inner foliage turns brown and dies, it can be removed by fine pruning. This produces an attractive billowy effect, which is beautiful in combination with the foliage color and texture.

Cornus macrophylla Wallich. Height 8–11 m. Hardy to −10°F. Big-leaf dogwood.

Our native dogwood (*Cornus florida* L.) and the kousa dogwood (*C. kousa* Hance) continue to be planted on islands, with various degrees of success. Many fail because they have been planted too deeply. Drought stress, salt damage, reflected heat and sunlight, or mechanical damage to the stem or root system are other causes of failure.

One relatively unknown dogwood with horticultural promise is the big-leaf dogwood, which is native to China and Japan. Tom Dilatush, an observant nurseryman and plant collector from Robbinsville, New Jersey, tells me that he finds *Cornus macrophylla* to be more drought tolerant than other arborescent dogwood species. He also says that it transplants more easily and recovers more quickly.

During early July large quantities of tiny creamy white flowers are borne on flat-topped terminal panicles and resemble those of red-osier dogwood (*Cornus sericea* L.). By early August clusters of tiny light green fruit appear against the dark green leaves. As the fruit ripens in September, the pedicels turn an attractive rose pink, while the fruit ripens to a blue-black color. Birds quickly strip the ripe fruit, but the pedicels remain for another 3–4 weeks. Autumn foliage color is unremarkable.

Big-leaf dogwood has a strong tendency to produce multiple trunks rising from near soil level, and in habit it resembles an overgrown shrubby dogwood. The mature tree has a rounded shape. One of the Arnold Arboretum's trees has grown from seed received in 1951 and today has a spread of 14 m, with four stems rising from just above the soil level to 9 m high.

Another specimen thrives in rich, moist soil in full sun. It grew from cuttings in 1980 and was transplanted to the grounds in spring 1982. By August 1, 1984, the new season's growth averaged 30 cm, and the plant was approximately 3 m tall.

Corylus colurna L. Height 9–15 m. Hardy to −20F. Turkish filbert.

Turkish filbert is now rare in street or island plantings, but I am certain that it will be more widely used once it becomes better known. Two factors offer promise for increased use. First, the filbert canopy is more open than that of most moderate-sized trees because of this tree's wide-angle branch formation. Second, when the filbert becomes established, it adapts to arid conditions and exposed sites.

Foliage is a rich, dark green throughout summer and fall. Pendent staminate catkins are present in a reduced size throughout the winter but grow and enlarge to a length of 5 to 8 cm as the weather warms in spring. Late each summer a nutlike fruit appears, surrounded by a curiously fringed light green involucre. Although not showy, the fruit is visually interesting. Squirrels quickly carry away ripening seeds, so no litter remains. The light brown filbert bark is distinctive, with small scales that flake off, revealing patches of pale orange-brown.

I have observed long-established Turkish filberts at the Arnold Arboretum, Mt. Auburn Cemetery in Cambridge, Massachusetts, the Brooklyn Botanic Garden in New York, Temple University in Ambler, Pennsylvania, and Cornell University in Ithaca, New York. At all locations the trees displayed beauty of form, crisp foliage, and freedom from insect and disease pests. *Corylus colurna* offers the promise of a completely new tree to widen species diversity in islands and other difficult urban locations.

Shrubs

Calycanthus floridus L. Height 2–3 m. Hardy to −15°F. Sweet shrub.

Outstanding foliage is this plant's chief asset. The leaves remain lush, dark green, and in superb condition until autumn, when they turn to yellow or pale gold.

At the Arnold Arboretum we have lifted several old plantings, divided off clumps, and reestablished colonies at new planting sites. The bare-rooted transplants in some cases were slow in becoming established but eventually developed a physical density and luxuriant appearance possessed by few other plants. Sweet shrub is singularly appropriate for creating mass plantings in either sun or shade. To maintain the richness of the foliage, the plants require shearing to soil level every five to six years.

Flowers are purplish brown and not particularly eyecatching but have a delightful spicy fragrance. The fragrant character varies enormously among plants produced from seed. Some nurseries have selected and vegetatively reproduced forms with outstanding fragrance, while others continue to produce inferior lines. One would hope that nurseries would evaluate and then purge their line of propagation stock with poor fragrance.

Colutea × media Willd. Height 2 to 3 m. Hardy to −10°F. Bladder senna.

Bladder senna is overlooked as a medium-sized shrub capable of thriving in full sun on dry, gravely, infertile soils. In fact, it will colonize sites too inhospitable for many plants and is therefore the most appropriate choice for restoring the banks of fresh highway cuts. It is also useful in planting islands and semiwild urban parklands.

Colutea × media is a hybrid of *Colutea arborescens* L. of southern Europe and *C. orientalis* Miller of Asia. At the Arnold Arboretum peak flowering occurs in mid-May, with scattered blossoms appearing throughout the summer. Flowers are pea-shaped and usually butter yellow, but some have markings or tints of copper, pink, or reddish brown. Flowers are followed by large, thin-walled, inflated pods that may be lime green or richly tinted with pinks and bronze. The seed pods are highly ornamental from June through late July, when they begin to ripen and turn straw brown. The ornamental qualities of these inflated pods rival those of many flowering shrubs.

Bladder senna is generally rounded in habit. The foliage is sparse and the branching is open — some might say rangy and unkempt. The shrub is least attractive in late summer, when the seed pods turn brown and the leaves lose their color. It looks best when grown in a low ground cover, such as *Symphoricarpos* × *chenaultii* 'Hancock' or *Aegopodium podagraria* L. 'Variegatum'.

Diervilla sessilifolia Buckl. Height 1–2 m. Hardy to −20°F. Southern bush honeysuckle.

Diervilla is an ideal tall, woody ground cover, for it forms dense, multistemmed thickets and is easily propagated and transplanted. At the Frelinghuysen Arboretum in Morristown, New Jersey, the staff maintains two large colonies in stock beds to provide plants for use in Morris County parks. When plants are needed, staff members cut back the tops and remove root clumps from the bed. After removal, the digging holes are backfilled and the area fertilized. The colony then renews itself from the root pieces remaining in the soil. Within a season or two, the bed is ready for removal of another crop. When I last visited the Frelinghuysen Arboretum in 1983, the mature bed stood approximately 1 to 2 m tall, perhaps 18 to 24 m across, and 8 to 9 m wide. The planting formed a dense, impenetrable barrier, which guided pedestrian traffic. The foliage was dark green and lush. Russell Myers, director of parks for the state of New Jersey, told me that he considers *Diervilla* one of the most reliable plants for mass and ground-cover plantings on the banks of highways. John Trexler, former horticulturist at the Frelinghuysen Arboretum, has noted that deer browse the foliage during late summer, a factor that must be considered in planting in rural situations.

I often walk along the Marginal Way in York Harbor, Maine, where *Diervilla lonicera* Mill. grows on the dry rocky soils of the cliffs, exposed to the winds and the salt spray from the Atlantic Ocean. This species is less handsome in leaf than *D. sessilifolia*, and it is said to be slightly less vigorous in growth. However, its tenacity under harsh environmental conditions is indicative of the vitality of the genus.

Diervilla can be cut to soil level each autumn, and snow and ice can be disposed of on the space occupied by the roots. Damage or harm to the planting itself is unlikely. Once well-established, the plants grow and thicken rapidly each spring. Flowers are borne on the wood of the new season and so are unaffected by the pruning. The flowers are yellow and appear in midsummer. Still later the purple-bronze foliage enhances the muted color spectrum of the autumn landscape.

Hamamelis virginiana L. Height 5–8 m. Hardy to −20°F. Virginia witch hazel.

During the months of October and November, the Virginia witch hazel blooms at the edges of woods and in clearings along streams in Massachusetts. Some of the flowers are obscured by withered leaves, but overall the effect of the pale yellow to bright gold flowers is quite stunning.

According to Geraldine Weinstein, director of horticulture for the New York Department of Parks and Recreation, the Virginia witch hazel transplants easily and even without maintenance generally survives heat and drought after transplanting. Few shrubs cling so vigorously to life during the period immediately after transplanting, and few resume normal shoot elongation as quickly. This shrub is one of the most successful in Central Park, despite a high level of environmental stress.

At the Arnold Arboretum we have several witch hazels approaching their centennial year, and during a midsummer inspection they looked robust enough to last another 100 years. One plant, which stands alone near the Centre Street gate, is approximately 5 m tall and 12 m across. It forms a dense wall and is graced by branches that brush the ground at the tips. In another location three plants spaced approximately 3 m apart give the appearance of a single plant with a spread of 17 m. In a third location the witch hazel grows in a natural-looking thicket with native dogwood and Carolina silverbell. On all Arboretum plants the oldest leaves are a dark green; younger leaves are light green; and the youngest are green tinged with shades of purple or bronze. Autumn color is an attractive clear yellow. Because of it stature, Virginia witch hazel is suitable only for islands over 8 m in diameter.

Microbiota decussata Komar. Height 30–60 cm. Hardy to −25°F. Microbiota.

Microbiota, which has the appearance of a prostrate juniper, is a rapid grower. In three to four years it forms a dense mat 30–60 cm tall and spreading 1–2 m across. It has a superb emerald green summer color plus a surface texture resulting from pendent branch tips. Branches pile up on top of one another, and lower ones retain foliage only where they extend beyond the shading canopy. Plants grow well in full sun to moderate shade. In winter shade is necessary to prevent them from turning brown. Macrobiota thrives in acid or alkaline soils and grows best in well-drained sites.

Better forms of this plant need to be developed for the winter landscape, and when seeds become available progeny testing ought to be performed. Once improvements are made, I am sure microbiota will become a substitute for junipers along the edges of islands. This plant is also suitable for interior planters in shopping malls; I am told that it has performed well in limited trials.

Rhodotypos scandens (Thunb.) Mak. Height 1–2 m. Hardy to −20°F. Jetbead.

Jetbead is a compact and rugged plant that looks attrative for many years with a minimum of maintenance. With its limited height and spread and dense crown, it forms an ideal background for taller and more leggy shrubs, such as beautybush (*Kolkwitzia amabilis* Graebn.) or lilac (*Syringa vulgaris* L.). One occasionally sees jetbead used as a clipped hedge, but it is at its finest when allowed to grow naturally and relatively informally with a layered or textured foliage surface.

Many small white flowers appear among the leaves during mid-May to early June. Later, shiny black fruits, resembling small peas, occur in groups of three or four. The summer foliage is light green, and its attractiveness is enhanced by a strongly indented vein pattern and doubly serrate leaf margin.

Autumn color ranges from yellow-green to amber-yellow. I have been enchanted by the mellow color effect of a hedge in autumn at Cornell University.

Jetbead resists insects and diseases, tolerates drought and salt spray, and thrives in both moderate shade and full sun. It also transplants easily and reestablishes itself quickly. Plantings in inner-city locations thrive many years after installation.

Jetbead's ornamental characteristics could be improved by selection. I am unaware of any existing selections and would welcome news of any that are available. Most plantings in the United States represent vegetative propagations from limited parental materials. We need to make more introductions from the full range of this plant's native habitat. Desirable characteristics include more abundant and larger flowers and a more compact size when mature. I have requested that a fall 1984 National Arboretum expedition to Korea seek variants of *Rhodotypos.*

Although it could benefit from selection, this is presently a more dependable and durable plant than many shrubs that are now more commonly employed in the landscape.

Rhus aromatica Ait. 'Gro-Low'. Height 37 cm. Hardy to −30°F. 'Gro-Low' fragrant sumac.

Fragrant sumac has already established its usefulness as a tall woody ground cover along highways, where one can see it growing on embankments and along the bases of bridge abutments. When grown from seed, *Rhus aromatica* can be quite variable in height, density, vigor, and area of spread. 'Gro-Low' fragrant sumac is a selection that was reproduced vegetatively and is therefore more predictable in its mature habit.

Because of its short stature, broad spread (1 to 2 m across), and adaptability to either full sun or moderate shade, this plant is an ideal substratum or ground cover. Its yellowish flowers, which appear in early spring, are inconspicuous. Its autumn foliage color, in shades of reddish purple to yellow-orange, is a more ornamental feature of this plant. This is an ideal species for islands with shallow, dry soils.

Rhus chinensis. Mill. Height 5–6 m. Hardy to −10°F. Chinese sumac.

The landscapes of late August and early September are considerably enhanced by the rich golden yellow flowers of *Koelreuteria paniculata* 'September' and the creamy white flowers of *Rhus chinensis,* the two most showy flowering trees of this season. Chinese sumac produces large, open cone-shaped terminal panicles 20–25 cm tall. Flowers last 10–14 days and then give way to clusters of small bony fruit, which turn orange when mature. As flower and fruiting qualities vary significantly from seedling to seedling, breeders are attempting to develop improved selections. Dr. Elwin Orton, of Rutgers University, submitted one selection called 'September Beauty' to the Pennsylvania Horticultural Society to be tested and evaluated for the Styer Award. This award recognizes plants with exceptional ornamental characteristics.

The dark green leaves of Chinese sumac are handsome all summer long. The prominent marginal tooth pattern and the winged leaf-rachis are also attractive. Autumn color can be bright orange or scarlet or rather drab, depending on weather conditions.

Chinese sumac (*Rhus chinensis*).

Chinese sumac is variable in growth and habit. With pruning, it can be maintained as a single-stemmed specimen tree. However, it tends to sucker from the root system, and as a result it is best used in multiple-plant colonies or thickets on large islands. Cutting the whole colony to the soil level every fourth or fifth year just before new growth begins will keep the colony lush and vigorous and in prime flowering condition.

At the Arnold Arboretum several Chinese sumacs grow in full sun and one in shade. The shaded specimen, which was received in 1952 and now stands 6 m tall, produces flowers but not so many as those in full sun. It also lacks significant autumn color. This sumac's adaptability to nutritionally impoverished dry, sandy soils renders it an ideal plant for islands and parking areas at summer resorts, where its late-summer flowering would be especially appropriate. The plant does require well-drained soil, however.

Factors that hamper development of *Rhus chinensis* as a commercial landscape plant are the nursery industry's view of native sumacs as having little ornamental value and the public misconception that these plants are poisonous. Although many plants have greater ornamental value, few match the Chinese sumac for late season bloom and for toughness in those difficult environments we call urban islands.

Sinarundinaria murielae (Gamble) Nakai. Height 1–3 m. Hardy to −10°F.

This bamboo, whose name has been the source of much confusion, was acquired by the Arnold Arboretum from the U. S. Department of Agriculture Plant Introduction Station in Glenn Dale, Maryland, in November 1960 (P.I. 262266). It rarely appeared outside botanical gardens until recently, when the landscape architectural team of Wolfgang Oehme and James A. van Sweden recognized its undeveloped potential and promoted its use.

When I arrived at the Arnold Arboretum, over eight years ago, a magnificent specimen grew in the shrub collection in Jamaica Plain, and another of equal merit grew in the perennial garden at the Case Estates in Weston, Massachusetts. Although these plants have since been removed as a source of propagating stock, I remember that they stood 2 m tall and spread in dense clumps (2–3 m across). They had a graceful arching habit and small and delicate foliage. Unfortunately, when the Arboretum's long-established clumps were lifted as a source of divisions to increase the stock on hand, 98 percent of the young plants were lost. Richard A. Simon, manager of Bluemount Nurseries, Inc., of Monkton, Maryland, has reported similar difficulties in trying to increase this bamboo. Development of this plant on a commercial basis will be hampered until better methods of propagation are discovered. However, once it has become established it clumps up rapidly and again becomes tough and dependable. At present we have a superb colony of four plants that were grown from divisions and planted in June 1981. The plants were spaced 1 m apart in a square pattern. By August 1984 the combined clumps appeared as one plant, which stands 2 m tall and spreads 3 m across. The planting is extremely dense, with upright central stems and arching outer canes. The plants often remain green until January, but by spring the persistent foliage is bleached to a tan color. I am told that in Washington, D.C., the plants are more reliably evergreen, but they do best with wind protection and shade to shield them from late afternoon sun. New growth, which begins late, arises from basal culms and branches. Once established *Sinarundinaria murielae* is a plant of distinctive habit and reliability, with minimal maintenance needs.

Sorbaria sorbifolia L. (A. Braun). Height 1–3 m. Hardy to −40°F. Ural false spirea.

On islands where a dense, multistemmed shrub is required, *Sorbaria* would be the first choice. This plant can spread to a much greater width than its mature height, and the habit varies considerably, from a low contoured mound in dry locations to a taller more blocky shape on fertile or well-watered sites. The plant's stoloniferous growth requires that one use it where it can be restrained by barriers such as walkways, walls, or curbs. *Sorbaria* is a superb selection where a natural look is called for, as it will fill in and unify a mixed shrub and tree border. It can also be used as an underplanting for a grove or group of trees. Landscape designers must exercise care in choosing companion plants, for *Sorbaria* will dominate smaller or slower-growing plants.

Close inspection reveals luxurious, light green leaves, which are pinnately compound. Individual leaflets are marked by the veins and bear bold serrations on the leaf margin, similar to those of European mountain ash (*Sorbus aucuparia L.*). Under optimal conditions the foliage remains crisp and attractive throughout the summer. When the plant lacks water, however, the leaves lose their freshness by late summer and turn yellowish brown. Pruning and fertilizing the plants in spring, as well as supplemental watering, will help to prevent this.

Terminal racemes of small creamy white flowers appear in late June to early July. The floral cluster can vary from short and slim to broad and bushy. The flowers resemble those of *Astilbe* but are much larger. Since flowers develop over several weeks, fruit and flowers are sometimes present together. The ripening fruit capsules are tan and brown and provide a discreet montage of color with the white flowers.

Sorbaria sorbifolia roots readily from cuttings and as a result is generally propagated vegetatively. This factor, combined with the fact that the plant is so infrequently grown, has meant that no selections or horticulturally improved forms are available. A plant selector might seek larger flowers, fuller racemes, or a more compressed flowering cycle in which all the floral clusters would appear at approximately the same time.

Flowers of Ural false spirea (*Sorbaria sorbifolia*).

Forms that remain compact would also be desirable. *Sorbaria grandiflora* is a smaller shrub than *S. sorbifolia,* with a mature height of 1 m or less and larger flowers. According to the Plant Science Data Center, the Arnold Arboretum has the only representatives of this species in the United States. Our plants were obtained as seed from Domaine des Barres, Nogent-sur-Vernisson, Loiret, France, in April 1939. In late July they were 1 m tall, with full-bodied flowers.

Sorbaria is tolerant of salt spray and occupies the same habitats as *Rosa rugosa* Thunb., dry, rocky slopes facing the sea. Because of its size and spread, it is not suitable for islands smaller than 4 m in diameter. It can be used to create a mound or design contour on sites where budget limitations preclude moving soil to manipulate the grade.

Spiraea × *bumalda* 'Gold Flame'. Height 1 m. Hardy to −30°F. 'Gold Flame' spirea.

Japanese and bumald spirea are compact, hardy, long-lived, and troublefree. They also have the advantage of an early-to-midsummer flowering period. Spireas can be used en masse as a woody ground cover to unify plantings of larger shrubs such as rhododendron, forsythia, or winged euonymus. These taller shrubs are often planted to create the effect of a thicket but do not do so for many years. In the interim a mass planting of *Spiraea* × *bumalda* could be used to fill the empty spaces and unify the plantings. While they may ultimately become crowded out, spireas will cling to any and all niches that remain favorable for their growth. *Spiraea* × *bumalda* 'Gold Flame' is one of the best cultivars for mass plantings, for it intertwines with itself to form a continuous carpet. Used to unify a planting of *Taxus* or *Euonymus alata,* it would provide a more immediate finished look to the total planting.

The flowers are pinkish, and the green leaves are tinged with shades of reddish orange and gold in spring and summer. In fall, foliage exhibits a rich mosaic of colors.

Tripterygium regelii T. Sprague & Takeda. Height 5–8 m. Hardy to −20°F.

Tripterygium is a scandent shrub that exhibits all the toughness of its relative, bittersweet (*Celastrus scandens* L.). When it stands alone, its branches grow upward to approximately 2 m and then arch outward. Their length and weight pull the stems downward so that the outer branches arch to the ground, creating a skirtlike effect. Next to another plant, a trellis, or a chainlink fence, *Tripterygium* will twist about the support as a vine. It can be used to cover ugly fencing, for the vegetation will provide a leafy screen that can be managed by occasional shearing to control growth. One caution: *Tripterygium* should not be grown on supports near walkways, for branches that extend outward will interfere with pedestrian traffic. The variable growth habit of this plant presents some difficulty when *Tripterygium* is grown with other plantings, for it becomes entangled with and overgrows shrubs and small trees. It is most appropriate on islands with rocky outcroppings or landscape mounds that it could cascade over. It is also suitable for highway median strips and ideal as a means of masking the cast-concrete units known as Jersey barriers, which are increasingly seen along highways.

Dense terminal panicles of small creamy

Tripterygium regelii.

white flowers are this plant's chief ornamental quality and reach their peak in late June or early July. The flowers are followed by three-angled, conspicuously winged fruits, which at first are lime green and then ripen to light brown.

Xanthorhiza simplicissima Marsh. Height 60–90 cm. Hardy to −30°F. Yellow-root.

Although yellow-root lacks the refinement of many cultivated plants, it is ideal for naturalistic groupings. It is extremely flexible in its habitat requirements, growing in full sun or moderate shade and in wet or dry soils.

At the Arnold Arboretum we collected seed from a planting at Garden in the Woods and grew a large seedling population to establish a mass planting along Willow Path. Four-year-old seedlings bloomed freely.

Mature plantings form a short thicket of stems that surround and face down neighboring plants. Flowering in yellow-root is rather insignificant, for blossoms are tiny, brown-purple, and appear before the foliage in late April. Casual observers can walk past a colony in full bloom and not notice the flowers. The foliage stays green later in the season than that of most deciduous plants and rarely colors before November, at the same time as or slightly after the oaks. Arboretum plantings turn a bright amber yellow, and a mass planting makes a strong visual impact, mainly because the color appears when other yellows have long since passed.

Yellow-root is ideal massed around taller shrubs, such as *Calycanthus floridus* L., *Rhododendron vaseyi* A. Gray, or *R. calendulaceum* Michx., *Vaccinium corymbosum* L., or *Philadelphus* spp. In marginally swampy soils it combines with *Magnolia virginiana* L., *Clethra alnifolia* L., and *Ilex verticillata* (L.) A. Gray.

Yellow-root must be mowed to the ground occasionally in order to maintain density. Otherwise, it thrives with little care or attention and is therefore a first choice for urban islands.

Herbaceous Perennials

Arundinaria viridistriata (Siebold ex Miq.) Mak. Height 1 m. Hardy to −15°F. Golden stripe bamboo.

This colorful bamboo has been growing at the Arnold Arboretum since the early 1900s and is noted for its exceptional hardiness,

Shrub yellow-root (*Xanthorhiza simplicissima*).

rampant vigor, and dense canopy. Its green-striped golden foliage is attractive throughout the summer. The foliage is especially attractive when back lit by the evening sun, which tends to intensify the color and gives the plant a golden glow. The leaves shimmer in the breeze. The plant is at its best in full sun. It grows successfully in shade, but the leaves turn to muted shades of gold or green.

Arundinaria viridistriata is extremely invasive and it must be contained. In my own garden it sends out underground stems that grow outward at the rate of 1 to 2 m each season. Perhaps this intrusive vigor is what is needed on island plantings, and what better containment exists than a traffic or parking island? This bamboo should be grown only in islands with granite or concrete curbs, as it may penetrate asphalt and colonize adjacent grass areas. Companion plants must be large shrubs or trees that rise above the bamboo and have a competitive advantage because of size, as this plant will dominate low or slow-growing neighbors.

The golden stripe bamboo is especially attractive when grown in front of a New England stone wall or when used in large masses. Successful plantings I have observed include a ground cover of *Arundinaria* crowned with the golden foliage of an individual or grove planting of *Chamaecyparis obtusa* (Siebold & Zucc.) Endl. 'Crippsii', which provides contrast in color, texture, and mass as well as permanence in the winter landscape. Another possibility is individual plants or drifts of *Miscanthus* *sinensis* 'Variegata' interplanted with a mass of the bamboo. The *Miscanthus,* with leaves striped white, exceeds the height of the bamboo by half a meter and provides a permanent Victorian bedding effect. Used alone, this bamboo will form a solid, dense stand capable of restraining all but the toughest woody weeds.

Once the bamboo is subjected to a killing frost, the foliage turns a tan color. Early winter ice, sleet, and snow often cause it to break or lodge over and become untidy. When this occurs, it can be mowed to the ground, creating space for the disposal of snow without fear of injury to permanent plantings. This seasonal mowing would also help to retard or eliminate the encroachment of woody plant invaders.

After transplanting, bare-root clumps require two to three years to resume normal growth, but this recovery time should be much shorter when container-grown nursery stock is used. In order to keep a landscape planting dense, it should be top dressed with a high nitrogen fertilizer at the beginning of each growing season.

Lamiastrum galeobdolan (L.) Ehrend. & Polatsch. 'Variegatum'. Height 30–46 cm. Hardy to −10°F. Yellow archangel.

Yellow archangel is a perennial that tolerates both dense shade and dry, impoverished soils. It blooms in early May on erect stems 46–60 cm tall. The flowers are small and bright yellow, typical of the mint family, and partially hidden by the leafy stems. After flowering, which generally lasts 2–3 weeks, trailing viny stems emerge and root vigorously where leaf nodes touch the soil. The stems eventually form a solid mat of branches, which can be used to soften the edges of islands.

The ovate leaves are green, with broad silvery markings over approximately ⅓ to ½ of the leaf surface. These silver markings are useful in helping to brighten shaded situations. The foliage is tough and remains green and in fair condition in Boston until November or December.

Pierre Bennerup of Sunny Border Nurseries in Kensington, Connecticut, grows yellow archangel beneath a colony of mature maple trees, and the perennial is both full and successful. It will grow in full sun, and I recently saw fully exposed plantings on Nantucket, Massachusetts. The leaves were yellowish, however, and lacked the crisp attractiveness I normally associate with the foliage of this plant.

Perennial companion plants that grow through a ground cover of *Lamiastrum* include common bleeding heart (*Dicentra spectabilis* [L.] Lem.), Solomon's seal (*Polygonatum commutatum* [Schult. f.]) A. Dietr., bugbane (*Cimicifuga racemosa* [L.] Nutt.) turtle head (*Chelone lyonii* Pursh.), common peony (*Paeonia lactiflora* Pall.), and gas plant (*Dictamnus albus* L.).

The only special care yellow archangel requires is occasional pruning during summer to restrain growth. If planted in or near natural woodlands, it tends to become invasive and may overgrow native vegetation.

Miscanthus sinensis Anderss. Height 1–2 m. Hardy to −30°F. Eulalia grass, Chinese silver grass.

Decorative ornamental grasses are still rare in New England gardens. One lovely, hardy species is *Miscanthus sinensis,* which is available in several useful and distinctive cultivars that vary in habit, height, leaf texture, and foliage colors. During October this plant bears showy fan-shaped panicles of gray to purplish flowers, and these mature to a tan color and remain throughout the winter. Although not invasive, it can seed itself into adjacent areas. An example of an escaped planting can be seen in a stretch of the Pennsylvania Turnpike several miles west of the Valley Forge interchange.

Miscanthus sinensis can be used either as a specimen plant or in mass plantings or hedges. It provides the same substance and permanent effect as a shrub. When *Miscanthus* becomes dormant in winter, the foliage turns to colors of tan and beige, and this combined with the foliage texture provides an ornamental effect as trees and shrubs lose their leaves. Winter storms tend to cause the tall stems to break and with time give the plant a progressively more disheveled appearance. When this happens, it should be pruned to just above soil level.

To thrive *Miscanthus* requires full sun, for in shade the stems are weak and often break. It adapts to many soils, however, from acid to alkaline and from quite dry to wet.

Worthy cultivars include 'Gracillimus', 'Variegatus', and 'Zebrinus'. 'Gracillimus' has leaves 1 to 2 m tall that are shiny, dark green, upright, and extremely thin, with a texture unlike those of any other *Miscanthus* species or cultivar. This cultivar forms clumps easily. 'Variegatus' is 1 to 2 m tall. Its foliage is variegated with white to cream-colored stripes running the length of the leaves. In habit it is fountainlike, with the outer leaves drooping downward. 'Zebrinus' is 2 m tall. Its leaves are green with horizontal bars of yellow. This plant is virtually identical to 'Strictus' but much fuller at the base, and as a result the stems and habit are more upright.

One cultivar formerly incorrectly identified as *Miscanthus sacchariflorus* (Maxim.) Hack. 'Gigantea' is now known as *Miscanthus floridulus*. It forms a massive clump and spreads by stolons, so its outward growth needs to be planned for or restrained. It is useful for accent or as a hedge or screen. Given a few years to establish itself, it has the capacity to form a dense solid wall for most of its full height, providing privacy that shrubs require many years to produce.

All of the *Miscanthus* mentioned here are tough, hardy, and long-lived and require little maintenance. Cutting back once each year is sufficient. They are generally well behaved in the landscape and with a little foresight and planning will not overwhelm their neighbors.

In York, Pennsylvania, and Baltimore, Maryland, I have seen *Miscanthus* used successfully in the parking lots of fast-food restaurants, where ease of maintenance is a high priority. The grass was mixed among trees and shrubs in narrow planting islands. A word of caution: care must be taken to avoid confusing *Miscanthus* with weeds early in the spring, when it is difficult to distinguish from invading grasses.

Petasites × *hybrida*. Mill. Height 1 m. Hardy to −25 °F. Butterbur.

Butterbur is a plant whose size and vigor often intimidate designers. It forms a massive colony with a bold tropical effect. Individual leaves are huge (60–90 cm wide) and architecturally distinctive because of the

Eulalia grass (*Miscanthus floridulus*).

way the petiole joins the center of the undersurface of the leaf.

Butterbur is in the daisy family, and the flowers are among the earliest to appear each spring. They occur in great numbers in rounded cones that rise only a few centimeters above the soil surface. A casual observer can mistake the greenish yellow flowers for early leaf growth. *Petasites japonicus* (Siebold & Zucc.) Maxim., a relative, is much more dramatic in flower, producing tall spikes of rose pink flowers later in the spring. Unfortunately, this species is not successful as a large-area ground cover, for individual stalks are widely scattered, and as a result the plant is not effective as a mass. At the Arnold Arboretum both types grow at different sites between Willow Path and Goldsmith Brook and are the subject of much attention and inquiry from visitors.

Petasites × *hybrida* is rampant and spreads across even larger areas each season. Its growth is hastened by moist to wet soil and full sun to light shade. It tolerates full sun in dry soils, but without adequate moisture the leaves wilt during the heat of the day. Even with adequate moisture, the hottest summer days may cause foliage to wilt. Although invasive, this plant is easily contained by an in-ground soil barrier such as a curb.

Butterbur can be seen in a number of Massachusetts landscapes, for it was once used as a logo by the landscape architect Fletcher Steele. One of the finest remaining examples of Steele's work is a public planting at Naumkeag in Stockbridge, Massachusetts.

The most elegant planting combination I know is at the Arnold Arboretum, where a vast patch of *Petasites* surrounds a lovely specimen of dawn redwood (*Metasequoia glyptostroboides* H. H. Hu & Cheng) with delicate fernlike foliage.

Phalaris arundinacea. L. var. *picta* L. Height 1–2 m. Hardy to −30°F. Ribbon grass.

Ribbon grass is an exceptionally decorative plant, with multiple cream-colored stripes that run longitudinally against a background of green. Dense, stoloniferous, and vigorous, it will quickly invade neighboring plantings unless restrained by a barrier. It is most useful as a ground cover planted under complementary shrubs and trees.

New growth on ribbon grass begins early in spring, and the plant reaches mature height quickly. The leaves remain in prime condition until midsummer. Thereafter, the heat and drought of New England summers cause the foliage to become yellow-brown, especially at the bases of the stems. Also, strong winds and heavy rains can break

Ribbon grass (*Phalaris arundinacea* var. *picta*).

the stems. At this point, the planting should be cut or mowed back to soil level, the area watered well, and a liquid fertilizer high in nitrogen applied. In three to four weeks the grass will recover, return to its normal height, and remain vigorous until frost kills the foliage.

The habitat requirements of ribbon grass are easily met. The plant is best grown in full sun; it will tolerate light shade but will not reach its full potential there.

The species grows wild at the Arnold Arboretum in wet or poorly drained soils. In my garden the variegated variety has grown for seven years in dry, sandy soil where it is baked by the summer sun and heat from an adjacent brick wall. Under the maintenance regimen discussed above, it remains lush and healthy.

I have found *Phalaris* to be a good companion for early spring bulbs such as narcissus and the large-flowered hybrid tulips. When first planted, the tulips exhibit the large blossoms illustrated in bulb catalogues, but over the years the flower size diminishes and the bulbs divide and increase, producing a multitude of smaller but more charming flowers scattered through a sea of striped grass. The leaves of both the narcissus and the tulips ripen off before I mow the grass in midsummer, so the bulbs are not disturbed.

Vines

Campsis radicans. (L.) Seem. ex Bur. Height 9–12 m. Hardy to −20°F. Trumpet vine.

Islands are often too small or narrow to allow trees and shrubs to grow successfully. For these confined spaces I propose a novel use of the trumpet vine. Upright supports, such as slender concrete columns, wood posts, or light standards could be installed individually or in groups as supports. Trumpet vine can be planted at the base of each support, and using rootlike holdfasts to cling, it will grow upward. As the vine reaches the top of each support, it will produce branches that spread outward, resembling the crown of a small tree. Rigid horizontal arms installed at the top of each column will increase the spread. Also, loops of heavy architectural chain, ropes, or cable strung between supports can be used to create a garland effect.

Trumpet vine flowers in July and August in colors of orange, scarlet, or yellow. The extra large orange-red flowers of *Campsis ×tagliabuana* (Vis.) Rehd. 'Mme Galen' provide a spectacular complement.

I have selected *Campsis radicans* over other vines because of its ease of culture even in difficult inner-city environments, quick recovery from transplanting or pruning, long life, and ability to recover from repeated attacks of vandalism.

Gary L. Koller is managing horticulturist at the Arnold Arboretum.

Books

Landscape Plants for Eastern North America, Exclusive of Florida and the Immediate Gulf Coast. By Harrison L. Flint, with drawings by Jenny M. Lyverse. 1983. New York: John Wiley and Sons. 677 pp. $59.95.

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Imagine having one of the world authorities on woody landscape plants for a next-door neighbor, someone you could turn to without hesitation for recommendations about what to plant and advice on how to care for it. Now reach for a copy of Harrison Flint's latest book, and you have that neighbor.

This comprehensive work covers approximately 1500 species of landscape plants, not including cultivars and varieties. Each species is illustrated with two line drawings, one of the young plant (between 5 and 10 years old) and another of the mature specimen (20 to 80 years). These drawings portray the plants accurately and also are aesthetically pleasing. For scale, an object or person appears unobtrusively in the corner of each picture. The portraits of the plants at different stages of growth enable one to determine the best use of the plants in the landscape.

A high-quality black and white photograph also accompanies the descriptions of most species. Finally, a set of "adaptability bars" graphically describes each plant's requirements for sunlight, wind, soil moisture, and pH. A seasonal-interest "clock" describes those times of year when the plant under discussion can make a contribution to the garden landscape.

As a result of this book's outstanding graphics, the amount of text is greatly reduced in comparison to that of most similar works. Without reading a word, one can very quickly learn how a plant looks and what its growth requirements are. The text is devoted to describing, in nontechnical terms, the nature of the seasonal interest, any problems associated with the plant, and its maintenance requirements. The "Varieties and Cultivars" section under each entry generally contains a substantial amount of text.

Interestingly, Dr. Flint refrains from expressing his feelings about the plants. This is not a book to read for its engaging style; rather, it is a reference book to return to for solid information about how a particular plant will perform in a specific site.

While the book contains much information about nonhardy plants of zones 8 and 9, it is particularly strong in the area of plant hardiness. This is to be expected, as Dr. Flint has had years of both practical and academic experience at the Arnold Arboretum, the Cooperative Extension Service of the University of Vermont, and Purdue University, where he is now professor of horticulture.

My only criticism of the book's organization is that under the entries for the main species a "Related Species" section often creates strange bedfellows. *Zanthoxylum* species, for example, are listed under the *Evodia* entry. However, the thorough index makes it possible to locate such plants. In a 30-page section at the back of the book, plants are grouped according to some 23 categories such as size, fall color, flowering time, and salt tolerance. The addition of a bibliography would have improved this book.

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The following two issues of *Arnoldia* are available from the Arnold Arboretum:

Street Trees for Home and Municipal Landscapes (1979), 164 pages. $5.00.

Wild Plants in the City (1974), 113 pages. $3.00.

An urban island in Arlington, Massachusetts, planted with ash (*Fraxinus* sp.) and juniper (*Juniperus* sp.). Photograph by Bruce Applebaum.

The Arnold Arboretum of Harvard University, a non-profit institution, is a center for international botanic research. The living collections are maintained as par of the Boston park system. The Arboretum is supporte by income from its own endowment and by its members, the Friends of the Arnold Arboretum.