arnoldia
The Magazine of the Arnold Arboretum

Index to Volume 46 (1986)

(Numbers in parentheses refer to issues, those in boldface to illustrations.)

arnoldia

The Magazine of the Arnold Arboretum
Winter 1986

Vol. 46 No. 1 Winter 1986

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

Subscriptions are $12.00 per calendar year domestic, $15.00 per year foreign, payable in advance. Single copies are $3.50. *All remittances must be in U.S. dollars, by check drawn on a U.S. bank or by international money order.* Send subscriptions, remittances, change-of-address notices, and all other subscription-related comunications to: *Arnoldia*, The Arnold Arboretum, The Arborway, Jamaica Plain, MA 02130.

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Front cover: Japanese wood-block print of a camellia, probably of *Camellia japonica*. Unso-Do Atelier, Kyoto, Japan. The Japanese characters in the lower left-hand corner are the artist's signature and his descriptive title. (See page 2.) Courtesy of Esther G. Parker. *Inside front cover*: Three tissue cultures illustrating the use of phytohormones in plant micropropagation: cytokinin-controlled shoot multiplication in *Actinidia* (left) and *Hosta* (right); auxin-induced somatic embryogenesis in carrots (center). (See page 36.) Photograph by John W. Einset. *This page*: A cone, two cone scales, two seeds, and two branchlets (left with juvenile leaves, right with adult leaves) of *Abies pinsapo* var. *tazaotana*. (See page 20.) Drawing by Karl Heinz Kindel. (Branchlet with juvenile leaves copied from Liu, *A Monograph of the Genus Abies*.) *Inside back cover*: Drawing of *Camellia japonica* from Samuel Curtis's *Monograph on the Genus Camellia* (London, 1819). The drawing was done by Clara Maria Pope. (See page 2.) *Back cover*: *Abies pinsapo* var. *marocana* (Trabut) Cetallos & Bolanos on Mount Tisouka, Morocco. (See page 20.) Photograph by Robert L. Nicholson.

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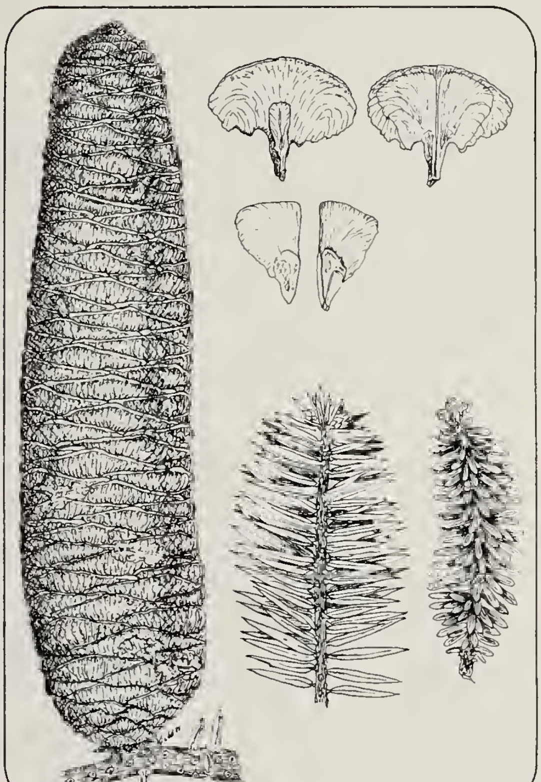

The Chinese Species of *Camellia* in Cultivation

Bruce Bartholomew

Though new camellias have been introduced to the West from China for 250 years, only a quarter of the known species are yet cultivated here

China is the origin of many cultivated plants that now are grown throughout the world. Some of them, such as the peonies, chrysanthemum, wintersweet, and osmanthus, traditionally were grown in Chinese gardens. In most cases these Chinese garden plants started being brought into cultivation in the West in the Eighteenth Century, and the earliest introductions of live plants from China were mostly restricted to garden plants. Another and far-richer source of cultivated plants has been the indigenous flora of China, particularly of the mountains of southwestern China. These wild plants were brought into cultivation from the late Nineteenth Century through to the present, after Western collectors and, more recently, Chinese collectors, started exploring the riches of the Chinese flora.

The genus *Camellia* includes species in both of these categories; thus, the history of the introduction of *Camellia* species into Western gardens spans the period from the first half of the Eighteenth Century up to the present. Even with this long history, only about one in four of the currently recognized species is in cultivation in the West, or even in Chinese botanical gardens.

Opposite: Camellia euryoides *as depicted in Loddiges's* Botanical Cabinet *in 1832. This small, white-flowered camellia was unknown in the wild for over a century after it was described from cultivated material.*

Camellia is basically a Chinese genus, some nine out of ten of its species being endemic to China. Its main center of species diversity straddles the Tropic of Cancer across southern China. Diversity drops rapidly to the south and more gradually to the north. Although most of its species are continental, the genus extends to the islands of Japan, Taiwan, and Hainan, one species, *Camellia lanceolata*, reaching the Philippines and Indonesia.

The genus as a whole has primarily a subtropical and warm-temperate distribution, and even the most northerly species have only a moderate degree of frost hardiness. As a result, camellias as garden plants are restricted to areas with relatively mild climates; in areas with more severe climates, plants must be grown in greenhouses during the winter. As horticultural plants, the most important species are the more temperate ones in the genus, with *C. japonica* being by far the most prominent. In fact, if one mentions camellias, the image that comes to mind for most people is this species.

Camellia japonica

Camellia japonica was the first species to be brought into cultivation in the West, and although it was described on the basis of material from Japan, probably all the early introductions during the late Eighteenth Century and early Nineteenth Century were from China. Linnaeus named the species in 1753 on the basis of the illustration and description in Engelbert Kaempfer's *Amoenitatum Exoticarum Politico-Physico-Medicarum*, published in 1712. Kaempfer's work was the result of a visit to Japan from 1690 to 1692, when he was employed as a doctor by the Dutch East-India Company. The earliest illustration of *C. japonica* in the West was by the English apothecary James Petiver, who published a description and illustration of this species in his *Gazophylacii Naturae & Artis* in 1701 based on a collection sent back to England from China by James Cunningham. Cunningham's collections were among the earliest specimens of Chinese plants available to Western botanists. Cunningham collected his specimens when he was a physician in the service of the English East-India Company, which had established a trading post, or factory, as they were then called, on Zhushan (Chushan) Island, opposite the city of Ningpo. Although the post lasted only a few years, Cunningham collected plants representing about 600 species, which he sent back as herbarium specimens to James Petiver and Leonard Plukenet. Among them were specimens of *Camellia japonica* and *C. sinensis*, as well as of *C. fraterna*, although the last specimen was not determined until the 1950s. The Petiver and Plukenet collections were later purchased by Sir Hans Sloane, and Sloane's collection became the foundation of the British Museum (Natural History).

Neither Cunningham nor Kaempfer was responsible for bringing *C. japonica* into cultivation in the West, and although this species is a conspicuous element in the forests of southern Japan, the earliest introductions were all from Chinese gardens. The first plant for which we have any historical record was one grown by James Lord Petre at least as early as 1739. This plant was the model for the first color illustration of a *Camellia* in the West, which was used as a prop for an illustration of a Chinese pheasant published by George Edwards in 1745. The origin of Lord Petre's plant is not known, although it is obviously a cultivar of *C. japonica* and must have been brought back from China by one of the ship captains of the English East-India Company. Lord Petre died of smallpox at the age of 29 in 1742, but many of his plants were taken over by his gardener, Philip Miller, who was in charge of the Chelsea Physic Garden, and it is quite likely that his *C. japonica* was among them. During the second half of the Eighteenth Century, *C. japonica* was grown in England, but its popularity can be traced to the importation of several specific cultivars from China in the late Eighteenth Century.

During this period the British were rapidly expanding their trade in southern China, and ship captains were encouraged by wealthy British horticulturists to bring back plants for their gardens. Two *C. japonica* cultivars, 'Alba Plena' and 'Variegata', are of particular note. They were brought back to England in 1792 by Captain Connor of the East-India Merchantman *Carnatic*, and were illustrated in *Andrews's Botanical Repository* in 1792. The great enthusiasm for growing *C. japonica* from the end of the Eighteenth Century through most of the Nineteenth Century can really be dated from the importation of these two cultivars. Over the next few decades there was a great flurry of interest in this species, as can be seen from the sumptuously illustrated books and hand-colored plates in periodicals of the early Nineteenth Century. Between 1792 and 1830, at least twenty-three cultivars of *C. japonica* had been introduced from Asia, most if not all of them from China. Subsequently, a great many new cultivars have been named from seedlings grown in the West, as well as from later introductions from Asia. At present, there are several thousand named cultivars of *C. japonica*, with many more being named every year.

Camellia sinensis

The second species to be brought into cultivation in the West was *C. sinensis*. This species was known to be the source of tea that had been imported to England and Europe since the Seventeenth Century. Live plants of *C. sinensis* may have been cultivated in England as early as 1740 by Captain Geoff, who was a director of the East-India Company and brought plants back as a gift for his wife. However, it appears that these plants died, and therefore that the first person to cultivate plants of this species in Europe successfully was Linnaeus.

Linnaeus was familiar with the tea plant from the publications of Siebold, and it was on the basis of Siebold's published description of the tea plant, and the accompanying illustration, that Linnaeus named the genus *Thea* in 1735 and the species *T. sinensis* in 1753. However, it is quite certain that when Linnaeus named this species he had not yet

Two renditions of Camellia sasanqua *from* Curtis's Botanical Magazine *(1859 and 1940, respectively). The plant in the left-hand drawing is called* "Camellia sasanqua *var.* anemoniflora," *the anemone-flowered variety.*

seen a living plant or even a dried specimen of it. *Thea* is no longer recognized as a separate genus, and the species *T. sinensis* has been transferred to the genus *Camellia*. By the middle of the Eighteenth Century, tea was already an important import from Asia, and there was considerable interest in obtaining living plants of *Thea sinensis*. Although Sweden did not have as significant a role in the commerce with eastern Asia as did England, Portugal, or the Netherlands, there was still a Swedish East Asia Trading Company, and it was through the efforts of the Swedish captain Carolus Gustavus Eckerberg that Linnaeus was able to obtain live plants. The seeds were obtained in China and were planted in pots shortly after Eckerberg set sail for Europe. Live plants were presented to Linnaeus on October 3, 1763. Although *C. sinensis* is the only species of any major economic importance in the genus, it has never received much attention as a garden plant.

Camellia sasanqua and *C. oleifera*

The first two species of *Camellia* to be described were also the first two to be brought into cultivation, but this pattern did not always continue with subsequent species. The third species to be formally named according to the binomial system of Linnaeus was *C. sasanqua*. It was named by Thunberg, one of Linnaeus's students who made major collections in both Japan and South Africa. Although it is a Japanese species and thus beyond the scope of this article, *C. sasanqua* must be mentioned because it has been confused with several subsequently described and introduced Chinese species. *C. sasanqua* had been known by earlier travellers to Japan, as it was mentioned by Siebold, but unlike *C. japonica* and *C. sinensis*, this third species was not named by Linnaeus. *C. sasanqua* remained somewhat of an enigma up until the latter half of the Nineteenth Century. The illustration in Thunberg's 1784 *Flora Japonica* is rather cursorily drawn, and although there is a specimen of it in Thunberg's herbarium, both botanists and horticulturists repeatedly confused *C. sasanqua* with other species from the mainland of Asia. It was not until after Japan had opened its doors to Western contact that live plants of *C. sasanqua* were grown in the West, in the second half of the 19th century.

Japan was quite effective in insulating herself from contact with the West, except for limited trading contact through the port of Nagasaki. China was not as successful. The

Camellia oleifera *(Edwards's* Botanical Register, *1826).*

Portuguese were the first major European traders to deal directly with China, and their trading port of Macau dated from 1557. In 1790, a Portuguese, Joannis de Loureiro, published a very important, although somewhat sketchy, account of the plants of southern China and of what is now Vietnam. Among the plants he described were four *Camellia* species. Most of these have turned out be variations of *C. sinensis*. Some of Loureiro's specimens were sent to Sweden and ended up in the British Museum, and others remained in Lisbon and have disappeared, except for those which were stolen by Napoleon's army and are now in the Natural History Museum

Camellia maliflora *(*Curtis's Botanical Magazine, *1819).*

in Paris. Unfortunately, *C. drupifera* is not among the specimens that are extant. Loureiro's description of this species is incomplete, and confusion over its identity has led various botanists to apply the name to what are in reality various other species. Because of this confusion and the lack of an extant Loureiro specimen, the name now used for what may well be Loureiro's *C. drupifera* is *C. oleifera*.

The name *Camellia oleifera* was first used by Clarke Abel for a plant that he found when he accompanied Lord Amherst's embassy to the Chinese Court. Essentially all earlier botanical collections from China were from coastal areas, and it was fortunate that the Amherst embassy had a naturalist along during its trek across eastern China. *Camellia oleifera* is one of the most common species in China, largely because it is used as an oil corp, a fact implied by the specific epithet, which means "oil-bearing." This species was first brought into cultivation in 1803, fourteen years before Abel described it. A double form of *C. oleifera* was sent back to England by William Kerr, who was a plant collector for Kew in Canton. The plant brought back to England as *C. sasanqua* was named 'Lady Banks's Camellia' and was listed in the second edition of Aiton's *Hortus Kewensis*. Single forms of this species were subsequently brought back to England and can be seen in early Nineteenth Century publications on camellias.

Camellia maliflora

The next Chinese camellia introduced to the West was *C. maliflora*, which is a double-flowered *Camellia* brought back from China by Captain Richard Rawes for Thomas Carey Palmer. This *Camellia* was illustrated in 1819 in *Curtis's Botanical Magazine* as *C. sasanqua* 'Palmer's Double', but in 1827 John Lindley recognized it as a distinct species and named it *C. maliflora*. This species has small, double, pink flowers that measure only about 4 centimeters (1.5 inches) in diameter. The species has never been found in the wild, even as a simple-flowered form, and it is quite likely that it is in reality a hybrid species.

Aside from *C. japonica*, probably the most important species to horticulture described during the 19th century was *C. reticulata*, although its horticultural potential was not fully realized until over a century later. The history of this species's introduction to the West is quite different from that of *C. japonica*, and the impact of *C. reticulata* on the cultivated camellias in the West is still at a rapid stage of development. One of the main virtues of this species is its large flowers, with the flowers of some cultivars such as 'Dali Cha' having a diameter of 22 centimeters (8.7 inches).

Camellia reticulata *(Edwards's* Botanical Register, *1827).*

Introduction of *Camellia reticulata* into Western Gardens

Because of the rather interesting history associated with this species and my own involvement in the recent developments concerning introduction of cultivars from China, I would like to give a more detailed account of facts surrounding its introduction into Western gardens. *Camellia reticulata* was described by Lindley in 1827 on the basis of a cultivated plant intoduced to England in 1824 by J. D. Parks and given the English name 'Captain Rawes's Camellia', in honor of the ship's captain who brought what was apparently the same cultivar from China in 1820 for Thomas Carey Palmer. Lindley expressed concern that this camellia was sterile and questioned whether it deserved designation as a species, but the plant was obviously different from any previously known camellia. The reason for the sterility of this cultivar is that it is a triploid, although all later material of this species has been shown to be hexaploid. The exact origin of the 'Captain Rawes's Camellia' is uncertain but it must have been obtained as a potted plant in either Macau or Guangzhou (Canton). A second cultivar of the same species was brought back from China by Robert Fortune, probably during his second expedition to China, between 1848 and 1851, when he was collecting plants in China for the nursery of Standish and Noble. This cultivar was named 'Flore Pleno' by Lindley in 1857, but the cultivar name usually given to this camellia in England is 'Robert Fortune'. We now know this cultivar to be the one grown in Yunnan as 'Songzilin', or "pine cone scale." Throughout the Nineteenth Century, *C. reticulata* was known in the West only by these two cultivars.

It was not until the 1930s that Otto Stapf, an Austrian botanist at Kew, recognized some of the plants grown from seeds collected by the Scottish collector George Forrest as wild forms of *C. reticulata*. Forrest's collections were made near the town of Tongchong (formerly known as Tungyueh), near the Burmese border of Yunnan Province. Tongchong was the base of operations for Forrest during his various expeditions to China and also the customs station for commerce between Burma and China. In addition to collecting herbarium specimens, Forrest sent seeds back to Great Britain, where plants were grown by J. C. Williams of Caerhays Castle, Cornwall. In 1935 Robert Sealy, who took over Stapf's work on camellias when Stapf died in 1933, published the first illustration of the simple-flowered *C. reticulata* grown from Forrest's seeds.

The next stage in the introduction of *C. reticulata* into Western gardens can be traced to a 1938 article by the Chinese plant taxonomist, H. H. Hu, published in the *Journal of the Royal Horticultural Society*. Professor Hu presented a paper on the horticultural resources of China in which he mentioned that Kunming was a center of camellia cultivation and that some seventy cultivars of outstanding value were grown there. Although Hu does not give the source of his information, it seems certain that his information was from a 1930 publication in Chinese by the scholar Fang Shu-mei. In Fang's publication, *Tiannan Chahua Xiaozhi*, seventy camellia cultivar names are listed, although only a fraction of these names can be allocated to *C. reticulata*. It is surprising that none of the Western plant collectors who passed through Kunming from the late Nineteenth Century through the middle of the Twentieth Century mention these magnificent cultivated camellias.

Cultivars of *Camellia reticulata*

The first detailed information on the Kunming *C. reticulata* cultivars was in an article presented by T. T. Yü at the 1950 magnolias and camellias conference in England. Professor Yü had been working at the Fan Memorial Institute of Biology's botanical research station in Kunming during the late 1930s and early 1940s. One of his interests at the time was the cultivated camellias of Kunming. In the Kunming area many large trees of *C. reticulata* grow in the courtyards of temples such as those in Xishan and in Heilongtan. The latter of these is in fact right next to the research institute where Professor Yü was

Camellia euryoides *(Edwards's* Botanical Register, *1826).* *See page 12.*

working. In addition, Professor Yü had available to him the extensive camellia collection made by Mr. Liu, a wealthy merchant and camellia fancier. Professor Yü was able to identify eighteen cultivars of *C. reticulata* and four cultivars of *C. japonica* being grown in the Kunming area, and it is about these cultivars that he reported in his 1950 article.

The discrepancy between the seventy cultivars listed by Fang and the eighteen described by Yü can be attributed to the difference in approach of the two authors. Fang was not a botanist but a traditional Chinese scholar, and he based his list only in part on his own observations and drew liberally from the Chinese horticultural literature dating back to the Ming Dynasty. Most of these older names were cultivars of *C. japonica* and were not even from Yunnan. Professor Yü, on the other hand, was trained as a botanist and based his work on actual observations. After World War II, Professor Yü went to the Royal Botanic Garden, Edinburgh, where he worked on the eastern Himalayan species of *Cotoneaster*, and it was at the end of his stay at Edinburgh that he presented his paper on the Kunming camellias. He had also written a longer treatise on the subject that he hoped to get published in the West. When Professor Yü returned to China in 1950 the manuscript was in the possession of Robert O. Rubel of Mobile, Alabama, who operated a camellia nursery and who had been in correspondence with Mr. Liu in Kunming and, through this contact, with T. T. Yü. When Yü was in Edinburgh he sent his manuscript to Rubel, who planned to publish it. However, Yü returned to China in late 1950 before the publication was complete, and Rubel lost contact with him. In 1964 Frank Griffin published a photolithograph copy of the original typed manuscript, complete with handwritten corrections. It was with great pleasure that in 1980 I was able to present Professor Yü with a copy of this publication, which he did not have.

In the late 1940s two American camellia growers, Walter Lammerts and Ralph Peer, independently tried to obtain plants of the Kunming *C. reticulata* cultivars. Through their efforts, what at the time were believed to be nineteen cultivars were obtained from Kunming. Several of these cultivars were subsequently lost, and some of the cultivars were mislabeled, so it appears that only fourteen cultivars were in fact successfully introduced to the West. These cultivars have been responsible for a great resurgence in interest in camellias and have been used extensively for hybridizing as well as being grown for their own merits.

Following these initial introductions, contact with people in China was for the most part impossible, and for many years no further introductions took place. In the 1960s Colonel Tom Durrant of New Zealand systematically straightened out those cases where there was confusion over which cultivars had in fact been brought out of China in the 1940s. He was able to show that the true cultivars of 'Jiangjia Cha', 'Baozhu Cha', and 'Daguiye' were not being grown in the West. When New Zealand established diplomatic relations with China in the 1960s, Durrant was able to obtain several of the cultivars that had not been introduced in the late 1940s or that had been subsequently confused.

During the 1960s, a Japanese camellia grower, Ikada, discovered that there were additional cultivars still in Yunnan, and he started to obtain those that he could. He also made available to the English-speaking world some of the information on Kunming reticulatas.

Recent Work in China on *C. reticulata*

In 1978 I had the great privilege to be a member of the Botanical Society of America's delegation to the People's Republic of China, along with Richard Howard of the Arnold Arboretum and eight other American botanists. We were very fortunate to be able to visit the Kunming Institute of Botany. Kunming had just been opened to foreigners, and we were among the first delegations to be able to include Kunming in their itinerary. I was particularly interested in finding out about the work on garden varieties of *C. reticulata* being done at the Kunming Institute of Botany.

In 1958 T. T. Yü and Y. Z. Feng published a small book on the Kunming *C. reticulata* cultivars. This Chinese work basically contained much of the same information as the English publication that was written by Professor Yü before 1950 but not published until 1964. However, there were two additional cultivars, 'Jiangjia Cha' and 'Tongzimian', which were not known to Professor Yü in the 1940s. 'Tongzimian' is a particularly interesting cultivar. An old cultivar from the Dali area about 400 kilometers (250 miles) west of Kunming, it is the only cultivar with almost white flowers.

Camellia kissi *(Loddiges's* Botanical Cabinet, *1832). See page 13.*

After the Yü and Feng book was published, the work at the Kunming Institute of Botany concentrated in two directions. One was the selection of new cultivars from seedlings grown at the Kunming Institute of Botany, and the other was an investigation of the cultivars grown in the Dali area. The culmination of this work was an article by G. M. Feng and Z. M. Shi that was published in the short-lived journal *Zhiwu Yinchong Xuhua Jikan* ("Plant Introduction and Domestication"). This article was published at the beginning of the Cultural Revolution, and almost all the new cultivars mentioned by Feng and Shi no longer exist. However, the old cultivars survived and are still being grown.

Since the Cultural Revolution, work has concentrated on selecting and naming new cultivars at the Kunming Institute of Botany and on surveying the wild *C. reticulata* plants growing in the Tengchong area. As mentioned above, in the area around Tengchong are to be found single-flowered plants of *C. reticulata*. Whether these plants can really be called wild or semicultivated is hard to say. The plants are not grown in orchards, but the seeds are harvested and the oil expressed and used as a cooking oil. Mature plants of *C. reticulata* reach 10 meters (33 feet) or more in height and are, in fact, small trees. In a few areas this species forms camellia forests. These camellias have been systematically surveyed and numbered, and superior forms have been given cultivar names. Among these cultivars are not only single-flowered forms but some that are semidouble and double. The culmination of this work is a book on the *Camellia reticulata* cultivars of Yunnan, which has been published both in a Chinese and Japanese edition. An English edition is in press. These editions are in reality different books, because the texts are somewhat different, as are the sets of illustrations. Unfortunately, the named cultivars in the Tengchong area exist only as the parent plants and have not yet been propagated. If local farmers decide to use any of these trees as firewood, which does happen, the cultivars involved will be lost forever.

Camellia rosaeflora (Curtis's Botanical Magazine, *1858). See page 13.*

Since 1979, I have been attempting to obtain all of the Yunnan cultivars of *C. reticulata* and to distribute them to interested botanical gardens in the West. In cases where there is no question about the identity of the cultivar already growing in the United States there has been no need to obtain additional material from China, but if there has been any question concerning the correct identity, as there is with 'Baozhu Cha' and 'Daguiye', I have been able to obtain additional scions from Kunming even though the plants grown under these cultivar names are grown in the United States. I have obtained almost all of the old cultivars grown in Yunnan, as well as the new cultivars named at the Kunming Institute of Botany. However, I have obtained only one of the Tengchong cultivers, 'Xiaoyulan', which, as far as I have been able to ascertain, is the only cultivar of the more than thirty Tengchong cultivars that is currently being grown in Kunming.

Since 1981 it has been impossible to obtain any additional camellia cultivars from Kunming because of regulations imposed by China. I do not know the reason for these restrictions, but they have essentially stopped all exchange in camellias. At present we have available 65 of the 105 cultivars currently recognized in China, which is four times the genetic diversity with which the growing of this species became established in the early 1950s.

Other Species

Camellia euryoides is another species that was first known as a cultivated plant. It was named by Lindley on the basis of a plant that flowered in March 1826 in Cheswick Garden, England. The plant had been the rootstock for a *C. japonica* brought back to England by John Potts, a plant collector for the Royal Horticultural Society in India and China in 1821 and 1822. This same species appeared as a rootstock from plants brought back to England by Parks in 1824. For over a hundred years this small, white-flowered camellia was known in the West only from cultivated plants, but it has now been found in the wild, in Fujian, Guangdong, and Jiangxi provinces.

The next species to be brought into cultivation was *C. kissii*. This species is very widespread from Nepal all the way to southeastern China and Southeast Asia. It was described by Wallich in 1820, and live plants of it were obtained in 1823 by Samuel Brooks, who was a nurseryman particularly interested in importing Chinese plants.

Camellia rosaeflora is another species that was first described from a rootstock plant. The species was described by Hooker in 1858 on the basis of a plant that had long been grown at Kew as *C. euryoides*. *Camellia rosaeflora* was subsequently lost but rediscovered as a cultivated plant in Ceylon in 1935. More recently, the species has been found as a wild-growing plant in Hubei, Jiangsu, Sichuan, and Zhejiang provinces, China. It is interesting to speculate on the origin of the plants of *C. euryoides* and *C. rosaeflora* on which these two species were described. From the currently known wild distribution of these two species, it seems quite likely that *C. euryoides* was being used as rootstock for *C. japonica* in Guangzhou, whereas *C. rosaeflora* was being used as rootstock in Shanghai.

A double-flowered variety of Camellia rosaeflora. *Reproduced from* Gardeners' Chronicle *(1928).*

Camellia rosaeflora was the last Chinese species of *Camellia* to be successfully introduced to the West during the Nineteenth Century, although the Japanese species *C. sasanqua* apparently was brought into cultivation in France by 1869 and in England ten years later. Additional Chinese species were described during the Nineteenth Century, including *C. assimilis, C. caudata, C. edithae, C. fraterna, C. grijsii, C. hongkongensis* and *C. salicifolia*. Except for *C. hongkongensis*, which was briefly grown at Kew, none of these species were introduced to the West before the present century.

Twentieth Century Introductions

Comparatively few camellias were introduced during the first half of the Twentieth Century. A notable species is *C. cuspidata*, collected by E. H. Wilson in 1900 when he was collecting for the nursery of Veitch and Sons. Plants grown from the Wilson seeds first flowered in 1912 and were reported and illustrated in the *Gardeners' Chronicle*.

The most important introductions during the first third of the Twentieth Century were those by George Forrest. As mentioned above, Forrest collected in Yunnan between 1913 and 1931. During this period he was responsible for sending back seeds of *C. reticulata, C. saluenensis, C. taliensis*, and *C. tsaii*. Of these four species, the first two are the most important as garden plants.

The next period of *Camellia* introduction from China started in the late 1920s and 1930s and has continued with major interruptions to the present. The first two botanical gardens in China were the Sun Yat-sen Botanical Garden in Nanjing and the Lushan Botanical Garden on Mt. Lushan in Jiangxi province. In the 1930s, both *C. fraterna* and *C. pitardii* var. *yunnanica* were obtained from the Lushan Botanical Garden, and possibly a few other species now grown in the United States were sent out of China during this period.

It appears that from the late 1930s to the late 1970s no camellias were introduced to the West from the mainland of China except *C. reticulata*. However, there were two very interesting introductions from Hong Kong. In late 1955, Mr. C. P. Lau of the Hong Kong Herbarium found a single plant of a new and very spectacular *Camellia* in the New Territories of Hong Kong. This new species was named *C. granthamiana* the following year, in honor of Alexander Grantham, the Governor of Hong Kong at the time. This *Camellia* has a single white flower up to about 14 centimeters (5.5 inches) in diameter. This species has many characteristics that place it as one of the more primitive members of the genus. *Camellia granthamiana* has now been widely propagated both from seeds and cuttings.

Camellia cuspidata, *a species with a shrub habit, photographed in the Royal Botanic Gardens, Kew, by E. J. Wallis. Photograph from the Archives of the Arnold Arboretum.*

Another very interesting species from Hong Kong is *C. crapnelliana*, which was described from a single tree discovered in 1903 on the southern side of Mt. Parker on Hong Kong Island. The plant was collected only once, and that only for herbarium specimens. The species has large, glossy leaves, single white flowers, and smooth, brick-red bark. In 1965, Mr. Y. S. Lau of the Hong Kong Herbarium rediscovered what must be the same tree, but this tree has not yet flowered. In 1967, Father Joseph Ly found this species growing in dense woods in Mau Ping, New Territories, and a subsequent search found 58 trees bearing fruit and flowers, as well as several seedlings. This rediscovered species has now been extensively propagated in both Hong Kong and the West.

Recent Introductions

Since the normalization of relations between China and the United States quite a few *Camellia* species have been obtained from Chinese sources. The species that has received the most attention is *C. chrysantha*, which is a yellow-flowered species from Guangxi province. There has been a great deal of interest in this species since it was described in 1965 by Professor H. H. Hu, in an article on fourteen new species and varieties belonging to *Camellia* and segregate genera.

On January 23, 1980, I received five seeds of *C. chrysantha* at the University of California Botanical Garden, of which I was curator at the time. The seeds were sent to me by Professor Zhang Aoluo, who was then the director of the Kunming Botanical Garden. Professor Zhang had also sent five seeds to William L. Ackerman, of the U.S. National Arboretum, as well as five seeds each to people in Japan and Australia. These were the first seeds of this species sent out of China through regular channels, although some years earlier either seeds or scions had been obtained by camellia growers in Japan. The seeds sent by Zhang were collected in December 1979 by staff of the Kunming Botanical Garden at the Malu commune, Fengcheng county, in Guangxi, at an elevation of 300 meters (975 feet). Both Ackerman and I were able to germinate four seeds, and the resulting eight plants have been extensively propagated and distributed to botanical gardens and camellia growers on both the east and west coasts of the United States and abroad.

The main importance of yellow camellias, of which more than ten species have been described, is the hope by *Camellia* hybridizers to incorporate the genes for yellow flower color into other cultivated camellias, resulting in a much wider range of colors than now available. One of the problems is that *C. chrysantha* is in a different subgenus, the subgenus *Thea*, from the majority of cultivated species and hybrids, which belong to the subgenus *Camellia*.

Over the past few years I have been able to obtain seeds and scions of a number of other Chinese *Camellia* species from the Kunming Botanical Garden and other botanical gardens in China. Of particular importance are *C. chekiangoleosa, C. polyodonta*, and *C. semiserrata*, all of which belong to section *Camellia* and will be spectacular garden plants with large red flowers. Other species that I have been able to obtain include *C. cordifolia, C. forrestii, C. gigantocarpa, C. grijsii, C. octopetala, C. vietnamensis, C. yuhsienensis*, and *C. yunnanensis*. Most of these species have been distributed to camellia growers and botanical gardens in the United States. At present, almost fifty of the more than two hundred described *Camellia* species are in cultivation in the West, but still more than three-quarters of the currently recognized species have yet to be grown as cultivated plants, even in China. I hope that many of these remaining species will be cultivated in China and that the exchange that began in the late 1970s will resume for the enjoyment of people in both China and the West.

Bruce Bartholomew, collection manager for the Department of Botany, California Academy of Sciences, has made four trips to China in the last decade.

Camellias, Chinese New Year, Samurai Warriors, and the Arnold Arboretum

Ever since Charles Sprague Sargent visited Japan in 1892, the Arnold Arboretum has had a deep interest in plants from the Far East, primarily because the flora of northeastern Asia is strikingly like that of northeastern North America. Over the years, several members of the Arboretum's staff have written in passing on camellias, even though camellias are not hardy in Jamaica Plain. Three excerpts from those writings follow.

Charles Sprague Sargent on *Camellia* in Japan

In 1892, Charles Sprague Sargent, first director of the Arnold Arboretum, collected plants for ten weeks in Japan. He wrote several articles on his travels for *Garden and Forest*, the magazine he had founded in 1888. Later, the accounts were combined and published in book form as *Forest Flora of Japan*. Sargent discussed *Camellia* as follows:

In southern Japan the Camellia is a common forest-plant from the sea-level to an altitude of 2,500 feet, on the east coast growing as far north as latitude thirty-six, and nearly two degrees farther on the west coast. Here it is a dwarf bush only two or three feet high, although where the soil and climate favor it, the Camellia becomes a tree thirty or forty feet tall, with a handsome straight trunk a foot in diameter, covered with smooth pale bark hardly distinguishable from that of the Beech. In its wild state the flower of the Camellia is red, and does not fully expand, the corolla retaining the shape of a cup until it falls. In Japan, certainly less attention has been paid to the improvement of the Camellia than in Europe and America, although double-flowered varieties are known; and as an ornamental plant it does not appear to be particularly popular with the Japanese; it is sometimes planted, however, in temple and city gardens, especially in Tōkyō, where it is not an uncommon plant, and where beautiful old specimens are to be seen.

Tsubaki, by which name *Camellia japonica* is known in Japan, is more valued for the oil which is pressed from its seeds than for the beauty of its flowers. This oil, which the other species of Camellia also produce, is used by the women in dressing their hair, and is an article of much commercial importance. The wood of Camellia is close-grained, moderately hard, and light-colored, turning pink with exposure; it is cut into combs, although less valued for this purpose than boxwood, and is manufactured into numerous small articles of domestic use. *Sasan-kuwa, Camellia sasanqua*, a small bushy tree of southern Japan and China, is perhaps more commonly encountered in Japanese gardens than the *Tsubaki*, and in the first week of November it was just beginning to open its delicate pink flowers in the gardens of Nikkō, although the night temperature was nearly down to the freezing point.

—Excerpted from *Forest Flora of Japan: Notes on the Forest Flora of Japan*, by Charles Sprague Sargent (Boston and New York: Houghton, Mifflin, 1894), page 17.

Ernest H. Wilson on the Introduction of Camellias to the West

E. H. Wilson, who was affiliated with the Arnold Arboretum from 1906 until his death in 1930, made six collecting trips to the Orient between 1899 and 1919. He writes as follows on the introduction of camellias to the West:

Known to the Japanese as *Tsubakki*, the Camellia was long ago christened the Japan Rose, a very

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Opposite: *A Specimen of* Camellia japonica *Growing in Ongata village, Honshu, Japan. Thirty-five feet tall and with a trunk three feet in girth at its base, this specimen has attained true tree form. Photographed in April 1914 by Ernest H. Wilson. Photograph from the Archives of the Arnold Arboretum.*

appropriate name. It attracted the attention of the earliest foreign visitors to Japan, and Kaempfer wrote about it and pictured it in his book published in 1712. Just when or by what means it was conveyed to Europe we do not know, but it is on record that it was cultivated in England before 1739 by Lord Petre. Very probably it went first from Japan carried by Dutch traders to Batavia, thence to Holland in the same manner as the Camphor-tree, Chrysanthemum, *Azalea indica*, and a number of other plants. Be that as it may, it was grown in many of the best gardens of Europe toward the close of the 18th Century. It is figured in that wonderful old publication, *The Botanical Magazine*, in its second volume, plate 42 (1788), and the flower pictured is exactly that of the wild species.

It would appear, therefore, that up to that date little or no improvement in the Camellia had taken place. Considering what happened within the next few years, this may at first seem strange, but the explanation is simple. In Japan the *Tsubakki* was regarded with superstitious awe by the warrior or Samurai class. The color of the flower is red, and it has a bad habit of falling off at the neck almost as soon as its petals are expanded. The color suggested blood to the Samurai and the fallen flower a human head severed from the body, and so to those who lived by the sword the *Tsubakki* symbolized their probable fate by decapitation. One sees the plant in Japanese gardens today and one or two distinct varieties are grown, but the Japanese really favor another species (*C. sasanqua*). . . . On the other hand, the Chinese appear to have no superstitious dread of this plant. It was cultivated in China's nurseries, temple grounds, and gardens of the wealthy. Evidently quite a number of varieties were grown in Chinese gardens, for we find the old East India ships plying between Canton and England carrying Camellia plants back to their friends and patrons. Through this means eleven well-marked varieties were in cultivation in England in 1812; by 1819 the number had so increased and the plant established itself so firmly in popular estimation that Samuel Curtis published a special monograph, elephant folio size, with eight pages of text, enumerating twenty-one varieties and illustrated by five beautifully colored plates, one of which is reproduced here. The artist, Miss Clara M. Pope, evidently possessed great ability, for her drawings are admirably done and the coloring is remarkably good. This monograph is interesting as being about the only one of this size devoted to a single genus of flowering trees. As different varieties blossomed they were figured in the current magazines, which helped increase their popularity.

Early in the 19th Century nurserymen began the raising of Camellias from seeds. Later the intercrossing of varieties was diligently and successfully carried out and many hundreds of sorts resulted. As the Victorian age approached its optimum the breeders of Camellias lost sight of everything else but the regularity of the blossom and, moreover, kept the plants trimmed into ovoid masses, which in the end brought about a revolution. The old-fashioned varieties of Camellia, like 'Alba Plena', 'Lady Hume's Blush', prim, stiff, and solid, not inappropriately typify the period; indeed, this type of Camellia might well be its floral emblem. The single varieties with their cupped blossoms, their abundant yellow-anthered stamens, and the semi-double forms had passed out of fashion in favor of the severely double, regular shaped blossom types.

Camellia japonica *as depicted in* Curtis's Botanical Magazine *in 1788.*

One of the earliest introductions from China was known as the Warratah or Anemone Flower, and very beautiful it was with its mass of stamens partially converted into narrow petals. This was the forerunner of many similar varieties, and this class together with the single-flowered forms is coming back into fashion.

—Excerpted from *House & Garden,* Volume 57, Number 3 (March 1930).

Camellias and the Chinese New Year

Chinese New Year falls on February 9th in 1986. The camellia, like many other plants, was traditionally used in China to decorate homes, shops, boats, etc., during the New Year celebration. Franklin P. Metcalf, a research associate, writing in the February 13, 1942, issue of *Arnoldia,* described the use of camellias in Canton, China, nearly half a century ago. This year, New Englanders can view camellias in flower during February at the Lyman Estate in Waltham, Massachusetts, and at the Massachusetts Camellia Society's annual meeting in Jamaica Plain. For details, see the "New England Horticultural Calendar" published in this issue of *Arnoldia.*

Metcalf wrote as follows in 1942:

One of the most interesting customs in Canton, China, is that connected with the Chinese New Year, a variable date which may occur, according to the foreign calendar, some time during the month of January or February. On the Chinese New Year, every Chinese family in Canton feels the necessity of having in its home some flowers appropriate to the New Year season. All shops are likewise decorated. Every sampan, the home of the boat people, has its splash of color and so does the junk and flower boat. Without this symbol of life, and without the decorations of scarlet-red paper, the spirit of the New Year season seems lacking.

Camellia (*Camellia japonica* Linnaeus [*Thea japonica* (L.) Nois.]), *shan ch'a* in Chinese, a shrub with beautiful dark green, shining foliage and usually delicate pink flowers, is seen in the market either as shapely shrubby bushes, beautifully cultivated in attractive flower pots, or as cut branches. Red and white forms are not often seen during the holiday season. The larger shrubs are expensive.

This flower, as mentioned above, is extensively used as a floral offering to the temple gods when special requests for the New Year are presented. It may be mentioned also in passing that this flower is never worn as an ornament in a lady's hair, for the large buds of the Camellia take a whole year to open. To the Chinese this would symbolize the fact that a woman would have to wait one whole year for a son—much too long a period—and so the Camellia is not used by women as a floral decoration.

—Excerpted from *Arnoldia,* Volume 2, Number 1 (February 13, 1942).

Collecting Rare Conifers in North Africa

Robert G. Nicholson

Conifer seeds gathered on mountain peaks in Morocco may yield varieties more cold-hardy than those now in cultivation

As the cold came on, and as each more southern zone became fitted for the inhabitants of the north, these would take the places of the former inhabitants of the temperate regions. The latter, at the same time, would travel further and further southward, unless they were stopped by barriers, in which case they would perish. The mountains would become covered with snow and ice and their former Alpine inhabitants would descend to the plains. By the time that the cold had reached its maximum, we should have an arctic fauna and flora, covering the central parts of Europe, as far south as the Alps and Pyrenees, and even stretching into Spain.

—*Charles Darwin*
The Origin of Species

Had the master biologist, Charles Darwin, travelled in North Africa, he might have amended his discourse on glaciation to include those lands south of the Pyrenees and Spain. For in Morocco and Algeria a number of peaks are high enough to have harbored an alpine flora that was spreading from Europe during the periods of glaciation. And upon these mountains there live today relict populations of these refugees, remnants of the same migrating temperate and alpine floras that Darwin so eloquently described.

Most people are surprised to learn that these relict populations include among their members such familiar moist-temperate genera as *Acer, Lonicera, Paeonia, Rosa, Sorbus,* and *Viburnum*. The order Coniferae is also well represented: species of *Abies, Cedrus, Juniperus,* and *Pinus* are also found in the colder areas of Morocco

In September 1982 I travelled to Morocco to collect seeds and specimens of its hardiest plants. The resulting seedlings I would test in the nurseries of the Arnold Arboretum. I collected on four peaks in the two major mountain ranges, the Atlas and the Rif. My collecting focussed on the native conifers, which are poorly represented in botanical gardens. It was important that I collect the seeds from as high an elevation as possible to ensure that the resulting seedlings would be of maximum hardiness. This meant extensive travelling and walking, since the isolated peaks stand far from the major cities and stretch high above the nearest villages.

The first day's collecting was done in the Atlas Mountains, just south of Marrakech. Here, the massive Jebel Toubkal rises to 4,165 meters, making it the highest peak in northwestern Africa. It is a rocky, dry, and steep mountain that, despite its cold temperature regimen, had little to offer in the way of a temperate flora. Most woody species had tapered off by 2,300 meters, and the upper reaches of the peak offered just a few grasses, thistles, and fall-blooming crocus. *Juniperus thurifera*, the incense juniper, was plentiful in the foothills, as were two roses, *Rosa sicula* and *Rosa canina*. The latter grew among some boulders, was of fine habit, and possessed a large orange hip. Its seeds germinated readily at the Arboretum's Dana

Greenhouses and should provide some interesting hardiness testing in our nurseries.

From the Atlas region I proceeded by train to the ancient capital of Fez, a major city just south of the Rif mountain chain. Because delegates to a Pan-Arabian Summit Conference had flooded the hotels, I had to move on immediately from this exotic and quintessential Moroccan city.

The Atlas Cedar

A five-hour bus ride along the switchbacks of the Rif Mountains brought me to the village of Ketama. It is beautifully situated in an extensive grove of *Cedrus atlantica*, the Atlas cedar. The boughs of these giants were softly bouncing in the incoming evening fog, and after the jarring bus ride their gentle beauty provided a soothing welcome. I did not know at the time that Ketama is a town noted for, and supported by, its illicit drug trade, being a distribution center for *kif*, a local cannabis product. Any Westerner is immediately assumed to be there "for business," and convincing people otherwise—"Plants?!"—can be both bothersome and amusing at times.

Cedrus atlantica *on Mount Tidiquin, near Ketama, Morocco. All photographs are the author's.*

An enterprising young Berber, Mouhammed Boudgara, rode up to me on a motorcycle before I was twelve steps off the bus. He gave me the standard greeting, "Hello my friend, you need a guide?" Knowing how useful a motorcycle would be for getting into the mountains, I struck a deal with him for the next day's collecting. Mouhammed was to be one of the lucky breaks that occur when plant-collecting in odd corners. He warned off the local toughs, helped find supplies, and eased passage through otherwise precarious areas.

The next day, after Mouhammed had proudly showed me his *kif* harvest, we left the village and sped off on motorcycles to the foothills of Mt. Tidiquin, some ten miles away. I was a passenger on the back of a second motorcycle driven by Mouhammed's cousin, a young man who seemed intent on showing his skill at high-speed driving on dirt roads. At one point we paused to take in a good view of the nearing mountain. It was a gentle, tapered cone, rising to 2,455 meters, its flanks covered with the flat blue–green color of *Cedrus atlantica*. We parked our motorcycles at a farming village in the foothills and, after my guides had renewed old acquaintances, walked upward. The gentle incline seen from five miles off was in reality quite steep, and the forest now rose a hundred feet over our heads. It was a thin forest with little undergrowth, and the *Cedrus* was the only species of any size. Full-sized specimens grew up to 120 feet in height at these lower elevations. A crude dirt road allowed for some limited forestry.

Cedrus atlantica has a long history of cultivation, having been introduced into cultivation by A. Sénéclauze in 1839, while G. Manetti rendered the first description in 1844. It has long been a favorite ornamental in Europe, with about a dozen cultivars now being used. It has also found favor with French foresters, some extensive plantations of it having been established on the poorest soils of Dijon and Vaucluse.

In the northeastern United States, *Cedrus atlantica*, like *Cedrus deodara*, could hardly be called ironclad hardy. Even the variety *glauca*, which seems to be the hardiest cultivar of the Atlas cedar, tends to brown some or even to drop most of its needles in the coldest winters. I had hoped, then, by collecting seed from an area of maximum hardiness, that a hardier race of *Cedrus atlantica* could be introduced to the Boston area.

It is on Mt. Tidiquin that the Atlas cedar reaches the uppermost limit of its range and inhabits the craggy summit in a gnarled, stunted form evocative of the bristlecone pine in this country. At the summit, one side of the mountain presented a clear aspect, a rock field bare of topsoil and trees, with just a few ground-hugging plants nestled among the stones. The opposite side of the summit was a sheer cliff, a few struggling cedars locked into its side. The view from the peak gave one a stunning 360-degree panorama of the central Rif chain, a sinuous and involved series of mountains, very rugged and not unlike the mountains of central Idaho and northern California in its limited accessibility.

All of the *Cedrus* I saw in the uppermost 75 meters were barren of cones, so I assume that either the coning is erratic in the upper reaches or that the trees growing there were established from seeds blown up the mountain from the fertile plants immediately below. I busied myself collecting seeds and pressing specimens, while my guides had a *kif* break in the shade of a small cedar. As the number of different specimens was small, a complete representation of the summit flora was soon in hand. Like many mountains in Morocco, this peak showed the effects of goat herding. Many of the plants had been chewed almost to the ground, and I suspect that some species had been erased completely.

On the trip down the mountainside, I found a fine plant of *Digitalis purpurea* var. *mauretanica* and took a good amount of seed. *Rosa sicula* appeared in the understory of the cedar forest, and I collected seeds from it, too.

At the farm village, a Berber wedding was in full swing as we slipped back through the streets and alleys. A truckload of master musicians was blending the unique shrill of their olive-wood pipes with the rapid toom-toom of the skin drums, while the townspeople, dressed in their finest colors, followed these pipers through the village streets. After a quick look at the proceedings we pushed our motorcycles to the outskirts and were off.

Next morning, after farewells to my guides, I boarded an aged bus headed west. The ride's unfortunate highlight was a police roadblock and subsequent search. Searched, along with a half dozen others, I was luckily able to explain a bagful of plant material in rapid pigdin French. Another passenger, however, was found with a small chunk of *kif*. He was led away in handcuffs, while his wife could only sit silently by. The example having been set, we were allowed to pass, and an hour later I was let off on the roadside. Looking up into the foothills, I saw the starched white city of Chechaouèn.

Chechaouèn has a distinctly Iberian cast to it, a maze of narrow cobbled streets winding between the bleached walls and tiled roofs. The feature of the city that pins itself to my memory is the distinctive blue hue applied to all the shutters and doors. Chechaouèn is a child's paradise, and young children are constantly scampering through its twisting streets.

A Moroccan Variety of the Spanish Fir

In 1906, the botanical world was alerted to the existence in Africa of a second species of *Abies*. Only *Abies numidica*, discovered in Algeria in 1861, had previously been known. M. L. Trabut wrote of the later discovery by a Mr. Joly in "the mountains of southern Te'tuan at Chechaouèn" of a new species intermediate between the Spanish and Algerian firs. Trabut named it *Abies marocana*. However, in subsequent years, the plant was taxonomically reduced to a variety of *Abies pinsapo*, the Spanish fir. Eventually, it was brought to European botanic gardens and made its way to this hemisphere in the 1950s as seed from trees of the Arboretum des Barres in France. But there is reason to doubt the pedigree of the trees in this country, since most of the few specimens that there are seem to be hybrids, a frequent problem with seed from cultivated plants. The Arnold Arboretum has such a tree in its collection; it puzzles anyone who takes a key to it. I felt, therefore, that a fresh introduction of seed of *Abies pinsapo* var. *marocana* would guarantee authenticity and facilitate distribution of

A view in the village of Chechaouèn.

this rare tree.

The mountains the fir inhabits rise to 2,170 meters to the east of Chechaouèn and are uninhabited save for a few goatherds. Once the fog that obscured the top of the mountain had lifted, I could see a band of dark green covering the uppermost level of the peak. I was excited at the prospect that it was a forest of the rare fir.

The next morning I set out. The lower foothills were dry, olives, figs, and almonds being cultivated there. Following the paths made by woodcutters and goatherds was the only way to reach the upper reaches of the range, and after a few hours I was well above the city.

At around 1,300 meters the first surprise of the day's collecting occurred when I found my first plants of the Moroccan peony, *Paeonia coriacea*, a perennial species reaching to two feet. A dried flower still on its stalk suggested a floral color of deep pink or rose. Its bright-scarlet seed pods, which hold seeds of a contrasting ebony, make it a species that is easy to spot. I collected about one pound of seed from various stands on the mountain, which I have processed at the Dana Greenhouses of the Arnold Arboretum.

As I entered the colder zones of the mountain I could see ahead the unmistakable conical habit of the genus *Abies*. I also began to find additional temperate elements, such as

Abies pinsapo *var.* tazaotana, *Tazaot.*

Juniperus communis, the common field juniper of North America.

At about 1,400 meters I reached the lower edge of the fir population and could see the cones I had travelled so far to collect. The terrain here was steep and dry, with little or no topsoil. Large, exposed areas of loose, calcareous rock made the footing treacherous. I focussed my attention on my feet. As I scuttled upward through the forest I could see that it was largely a pure stand with specimens reaching over 30 meters in height. Some logged tree stumps had diameters of 150 centimeters. Other elements associated with a more temperate flora appeared, such as *Viburnum tinus* (laurustinus), *Sorbus aria* (the white beam), and *Crataegus monogyna* (a species of hawthorn). A maple, *Acer opalus* var. *granatense*, appeared as a low tree. Though of scraggly habit, it impressed me by its mere presence. *Cedrus atlantica* was the only other tree of size and, along with the firs, grew to the very top of Mt. Tisouka. I collected cones in the upper range. Although taken green in mid-September, they yielded hundreds of seedlings.

It is a uniquely fulfilling experience to rest on a mountain peak and to survey below you a forest of rare species. It is a sensation that might even be unique to botanical collecting, one that makes the trip down the mountain far easier than it might otherwise be.

The Tazaotan Fir

The following day I spent procuring pressing supplies (a task that is not as easy to do in Morocco as it is in Harvard Square) and pressing the specimens I had collected. On September 15, I travelled to the only site of the other fir known to Morocco, *Abies pinsapo* var. *tazaotana*.

This fir was first brought to the attention of the botanical world by a Spanish forester, Santiago Sanchez Cozar. In 1946 he presented a paper in which he enumerated the differences between this variety and its relatives to the south, *A. pinsapo* var. *marocana*, and east, *A. numidica*. It is a larger tree, reaching to 50 meters and forming a dense forest on the top of the massif of Tazaot. Cozar's comparisons led him to believe that he had found a new species and, on the basis of morphological characteristics he named the plant *Abies tazaotana*.

Little else has been written about the plant save for an article in 1954 by J. Pourtet and P. Turpin, in which the plant was reduced to a variety of *Abies pinsapo*. Tang Shui Liu concurs in the plant's varietal status in his recent monograph of the genus *Abies*, although his section on the Tazaotan fir contains a number of major errors. For example, the plate illustrating the fir seems to be of a branch of juvenile foliage; it gives a false impression of the shape of the needles and their placement upon the branch. The preceding plate, of *Abies pinsapo* var. *marocana*, is a much closer representation. Also, Tang's map of the variety's range places the population about 100 miles southeast of where it should be.

The stand of fir grows far from major centers of population. In a land largely devoid of timber trees, this remoteness probably saved the firs from lumbering, and certain elimination, for thousands of years.

The closest major town is Chechaouèn. From Chechaouèn one must take a bus to the junction with the road that cuts east to the Mediterranean. Transportation from the junction can be described as "catch-as-catch-can." Trucks can be flagged down and a deal struck for a ride up into the sharply steep terrain. The mountains in this part of the Rif are very rugged, and only a few roads twist along the rocky flanks of the mountainsides. The people generally are farmers, growing mainly a mixture of maize, figs, and vegetables. They are, thankfully, only too happy to give directions. It seems to be one of the moistest areas in Morocco, as the rivers there are dependable enough for generating electricity and the creation of reservoirs.

A turn from the main road brings one down to a river gorge, where the road ends at the hillside village of Talembote. Its one main street is lined with small stores and houses, and any thoughts of an anonymous entry are quickly abandoned, as any stranger to town is an instant celebrity. The townspeople were initially reserved, mainly because Westerners have a reputation of smuggling, and because of the presence of a nosey and bored garrison of government militia.

Once the legitimacy of my purpose had been established, the townspeople arranged for a guide and donkey. After some friendly haggling in pidgin French, "*les cinquante dirhams et mon couteau ou le couteau et mon chaussures*," an arrangement was made and a 10-kilometer ride up the mountain began. From the village the dirt road gradually wound to the fir forest through zones of various Mediterranean scrub. The genera I encountered were both familiar and new. At one elevation I collected seeds from *Arbutus unedo*, a small ericaceous tree whose range stretches as far north as Ireland and whose relative, *Arbutus menziesii*, the madrone, I had encountered in British Columbia as a 100-foot tree. A beautiful heather, *Erica terminalis*, grew 2 feet high next to a small spring. An odd shrub with indumented, whitish leaves confused me, as I had never seen even the genus before. I found it to be *Cistus albidus*, a rock rose.

As we neared the higher part of the massif, a thick bank of fog began streaming in, billowing over the lower ridges like a slow-moving breaker. The fog would continue to plague us for the remainder of the day.

We rounded a curve and crossed a slight depression; finally, I could see the edge of the fir forest. As we entered the forest we passed a giant that had been struck down by lightning. My guide, warming by now to photography, insisted I pose against the weathered carcass.

I had explained to my guide that I wanted to collect cones from the uppermost region of the population, and we proceeded farther upwards into the forest as the fog continued to swirl around us. Before long we heard the dampened thud of axes working inward upon the trees. My guide felt it best that we skirt the unseen woodcutters ("They are from a different village," he explained), and we continued quietly through the fog. At this point visibility was about 15 feet, which slightly hindered collecting; locating plants by touch rarely proves productive.

The mountain flattens out at 1,700 meters, and my guide assured me that there was really no peak to speak of. The forest was primarily firs and, unlike Mt. Tisouka, there were no *Cedrus* specimens to be seen.

We staked our donkey, and as my guide broke for lunch I busied myself climbing fir trees and cutting down the cones. These were about 10 inches long, quite large for a fir, and very green, which made me fear I had travelled all these miles for naught.

I finished climbing and began gathering the cones. As I did so the woodcutters we had avoided previously emerged ghostlike through the fog, each carrying on his shoulder a 3-meter-long, handhewn beam. We exchanged a few mumbled greetings with them, and they merely continued trudging down the mountain to their village.

When breaks in the fog occurred, we could see the full dimensions of the trees, which grew as high as 50 meters with a gradual taper. This large size makes the Tazaotan fir one of the largest firs of the Mediterranean region and, with the possible exception of *Cedrus atlantica*, the largest conifer in North Africa. Given the large size of this fir and its adaptability to lime soils, there may be a niche for it in forestry, possibly on the lime coasts of England.

There is a question as to whether the size difference between the two Moroccan firs might be the effect of local climate. The area of the Tazaotan fir has a more fertile humus soil and seemingly a higher level of moisture. Comparisons of the two plants over a period of time in botanic gardens will help to settle the question.

In addition to the *Abies*, seeds of other woody species were collected at the top of Tazaot. These are now under propagation at the Dana Greenhouses and include *Acer opalus* var. *granatense, Crataegus laciniata, Lonicera arborea, Berberis hispanica,* and a number of others.

Origins of Morocco's Alpine Flora

While collecting in these Moroccan conifer forests, I had to remind myself continually that I was in Africa. How could such an atypical flora have come to rest here? What was

The summit of Mount Tisouka.

the genesis of these odd pockets of African conifers and how long had they existed? Upon my return to the Arnold Arboretum I sought answers for these questions.

In the *Origin of Species*, Charles Darwin provided a partial answer:

> As the warmth returned, the arctic forms would retreat northward, closely followed up in their retreat by the production of the more temperate regions. And as the snow melted from the bases of the mountains the arctic forms would seize on the cleared and thawed ground, always ascending, as the warmth increased and the snow still further disappeared, higher and higher, whilst their brethren were pursuing their northern journey. Hence when the warmth had fully returned, the same species which had lately lived together on the European and North American lowlands, would again be found in the arctic regions of the Old and New Worlds, and on many isolated mountain summits far distant from each other.

Darwin's remarks deal mainly with arctic plants and animals in Europe, but we can easily imagine the same process of regional climatic change at work farther south, in the Rif Mountains. The exodus of the Moroccan conifers to their present sites is a story that can be told only in terms of hypothesis. Fossils of *Cedrus* have been found in France (Miocene), Greece (Pliocene), and southeastern Russia (Oligocene), so we can see that a more northerly distribution existed prior to the glacial onslaught.

The lowering temperatures in the Pleistocene drove the genus farther south to its present latitudes, and even farther. *Cedrus* is believed to have grown even in the Ahaggar Massif of the central Sahara during early Pleistocene times. Since the "Ice Age" its range has shrunk to a few scattered mountain peaks, one of them being Mt. Tidiquin.

The hardiness of the Moroccan firs has never been fully determined. In the mountains where they grow, full-sized populations extend to the summits. At the lower elevations firs mingle with a warm-temperate element, but their upper limit has yet to be determined, as they simply run out of sites on which to grow. Since another variety of *Abies pinsapo*, the variety *glauca*, has grown well for some 40 years in Boston, there is real hope that its two African relatives will prove hardy also.

As with the *Cedrus*, the genesis of the *Abies* in their mountain havens can only be guessed at. The fossil record of firs in Europe extends back over 25 million years. For the genus worldwide, fossils have been found that date back 60 million years.

Abies pinsapo has been found in the European fossil flora from the Pliocene epoch, some 13 million years ago. This long history makes *Abies pinsapo*, along with the European species *A. cilicica* and *A. alba*, the only firs known to predate the Pleistocene epoch and the four waves of glaciation that occurred within it. *Abies pinsapo* may, then, have become established in North Africa prior to the Pleistocene glaciations.

It is more probable, though, that the temperate elements of the Moroccan flora arrived during the periods of glaciation, when the Mediterranean had receded and the gap between Europe and Africa was narrower or absent altogether. Glaciers are known to have existed at the time in the Sierra Nevada of southern Spain, the present home of *Abies pinsapo*. According to Burkhard Frenzel, during the third glacial period (the Saalian), "groves of extremely cold resistant conifers" were growing in the vicinity of Gibraltar.

During the final glaciation (the Weichselian), the Atlas Mountains of Morocco are known to have harbored glaciers of some magnitude, while the Rif area is thought to have had permanent snowfields. Again according to Frenzel, the whole of the Iberian peninsula was covered with "groves of extremely cold resistant conifers and deciduous trees within the prevailing steppe vegetation." It was during these final two glacial periods that North Africa probably experienced the greatest influx of plant species from Europe, and the flora of the Rif probably paralleled that of Iberia, much as it does today.

After the last glaciation, the region's climate began to warm up and dry out, driving the *Abies* to their present refuge, the highest peaks of the Rif Mountains in Morocco and the Atlas Mountains in Algeria.

These isolated populations of obscure conifers illustrate just how far south the temperate flora of Europe was driven into Africa and offer mute testimony to the fickle nature of climate.

Epilogue

I am happy to report excellent germination of seeds of the two Moroccan firs. Seedlings of both have survived their first winters in Boston. Three-year-old seedlings of *Abies pinsapo* var. *marocana* and of *A. pinsapo* var. *tazaotana* are available for sale, with the proceeds going toward defraying the costs of seed collection. For $15.00 the pair you may experiment with your own small piece of Africa. Write:

Robert G. Nicholson
The Dana Greenhouses
The Arnold Arboretum
Jamaica Plain, MA 02130.

Robert G. Nicholson, a member of the Arboretum's grounds staff, travels widely and often in search of interesting plant materials.

Report on Hurricane Gloria

Jennifer L. Hicks

A timely shift in course spared the Arboretum's Living Collections the brunt of a potentially destructive storm

In the course of our work, we are continually reminded of the Arnold Arboretum's losses in hurricanes and other storms. Thus, the staff of the Arboretum faced Friday, September 27, 1985, with mounting anxiety: Hurricane Gloria was headed our way. The plant records abound with notations of damage and losses, and the photographic archives document trees felled by the hundred, massive limbs torn from more-firmly anchored trees, and plantings flooded by the heavy rains generally associated with hurricanes. The Living Collections themselves carry the mark of every major storm of the Twentieth Century: groves of native species planted by Charles Sprague Sargent as a framework for the collection have been thinned to scattered specimens, and few mature trees do not bear the scars of storm damage.

By far the worst damage was caused by the "Great Hurricane" of September 1938, which destroyed nearly 1,500 trees in the Arboretum. As Gloria approached, the weather reports invited comparisons between the two. Both were spawned off Africa's west coast, and Gloria followed a route across the Atlantic almost identical to that of its predecessor. With wind velocities of 130 miles per hour off the Carolinas, Gloria threatened to be as destructive as the "Great Hurricane" had been. The grounds staff were mobilized to secure the buildings against the coming storm. Four men labored for over an hour to move the Lars Anderson Bonsai Collection to safety. An irreplaceable collection of 31 specimens with documented ages of up to 250 years and weights of up to 250 pounds, these were the only plants for which any precautions could be taken.

*Pin oaks (*Quercus palustris*) blown over by the 1938 and 1985 hurricanes, left and right photographs, respectively. Photographs of damage that occurred in 1938 were taken by Donald Wyman and are in the Archives of the Arnold Arboretum, those of damage caused by Gloria were taken by Peter Del Tredici.*

*Tulip trees (*Liriodendron tulipifera*) blown down in 1938 (top) and 1985. Both victims grew in the same grove, behind the Hunnewell Visitor Center.*

A Shift in Course

As Gloria continued up the coast, however, it took a more northwesterly course than the 1938 hurricane had done and, travelling along the coastline rather than over open water, steadily diminished. It travelled up the Connecticut River valley some 50 miles to the west of the course that would have brought the brunt of the storm through eastern Massachusetts, thus sparing the Boston area its full force.

In the Boston area, Gloria's wind speed hardly reached hurricane force (74–75 m.p.h.). Sustained winds of between 50 and 60 m.p.h. were felt for about two hours, with a maximum speed of 76 m.p.h. recorded at 4:08 PM by the U.S. Weather Bureau. The Blue Hill Observatory recorded gusts of 103 m.p.h. By contrast, sustained winds of over 60 m.p.h. were recorded for nearly four hours in 1938; the U.S. Weather Bureau recorded a maximum speed of 87 m.p.h., and the Blue Hill Observatory reported gusts in excess of 150 m.p.h.

Another contrast between the two storms was in the amount of rainfall associated with them. In 1938, the hurricane was preceded by four days of soaking rain, and the sodden ground provided no anchor against the wind. Gloria brought an official 0.28 inch at Boston's Logan Airport, although the weather station at the Arboretum's Dana Greenhouses recorded 0.47 inch.

Despite its shortcomings in the eyes of Boston's stormlovers, some 25 of whom gathered atop Peter's Hill during the peak of the storm, Gloria left its mark on the Arboretum. The staff who follow us will find record notations, archive photographs, and scarred trees to document the immediate loss of 45 trees and major damage to another 100 in the collection, and the loss of approximately 30 native trees from the Arboretum's natural areas and 20 from the Case Estates woods.

Gloria struck on a Friday afternoon, and although several staff members surveyed the grounds for damage after the storm had passed, it was not until Monday morning that a full evaluation could be made and the task of cleaning up could begin. As curatorial staff charted damage, the grounds staff were already at work clearing the road and path system. The entire grounds staff of nine was assigned to clean-up for a week, at the end of which time the roads and paths were clear and dangerous hanging limbs had been removed. The task will continue for some time, however. Fall planting had just begun when the hurricane struck, and although almost a third of the plants scheduled for addition to the Collections this fall could be set aside for spring planting, there were a thousand plants still to be added before the planting season drew to a close. Renovation work in the Bradley Rose Garden could not be delayed until spring. The two-man pruning crew, with additional help as available, will continue storm clean-up through the winter. Gary L. Koller, the Arboretum's Managing Horticulturist, estimates that the total cost of removal will be $40,000 or more, and that the value of plants lost is in excess of $100,000.

Damage to the Collections

As damage reports were drawn up, the propagation staff were advised of those plants for which immediate action was necessary. Scion material was collected from fallen trees before desiccation could render the material unusable, and put in cold storage to await the proper time for grafting onto suitable understock. Roots were dug from beneath a severed *Euptelea*, in hopes that suckers will continue the lineage through another generation. When possible, damaged trees will be allowed to

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Opposite: *Albert W. Bussewitz examines one of the fallen tulip trees (1985).*

stand until the proper time for scions or cuttings to be taken, as this will increase the chances of success. Fortunately, few of the casualties were not represented by specimens elsewhere in the Collections; the aesthetic damage to the Arboretum is significant, however. Major damage was done to the hickories (*Carya* spp.), oaks (*Quercus* spp.), maples (*Acer* spp.), ashes (*Fraxinus* spp.) and poplars (*Populus* spp.), and significant damage to the magnolias (*Magnolia* spp.), willows (*Salix* spp.), and lindens (*Tilia* spp.). Among the most distressing individual losses are:

☐ Two tulip trees (*Liriodendron tulipifera*), aged 79 and 91 years, one reaching 85 feet in height, torn from the hillside behind the Hunnewell Visitor Center;

☐ A silver maple (*Acer saccharinum*), aged 104 years, which was so badly damaged that it will be removed from its prominent location along Meadow Road, while another of the same accession lot, taller but with a narrower crown, standing nearby, was relatively

*A beautiful specimen of white pine (*Pinus strobus*), near the top of Bussey Hill, damaged (photograph at right) by Gloria. Many people considered it the most picturesque tree in the entire Arboretum. Already well established when the Arboretum was founded in 1872, the tree had survived many natural disasters, including a strike by lightning, before Gloria broke its beautiful overhanging limb, shown intact in the left-hand photograph. Because the limb grew at a right angle to the trunk, extensive amounts of reaction wood had been deposited along its lower surface in response to the tremendous load it therefore had to carry. Both photographs were taken by Peter Del Tredici.*

untouched;

☐ A European larch (*Larix decidua*), aged 99 years, uprooted near the Walter Street Gate;

☐ Three Japanese larches (*Larix leptolepis*), aged 65 years, two uprooted and one broken at 12 feet, on Peter's Hill;

☐ *Euptelea polyandra*, aged 93 years, and the only remaining representative of seeds collected by C. S. Sargent in Japan, severed at its base;

☐ The Arboretum's only plant of ×*Crataegosorbus miczurinii*, an intergeneric hybrid of hawthorn and mountain ash, also severed at the base;

☐ A Carolina hemlock (*Tsuga caroliniana*), aged 99 years, snapped off at 12 feet, on Peter's Hill;

☐ A particularly handsome pin oak (*Quercus palustris*), aged 46 years, uprooted from its prominent location at the intersection of Valley Road and Conifer Path; and

☐ A magnificent purple beech (*Fagus sylvatica* forma *atropunicea*), one of the trees which remain from the original plantings at the Bussey Estate, badly broken but still standing; although only about half of the crown remains, it is expected that the tree will not have to be removed.

Earlier Hurricanes

With the exception of Hurricane Diane in 1955, whose major damage appears to have been flooding, every hurricane that has hit the Arnold Arboretum has been recorded in the *Bulletin of Popular Information*, or in *Arnoldia*, as follows:

Bulletin of Popular Information, Series 4, Volume 6, Number 12, October 7, 1938 (the "Great Hurricane" of 1938);

Arnoldia, Volume 14, Number 8, September 24, 1954 (Hurricanes Carol and Edna); and

Arnoldia, Volume 20, Number 7, September 23, 1960 (Hurricane Donna).

In addition, Donald Wyman's article on the selection of trees based on their performance in the hurricane of 1938, and the rehabilitation of trees injured by hurricanes, which was published in *Arnoldia*, Volume 14, Numbers 9–10, October 15, 1954, is still in print. Copies are available for $2.50. Address orders to: "Hurricane," Publications, The Arnold Arboretum, The Arborway, Jamaica Plain, MA 02130. Prepayment is required.

Jennifer L. Hicks, curatorial assistant, maintains the records of the Arboretum's Living Collections.

A Practical Guide to Woody Plant Micropropagation

John W. Einset

The spinoff from basic research on the physiology of plants, plant micropropagation is a simple, straightforward—and commercially profitable—technique

Although its commercial use as a method for multiplying plants is still fairly new, tissue-culture propagation (micropropagation) has already had a significant impact on the way people think about and handle plants. The example of pyrethrum (*Chrysanthemum cinerariaefolium*) is especially striking. During the last 15 years this plant has been exploited extensively as a source of chemicals, known as pyrethrins, that are used as "natural" insecticides. In fact, it is estimated that over 150 million pyrethrum flowers are harvested every day of the year in East Africa or Ecuador for the production of pyrethrin insecticides. Given the size of the industry (50 billion flowers per year), it is obvious why micropropagation is being used for pyrethrum. After all, the technology enables growers to obtain rapid, clonal mulitiplication of plants that produce exceptionally high concentrations of pyrethrins. With this capability, yearly increases in superior plants equivalent to one million-fold multiplication are obtained, and the total level of pyrethrin production is increased significantly. As a matter of fact, the pyrethrum example probably represents the single most important use of plant-tissue-culture technology in the world today.

Micropropagation is also becoming very important for woody plants, although the scale of this enterprise is minor compared to the pyrethrum industry. At the present time micropropagation is utilized commonly for species in two families, the Rosaceae (roses, apples, raspberries, and strawberries) and the Ericaceae (rhododendrons, azaleas, and mountain laurels). While it is not yet clear that the technology will be feasible with all woody species, the prospects are very promising for several of them. Because of this, the most spectacular applications for micropropagation are undoubtedly still in the future.

As a technique, micropropagation represents a direct, practical extension of scientific methodology devised over 30 years ago to study fundamental aspects of plant physiology, especially the role of phytohormones in growth and development. Essentially, micropropagation takes advantage of the control of plant development that can be exerted by phytohormone treatments. Thus, although tissue-culture media contain over 20 different chemical constituents, and in spite of the fact that environmental factors such as light intensity and temperature need to be carefully monitored, the crucial variable in micropropagation is the phytohormone content of the medium. (An article on "Chemicals That Regulate Plants," which appeared in the Spring 1985 issue of *Arnoldia*, discusses other practical uses of phytohormones.)

The Three Methods of Micropropagation

Depending on the plant, micropropagation involves one of three possible strategies: (1) regeneration from callus, (2) somatic embryogenesis (embryo formation from vegetative cells), or (3) shoot multiplication.

☐ **Regeneration from callus** was demonstrated first in the early 1950s by Professors F. K. Skoog and C. O. Miller, codiscoverers of the cytokinin class of phytohormones, both of whom were working at that time at the University of Wisconsin. These investigators showed that stem segments taken from tobacco plants will proliferate an unorganized mass of tissue, known as callus, when placed on a nutrient medium containing *cytokinin and auxin.* If the callus is then subdivided into smaller pieces and these are placed on fresh media, growth will continue. Significantly, the type of growth depends on the kinds and quantities of phytohormones added to the medium, especially the relative levels of cytokinin and auxin. Thus, high cytokinin-to-auxin concentrations result in shoot formation from callus, low ratios result in root formation, while intermediate ratios result in continued callus proliferation. Spectacular as this classic demonstration of plant developmental control is, there are surprisingly few plant species that respond in tissue cultures as tobacco does. Even though callus can be produced from practically any plant, the ability of these calluses to form shoots and roots in response to phytohormone treatments is rare.

☐ By contrast, **somatic embryogenesis** has already been utilized for species in over 25 different families. Like regeneration from callus, somatic embryogenesis involves an initial stage of callus formation, in this case using a medium containing *auxin* as the only phytohormone. The callus is then recultured on a medium lacking phytohormone or on medium with cytokinin. Often, several suc-

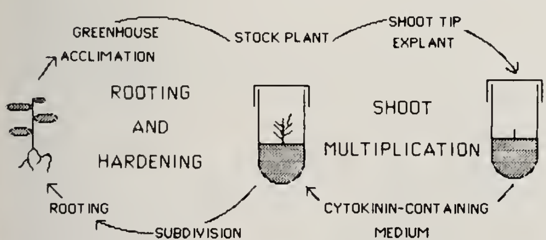


Figure 1. Steps in the Micropropagation of Woody Plants. Woody-plant micropropagation involves a shoot-multiplication cycle using controlled cytokinin treatments and a series of treatments to cause the rooting of cuttings and the hardening of plantlets.

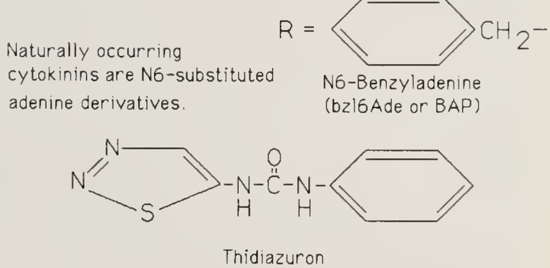


Figure 2. The Chemical Structures of Some Cytokinins. Chemically, naturally occurring cytokinins are considered to be derivatives of adenine, a basic building block of several important plant constituents. Thidiazuron, a synthetic cytokinin that has been shown to be effective in micropropagation, is a phenylurea cytokinin.

cessive passages are required before true embryos are formed. The technique, therefore, depends in large part on the finesse of the tissue culturist, a skill demonstrated first by Professor F. C. Steward of Cornell University, who was able to obtain somatic embryos from carrot tissue cultures during the late 1950s.

☐ The third technique, **shoot multiplication**, can almost be considered as the "standard methodology" as far as woody plant micropropagation is concerned. Exploited especially by Professor T. Murashige of the University of California at Riverside, who was involved in the early development of this technology for propagation, the method starts with a growing shoot tip and uses media with high *cytokinin* concentrations to promote growth and to overcome apical dominance. The result of this treatment is the production of a branched shoot system, which is subdivided. Individual shoots are then used for further shoot multiplication, or they are rooted.

The Stages of Micropropagation

According to Professor Murashige, all methods of plant micropropagation involve three basic types of manipulations, designated as Stage I, Stage II, and Stage III.

☐ During **Stage I**, establishment of the aseptic culture, an "explant" (part of a stock plant) is cleaned, disinfected, and placed on a tissue-culture medium. The objective of Stage I is to obtain a living and growing plant tissue free from microbial contamination. Surprising as it may seem, this goal is usually the most difficult thing to achieve in micropropagation.

☐ **Stage II**, also known as the stage of propagule multiplication, sometimes coincides with Stage I, especially when shoot multiplication is used. The aim of Stage II is the rapid increase in shoots or other structures that ultimately can give rise to plants. Often in shoot multiplication, explants respond almost immediately to the high cytokinin concentration of the medium by proliferating new shoots. In these cases, Stage II shoot multiplication has the potential of producing one million shoots in a year, starting from a single growing tip.

☐ **Stage III** involves all the manipulations required for establishment of tissue-culture-derived plants in soil. If, for instance, shoot multiplication is used for Stage II, then Stage III technology consists of a rooting treatment that produces plantlets and then a gradual process of acclimation (hardening) of these plantlets to the lower humidity and increased light intensity of the greenhouse or outdoor environment. Depending on the tenderness of the plantlets obtained from tissue culture, hardening may last two to eight weeks.

The Medium

A surprisingly large number of nutrients are needed by tissue cultures, at least in comparison to the requirements of whole plants. Thus, in addition to the expected inorganic (mineral) nutrients, media for tissue cultures need to contain sugar (*e.g.*, sucrose, or cane sugar), at least two vitamins, and one or more phytohormones. Presumably, whole plants generate all of these additional nutrients internally, although their production must be restricted to specific tissues. In fact, it is likely that localized vitamin and phytohormone synthesis is an important mechanism coordinating growth and function within plants.

Usually, inorganic nutrients are added to media as a standard mixture of salts. The so-called "Murashige and Skoog salts" ("MS salts"), for example, contain about 15 different salts, carefully formulated into a mixture that furnishes all of the inorganic requirements of tissue cultures, *e.g.*, nitrogen (N), phosphorus (P), potassium (K), and sulfur (S). Even though the MS salts mixture was originally devised for tobacco tissue cultures, experience has shown that it is adequate for most other plants, at least during initial attempts at micropropagation.

Sucrose and vitamins (thiamine, *i*-inositol, pyridoxine, and nicotinic acid) can be added separately or, alternatively, in preformulated mixes. At the Arnold Arboretum, we use a formulation called "Murashige's Minimal Organics Medium" (actually a misnomer), which contains sucrose, the vitamins thiamine and *i*-inositol, and MS salts, all in the proper proportions. After dissolving this mixture in the appropriate volume of deionized water, we add pyridoxine and nicotinic acid to complete the basal medium. Most commercial nurseries, on the other hand, prefer to add every component, including each of the MS salts, separately. As so often happens, the scale at which one is working determines the most economical method of operation.

Of course, the key component of the medium is the phytohormone; specifically, when micropropagation involves shoot multiplication, the cytokinin. Although over 200 different cytokinins are available, they all seem to have similar effects on plants, so it is usually only necessary to test a few compounds to find an effective cytokinin. Almost

Figure 3. The Tissue Culture Rooms at Nourse Farm in Whateley, Massachusetts. Nearly 500,000 strawberry and raspberry plants are produced annually by micropropagation at Nourse Farm.

all plants, for example, respond well to a medium containing the basal components plus 1 milligram per liter (mg/l) to 5 mg/l of the cytokinin N6-benzyladenine (abbreviated BAP, BA, or, preferably, bzl^{6}Ade). (One mg/l is equal to one part per million [ppm].) Likewise, N6-isopentenyladenine (2iP or i^{6}Ade), kinetin, and thidiazuron are usually also effective as cytokinins, though bzl^{6}Ade is generally the best choice. A curious exception to this rule involves ericaceous species such as rhododendrons, azaleas, and kiwifruits, which respond poorly, if at all, to bzl^{6}Ade but exhibit extensive shoot proliferation with i^{6}Ade. Obviously, there is something unique about the biochemistry of cytokinin in these plants.

Once all nutrients have been incorporated into the medium, the mixture is supplemented with 1 percent agar and then heated to dissolve the agar, and then the medium is dispensed into the culturing container. Practically any type of container can be used, the only requirements being that it permit light to enter, provide for ventilation, and not be destroyed by the heat involved in sterilization. At the Arnold Arboretum, we use glass test tubes with plastic caps, but have used baby-food jars, canning jars, and even kitchen cooking pans.

The agar provides an inert, jelly-like support that prevents the plant tissues from

Figure 4. Subdividing Clusters of Shoots and Planting Individual Shoots on Fresh Cytokinin-Containing Medium under Sterile Conditions. This procedure is carried out after each cycle of shoot multiplication.

sinking to the bottom of the culture vessel and suffocating from lack of oxygen. To most tissue culturists, however, agar (several different brands are available) is one of the most troublesome aspects of micropropagation. As a way of illustrating some of the problems involved, consider that, first, it is necessary to dissolve the agar by heating so that it will be uniformly distributed throughout the medium. Next, this very hot, agar-containing medium needs to be dispensed into the culture vessels both accurately and quickly, before the agar solidifies. If all has gone well to this point, the culture vessels can now be sterilized (for 15 minutes at 120 C in an autoclave, or for 30 minutes in a pressure cooker) and, after cooling, used for tissue culture. Unfortunately, this usually is not the end of problems with agar because, after growth is completed and the plant tissues have been removed, it becomes necessary to redissolve the agar so that the used medium can be discarded—not by pouring it down the sink, however, as the agar will gel and plug the drain!

Table 1. Chemical Constituents of a Standard Tissue-Culture Medium Used at the Arnold Arboretum for the Micropropagation of Several Woody Species by Shoot Multiplication

Based largely on research conducted at the University of Wisconsin in the early 1960s by F. Skoog, T. Murashige, and E. M. Linsmaier–Bednar.

Component	Concentration, milligrams per liter
Inorganic Components	
NH_4NO_3	1,650.0
KNO_3	1,900.0
$CaCl_2 \cdot 2H_2O$	440.0
$MgSO_4 \cdot 7H_2O$	370.0
KH_2PO_4	170.0
$Na_2 \cdot EDTA$	37.3
$FeSO_4 \cdot 7H_2O$	27.8
H_3BO_3	6.2
$MnSO_4 \cdot H_2O$	16.9
$ZnSO_4 \cdot 7H_2O$	8.6
KI	0.83
$NaMoO_4 \cdot 2H_2O$	0.25
$CuSO_4 \cdot 5H_2O$	0.025
$CoCl_2 \cdot 6H_2O$	0.025
Organic Components	
Sucrose	30,000
Agar	10,000
i-Inositol	100
Pyridoxine·HCl	5.0
Nicotinic acid	5.0
N6-Isopentenyladenine (i^6Ade)	5.0
Thiamine·HCl	0.4

Explants for Shoot Multiplication

By far the best starting material for micropropagation is a growing stem tip from a vigorous, healthy plant. Although seedlings are usually better sources for tips than mature specimens, the disadvantage of using seedlings is that the characteristics of the resulting adult plants are unpredictable. On the other hand, when shoot explants are taken from mature plants, one can be fairly certain that the individuals produced by micropropagation will be identical (that is, "clonal") to the stock plant.

Optimally, shoot tips are collected during the early flush of vegetative growth in spring rather than during summer, when growth has ceased, or during fall, when buds have entered their dormant period. The size of the explant depends on the objective of the micropropagation procedure. If the goal is to use micropropagation to obtain virus-free plants, for example, it is usually necessary to excise only the terminal millimeter of the growing point, to clean it, and then to plant this tissue onto the nutrient medium. Unfortunately, these manipulations require considerable manual skill and, therefore, the probability of success when small explants are used is quite low. Because of this, if the goal is solely clonal multiplication, it is easier to begin with shoot tips that are 0.5 to 1 centimeter long.

After they have been collected from the stock plant, the tips need to be disinfected thoroughly, to remove all traces of microbial contamination. At the Arnold Arboretum, we normally wash explants in detergent and then rinse them under tap water. Since these steps effectively clean the shoot tips of nearly all bacteria and fungal spores, the few remaining microorganisms can be killed simply by a soak in 1/10-strength household bleach (the active ingredient being sodium hypochlorite) for 2 to 15 minutes. Tips from most plants can withstand a 10-minute bleach treatment, although some tissues are very tender and will brown and die under these conditions. For this reason, it is best to experiment with different times for the hypochlorite treatment when a new plant is being used for micropropagation.

After they have been treated with hypochlorite, tips are transferred to sterile petri plates and a fresh cut is made at the base of each explant. The tips are then planted in nutrient medium with sterile forceps, and the cultures are incubated under light and temperature conditions that promote the optimal multiplication of shoots. We use artificial lighting recommended for houseplants and normal room temperature (75 F, or 24 C).

Growth normally becomes apparent after one to two weeks. Within about six weeks, it is usually necessary to subdivide the resulting shoot cluster and to use individual branches for further shoot multiplication on fresh medium or for plantlet production following a rooting treatment. Of course, the frequency of subculturing varies from species to species, as does the rate of multiplication. On the average, one can expect approximately a fivefold increase in shoot number every six weeks, a rate that theoretically would produce more than a million shoots, starting from a single tip, within 12 months.

Rooting and Hardening

Probably because they develop in the humid environment of the culture vessel and therefore have leaves that lack a protective cuticle, shoots produced through micropropagation are particularly sensitive to desiccation. It is essential, therefore, that they be maintained under moist conditions during Stage III. Several strategies have been used to accomplish this. In our laboratory, for instance, after dipping the bases of micropropagated shoots in a rooting powder, we transfer them to a humid plastic box containing moist vermiculite and a transparent cover. On the other hand, at Weston Nurseries in Hopkinton, Massachusetts, tissue-culture shoots of mountain laurels, rhododendrons, and azaleas are planted in the greenhouse, in beds of moist peat moss covered with polyethylene tents to maintain a humid environment. At Nourse Farms in Whately, Massachusetts, strawberry shoots are planted in a moist peat moss–soil mix, in a greenhouse equipped with a fogger-type humidifier.

If the appropriate treatments are used, roots usually form on tissue-cultured cuttings within about two weeks. Once rooting has occurred, the resulting plantlets begin to grow vigorously, and the gradual process of hardening them to lower humidities and higher light intensities can take place. With lilacs, for example, we incubate our covered, plastic boxes in the culture room for two weeks while roots are being initiated, and then we remove the covers from the boxes. Two weeks later, we transfer the boxes from the culture room to the greenhouse, where they are kept initially under shade for four weeks and then in full sun. By this time, the micropropagated plantlets are hardened enough to be handled as any other plant would be.

Often, plants produced by micropropagation are considerably more vigorous than conventionally propagated plants. This is hardly surprising in view of the optimal conditions of nutrient supply, moisture, and lighting under which they are grown. Genetically, micropropagated plants are identical to their stock plants, at least as long as shoot multiplication is used to produce them. If, however, the micropropagation method involves either regeneration from callus or somatic embryogenesis, then variant (mutant) plants are common. For some purposes this is desirable and, in fact, the variability that can be produced in tissue cultures is already being exploited commercially to obtain disease-resistant potato cultivars.

The Economics of Micropropagation

For about $250, one can purchase practically all of the supplies needed to set up a micropropagation laboratory. This price includes enough Murashige's Minimal Organics Medium, vitamins, cytokinins, and agar for 2,500 cultures ($100), 500 sterile plastic petri dishes plus covers ($50), 250 culture tubes with plastic caps ($50), flasks and beakers for media preparation, and stainless-steel for-

Figure 5. The Rapid Multiplication of Raspberry Shoots by Micropropagation.

ceps, scalpels, and blades. In addition to these items, one needs to be able to heat a medium (on a hot plate, for example) so that all of its components will be dissolved before it is dispensed to the culture tubes, and to sterilize a medium (with a pressure cooker, for example). Forceps and scalpels can be sterilized simply by dipping them in 95 percent alcohol and then burning the alcohol with a flame. A balance is also needed, unless one purchases chemicals already preweighed into lots. Of course, a transfer bench is required free from drafts, as is an artificially lighted incubation room equipped with racks for cultures.

Figure 6. A Micropropagator at Nourse Farm Subdividing Shoots before Transferring Them to Soil in the Greenhouse. (Shoots produced by tissue culture can either be used for further shoot multiplication, or they can be rooted.)

Commercial tissue-culture laboratories estimate that they spend approximately $0.50 for each plant they produce beyond Stage III of the micropropagation process. This estimate is calculated based on a minimum level of production (about 250,000 plants per year), at which several economies of scale become significant. In addition, the estimate fails to take into account expenses involved in developing refined technology for a new plant. Because of this, a newcomer to micropropagation will probably find that the costs per plant are much higher.

Research in universities and private firms during the last few years has resulted in a rapidly expanding catalog of information about the precise conditions of Stages I, II, and III for over 200 different plant species. Unfortunately, this information is not always presented in a style that is comprehensible to the beginner. Even more serious is the tendency of some commercial laboratories to explain micropropagation in an almost mystical, surrealistic fashion when, in fact, the technology involves a principle (phytohormone control of development) that is both simple and straightforward. If you are genuinely interested in micropropagation, remember that patience, flexibility, and confidence in the scientific basis of the methodology are the most important requirements for success.

John W. Einset, associate professor of biology in Harvard University, is a member of the staff of the Arnold Arboretum.

BOOKS

Manual of Cultivated Conifers, by Gerd Krüssmann. Edited by Hans-Dieter Warda; translated by Michael E. Epp. Gilbert S. Daniels, technical editor. Portland, Oregon: Timber Press, 1985. 361 pages, 160 plates, 225 figures. $65.00.

RICHARD WARREN

Gerd Krüssmann, director of the botanical garden in Dortmund, Germany, died in 1980 having made many outstanding contributions to the identification and classification of plants. His most prominent interest was the Coniferae. His first book on the subject, small in size, *Die Nadelgehölze*, was published in 1955, second and third editions following in 1960 and 1979. After the first two met with great acclaim, Krüssmann prepared a more exhaustive treatise in 1972, *Handbuch der Nadelgehölze*. The second edition appeared in 1983. Its completion was interrupted by Dr. Krüssmann's death, but Dr. Hans-Dieter Warda of the botanical garden at Hamburg completed the work. The English translation is by Michael Epp under the auspices of the Timber Press.

A modern German statement of interest in the conifers was ushered in by Ludwig Beissner's (1853–1927) *Handbuch der Nadelholzkunde* in 1891. In the dedication to his 1955 volume, Krüssmann gave Beissner full recognition of his pioneer work, and subsequent publications show him to be conscious of the tradition he is part of.

The present volume is the most elegant in format and the first to be translated into English. The translation is superb, but a slight clarification is in order: the English title, *Manual of Cultivated Conifers*, is etymologically accurate but might be misinterpreted as applying only to cultivated plants. This is not so. The book includes all conifers of whatever origin and is surely the most exhaustively complete modern work available on the subject. The German title, *Handbuch der Nadelgehölze*, carries no implication of restriction to cultivated plants.

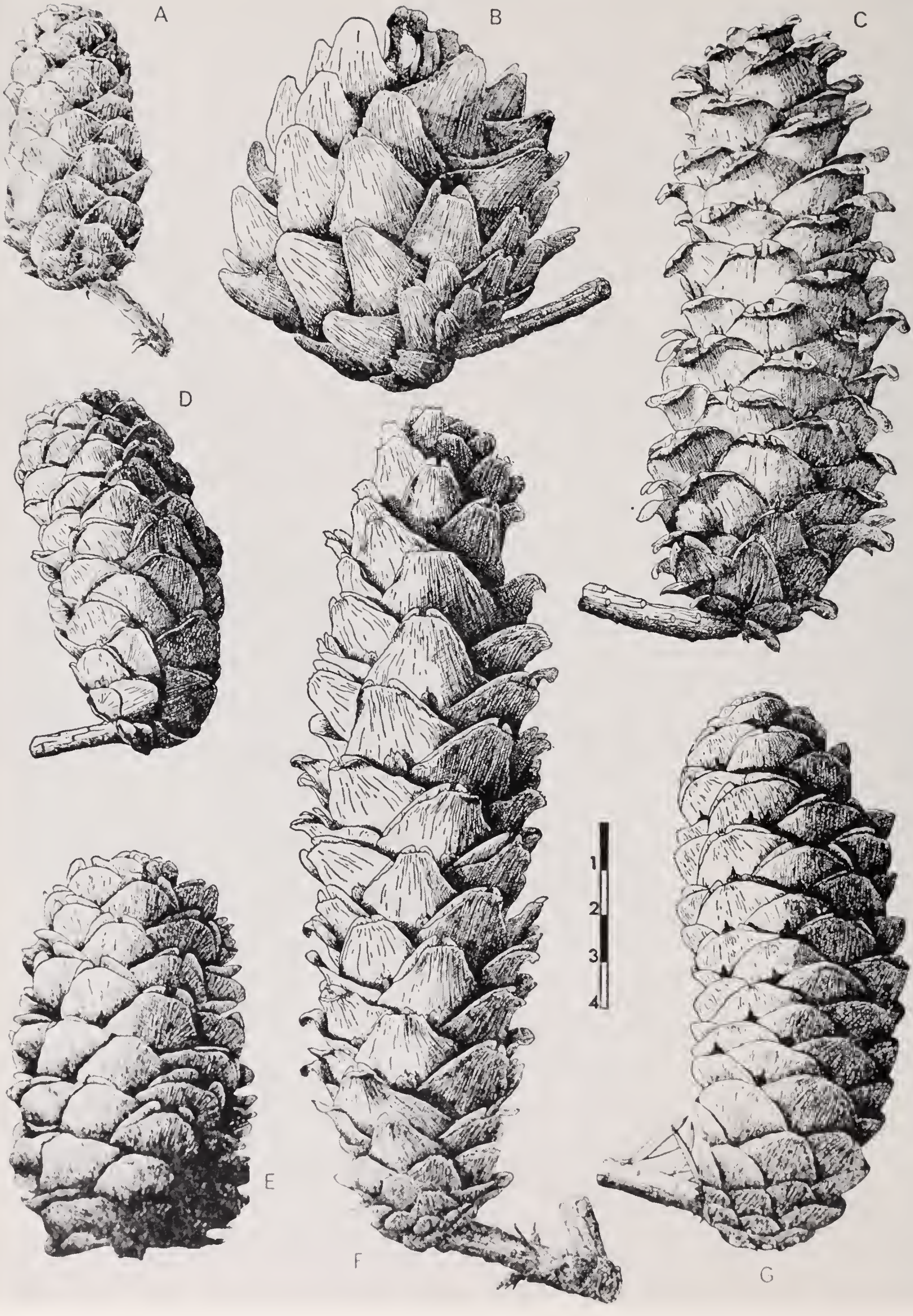
The book is certainly the most up-to-date of any possible competitors. The classification the author uses arranges the conifers into six families, the Taxaceae being in a different order, the Taxales. He includes in addition the other gymnosperms, touching in some depth on the Taxales and to a lesser extent on the Gnetales.

The scope of coverage of the subject reaches from the fossil record to such recently described genera as *Microbiota, Falcatifolium, Dacrycarpus*, and *Decussocarpus. Chrysolarix* is mentioned as a modern synonym for *Pseudolarix.*

The listing of infraspecific forms and cultivars is outstandingly comprehensive. For example, the sum of the cultivars of *Chamaecyparis lawsoniana* is 241, 25 more than in the 1972 edition and 42 more than in Den Ouden and Boom's *Manual of Cultivated Conifers*, published in 1965.

A helpful feature of the work are the hardiness-zone maps of Europe and Asia as well as of North America, and the small-scale, but clear, maps of the ranges of most of the genera and of the important species.

The illustrations are profuse and well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selected, aimed primarily at instruction rather than decoration. They are drawings and silhouettes of cones, leaves en face and in cross section, buds, all done in heavy black lines and shadings, several in one display for comparison. They serve their purpose admirably, but one feels that a more delicate technique would have been more pleasing. The author has included many excellent black-and-white photographs, mostly of foliage and plant habits.

The authors have used as aids in the identification of the plants not only keys, where the dichotomous descriptions are often guided by symbols rather than numbers, but tabular treatment of the contrast between characteristics of the species within a genus. This latter technique is helpful, for it is often less demanding on the reader's eye.

There is a good section listing botanical terms and their meanings in English, French, Dutch, German, and Latin. This was not present in the 1972 edition. It is supplemented by a table focussing on terms used in the book itself, arranged in the order of the conventional handling of descriptions: habit, stem, leaves, flowers, cones, seeds, "fruits."

The authors have carried on the custom of listing important collections of conifers around the world, a very beneficial step for rounding out the reader's knowledge and a useful guide to travel or correspondence in the field of conifers.

There is one inconvenience, not really a defect or major drawback. Readers of books in English are accustomed to a comprehensive index at the end of a work. Relying on the alphabetical arrangement of genera (which obtains in this book) involves more turning of pages than with an exhaustive index, even though space obviously is saved by the present method.

Krüssmann's *Manual of Cultivated Conifers* is a volume that anyone working with conifers, whether a beginning student or a mature expert, should have available for reference. We are grateful to have it now in English translation.

Richard Warren, M.D., an Associate of the Arnold Arboretum, is honorary curator of the Arboretum's Conifer Collection.

Books reviewed in Arnoldia *may be purchased from the Gift Shop of the Arnold Arboretum. Please call (617) 524-1718 or write for details.*

Opposite: *Cones of several species of* Keteleeria, *a genus of tall, evergreen trees of* Abies*-like appearance from China and Taiwan. In cultivation, the trees are often only shrubby in habit. From* Manual of Cultivated Conifers, *by Gerd Krüssmann.*

Spring 1986

arnoldia

The Magazine of the Arnold Arboretum

Vol. 46 No. 2 Spring 1986

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

Subscriptions are $12.00 per calendar year domestic, $15.00 per calendar year foreign, payable in advance. Single copies are $3.50. *All remittances must be in U.S. dollars, by check drawn on a U.S. bank or by international money order.* Send subscriptions, remittances, change-of-address notices, and all other subscription-related communications to: *Arnoldia,* The Arnold Arboretum, The Arborway, Jamaica Plain, MA 02130.

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Front cover: Inflorescence and leaves of *Catalpa speciosa*, the western, or hardy, catalpa. (See page 2.) Watercolor painting by Esther Heins. Courtesy of the artist. (See page 2). *Opposite*: Inflorescence of the Japanese honeysuckle (*Lonicera japonica* L.). From *Curtis's Botanical Magazine* for 1834. (See page 27.) *This page*: A tiger swallowtail (*Papilio glaucus* (L.)) approaching a hop tree (*Ptelea trifoliata* L.), one of the plants on which its larvae feed. From Mark Catesby's *Natural History of Carolina, Florida, and the Bahama Islands* (London, 1754). (See "Books," page 46.) *Inside back cover*: The elegant bark of the Amur chokecherry (*Prunus maackii* Rupr.). The conspicuous horizontal structures are lenticels, pores through which gasses enter and leave the interior of the trunk. Photograph by Albert W. Bussewitz. Courtesy of the photographer. (See page 11.) *Outside back cover*: An inflorescence of *Prunus maackii*. Photograph by Albert W. Bussewitz. Courtesy of the photographer. (See page 11.)

Page

The Great Catalpa Craze

Peter Del Tredici

Zealous promoters once made claims about the value of the hardy, or western, catalpa that far exceeded the tree's true economic potential, obscuring its real worth

Horticulturists, who make it their business to pass judgments on plants, generally consider the catalpa tree a disaster. Although very beautiful, its large, heart-shaped leaves create a major litter problem when they fall. And during the growing season, their lovely, soft-green tints are generally masked by infestations of powdery mildew. The catalpa tree is among the last to leaf out in the spring, and in the autumn its foliage turns brown and shrivels in response to the first touch of frost.

The catalpa is sparsely branched; consequently, for six months of the year it presents a very stark, almost gawky, appearance. Its long pods, which provide the reason for the plant's common name, the Indian bean tree, add a note of interest to the winter silhouette, but in the spring, when they fall, they provide the home owner with yet another reason to curse the tree. To top off this bleak situation, catalpa wood is quite brittle, and small branches regularly break off during storms.

Without a doubt the flowers are the primary ornamental feature of the catalpa. They are produced in early summer and rival those of the common horse-chestnut (*Aesculus hippocastanum*) in showiness, being quite large, pure white, and lightly speckled with purple and yellow spots arranged in parallel bands. Unfortunately, this bloom period lasts only about a week or so, depending on the weather.

In short, the catalpa has too many black marks against it to win favor with modern horticulturists. Yet, this was not always the case. There was a time, in the late 1800s, when planting catalpa was the thing to do, and people up and down the East Coast, across the Great Plains, and as far as California were madly planting the tree everywhere. The movement to plant catalpa was a fad not dissimilar to the one of planting *Paulownia* in the middle Atlantic states today or *Ailanthus* in urban areas, from the early to mid-1800s.

While the active planting of catalpa has by and large ceased, the tree has managed to increase its range on its own, as spontaneous seedlings sprout up along highway embankments, roadsides, and stream banks throughout the East Coast. In some towns, spontaneous catalpa is so well established that one is tempted to look upon it as part of the native vegetation.

The Two Species

There are two distinct species involved in the parentage of these escaped catalpas. Both are native to the eastern United States and, while very similar, occupy nonoverlapping ranges in their wild state and have quite distinctive growth habits. The first, the southern catalpa, *Catalpa bignonioides*, occupied a rather limited range before the European settlement, growing along river banks from central Alabama and Mississippi to western Florida. Because of its showy flowers, catalpa was very quickly and widely planted throughout the south, so that even the early

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Opposite: *Leaf, shoot, fruits, seeds, and ovule of* Catalpa speciosa. *From* The Silva of North America, *by Charles Sprague Sargent. Drawing by Charles E. Faxon.*

botanists could not determine its original range with certainty.

The second species, the western, or hardy, catalpa, *Catalpa speciosa*, is geographically separated from its southern cousin, growing in a small area encompassing southern Indiana, Illinois, Missouri, western Kentucky and Tennessee, and northeastern Arkansas. This disjunct population of catalpa was not recognized as distinct until 1853, when Dr. John A. Warder of Cincinnati, Ohio, first described it. While it is difficult if not impossible to distinguish the two species in the herbarium, they are fairly easy to separate in the field. For one thing, *Catalpa speciosa* blooms in late May or early June in New England, a good two weeks before *Catalpa bignonioides* does. For another thing, *Catalpa speciosa* usually is a tall, narrow tree, upwards of 80 feet in height, with a straight trunk, while *Catalpa bignonioides* is considerably smaller, usually around 40 feet, with a contorted or low-branched trunk and a wide spreading crown.

In areas where the two species are planted together, there is often an overlap in the end of the *Catalpa speciosa* bloom and the start of the *Catalpa bignonioides* bloom. This raises the distinct possibility of hybridization, which, if it occurred, would give rise to trees intermediate between the parents in stature and in time of bloom. It is quite possible that some of the spontaneous plants one sees along the roadsides are of hybrid origin, in contrast to the cultivated plants, which are usually identifiable as one species or the other.

The question remains as to why and how these two species of catalpa came to be so widely planted that they became part of the spontaneous flora of the East. The answer eluded me for many years, until I consulted the fountainhead of information on trees, *The Silva of North America*, by Professor Charles Sprague Sargent. This many-volume work is special because it was produced at a time when botany, horticulture, and forestry were not seen as separate specialties; it contains, therefore, everything that was known about trees through 1894.

Apostles for Catalpa

According to Sargent, two men, E. E. Barney of Dayton, Ohio, and Robert Douglas of Waukegan, Illinois, became apostles for the western catalpa during the 1870s, the former writing and publishing a book about the virtues of *Catalpa speciosa*, while the latter was the principal contractor for the actual planting of catalpa on large tracts of prairie owned by various railroad companies. By his own reckoning, Douglas had planted over two and a half million seedlings throughout Kansas and Missouri in less than six years. Barney's pamphlet of 1878, *Facts and Infor-*

Several fruits of Catalpa speciosa. *Photograph from the Archives of the Arnold Arboretum.*

mation in Relation to the Catalpa Tree, offers a clear picture of the catalpa gospel of the day.

A railroad man, Barney saw the catalpa as solving the specific problem of obtaining railroad ties for the construction of new lines across the treeless Great Plains. Barney felt that catalpa wood was the ideal solution to this problem because it was extremely resistant to decay. Catalpa was further suited to the task since it grew incredibly fast and was not particular about what type of soil it required. Barney predicted that seedlings planted in good soil would produce four to eight ties each after twenty-five to thirty years of growth.

In addition, Barney advocated its use for poles, fence posts, and, because of its beautiful flowers, general civic beautification. He also stressed the fact that while there were two distinct varieties of catalpa, only the hardy, or western, variety grew fast enough and straight enough to have any economic potential. The southern variety, while it was equally beautiful in flower, was a much smaller, less straight tree that was useless for railroad ties or poles. In the second edition of his pamphlet, published in 1879, Barney included articles by both C.S. Sargent and J.A. Warder, which made it much more scientific than the earlier work.

Barney did much more than attempt to convince people to plant the tree; he actually offered them seeds of *Catalpa speciosa*: "I will send by mail, postage paid, to anyone wishing the seed, enough to plant one acre four feet each way (2500 seeds), and a copy of this pamphlet, upon receipt of fifty cents." There can be little doubt that this early, at-cost distribution of seed played a key role in helping *Catalpa speciosa* to get established throughout the country. Catalpa seeds have no dormancy requirements; they germinate immediately upon sowing. No doubt this ease of cultivation also contributed to its successful establishment.

An Experimental Planting

A year after the second edition of Barney's pamphlet appeared, the most famous planting of western catalpa was undertaken by Horatio Hollis Hunnewell, Charles Sprague Sargent's friend and relation. Hunnewell was first and foremost a businessman who served either as director or president of some thirty-four different railroads between 1852 and 1901. He was also deeply interested in plants. In 1880, at the age of sixty-five, he managed to merge these two interests by commissioning Robert Douglas to plant four hundred acres of *Catalpa speciosa* and one hundred acres of *Ailanthus altissima* on a tract of prairie near Farlington, Kansas. The trees were planted on four-foot centers, which gave a density of two thousand per acre. The seedlings grew very rapidly at first, reaching an average height of twenty-two feet, three inches in diameter after only nine years. This growth rate was sufficient to have the experiment hailed as a success by all those who saw it (and some who didn't), and led to the planting of many more plantations by other railroad companies.

Horatio Hollis Hunnewell (left) and Charles Sprague Sargent in Horticultural Hall, Boston. Photograph from the Archives of the Arnold Arboretum.

Unfortunately, the growth rate of the trees in the Hunnewell plantation slowed down considerably after the first nine years as overcrowding became an inhibiting factor. When the trees were last measured in 1898, at eighteen years of age, the average height was only thirty feet and the average diameter slightly less than four inches. In other words, after showing an average height increase of 2.4 feet per year during the first nine years, the trees slumped to an average height increase of only 0.9 foot per year during the second nine years.

In 1902, William L. Hall, superintendent of tree planting for the U.S. Department of Agriculture's Bureau of Forestry, estimated the average value of the Hunnewell plantation to be about $400 per acre. When the trees were finally cut in 1905, the actual gross profit was near $500 per acre. Hall calculated the expense of establishing and maintaining the plantation at about $115 per acre. Subtracting this figure from the $500 gross leaves a net profit of $385 per acre after twenty-five years.

Interestingly, almost all of the harvested trees were made into fence posts, while a few of the tallest and straightest trees were made into telephone poles. According to A. E. Oman, writing in 1911, none of the plantation trees ever grew big enough to make railroad ties. On three other Kansas plantations that Oman looked at, totalling approximately one thousand acres, the story was repeated — plenty of fence posts, a few poles, and no railroad ties.

While fence posts were not exactly what had been envisioned when the catalpa plantations were set out, they did make a reasonable profit for their owners. Unfortunately, the twenty to twenty-five years that one had to wait for it was too long for most farmers (and businessmen) to wait. And so corn and wheat were planted instead of catalpa.

Once the initial publicity blitz for western catalpa was started by Barney, planting of the species seems to have attained a momentum all its own. The fact that the plantations produced fence posts rather than railroad ties after twenty-five years was not, of course, fully appreciated when the seedlings were set out.

A Practical Experiment

Even before the harsh economic realities of planting catalpa were fully appreciated by people, Hunnewell's cousin, the indefatigable Charles Sprague Sargent, raised serious questions about the widespread assumption that catalpa timber made good railroad ties. In 1886, Sargent published the results of an experiment that had been set up eight years earlier to test the practicality and longevity of catalpa ties:

> The Boston and Providence Railway Corporation began in 1878, at my suggestion, an experiment for the purpose of determining the value of different woods for cross ties. Fifty-two ties were laid on the 12th and 13th of December, under the direction of Mr. George F. Folsom, master carpenter of the corporation, who has had, from the beginning, the entire charge of the experiment, in the main outward track, at a point beginning 775 feet west of the Tremont Street crossing in Boston. The traffic at this point is very heavy, an average of sixty-five trains passing over this track daily. The following ties were laid:—
>
> Nos. 1 to 3, American Larch.
> Nos. 4 to 12, White Oak.
> Nos. 13 to 18, European Larch.
> Nos. 19 to 24, Western Catalpa.
> Nos. 25 to 30, Ailanthus.
> Nos. 31 to 36, Black Spruce.
> Nos. 37 to 38, Southern Hard Pine.
> Nos. 39 to 40, White Elm.
> Nos. 41 to 46, Hemlock.
> Nos. 47 to 52, Canoe Birch.
>
> The catalpa ties were furnished by the late E. E. Barney, of Dayton, Ohio, who for many years before his death was zealously engaged

in making known the value of the catalpa tree, and the remarkable durability of its wood.

Upon completion of the experiment, Sargent found that western catalpa had failed to live up to its press releases:

> The behavior of the catalpa is one of the most interesting features in the experiment. . . . The catalpa is a soft, light wood, with a specific gravity of only 0.4165; and it has not shown its ability to resist the heavy and constant traffic of the Providence Railroad as well as white oak and other heavier and harder woods. The two catalpa ties taken from the track in October, 1885, that is, after four years and eight months' service, are perfectly sound except under the direct bearing of the rails. These had cut down into the wood to the depth of five-eighths of an inch, while the whole mass of wood under the rail is reduced nearly to pulp by the separation of the layers of annual growth and the breaking of the fibre. This disintegration has penetrated so deeply that if the ties, otherwise perfectly sound, were turned over, the wood which would then come under the rail would not have sufficient thickness to hold the spikes. The pressure, however, to which these ties have been subjected has been unusually severe, and there is nothing in the behavior of these catalpa ties to show that they would not, in a road with lighter traffic, have stood for a number of years, and resisted as well and probably better than ties made from any other equally soft and less durable wood.

Sargent concluded that white oak made the best ties of any of the species included in his experiment. He noted, however, that

A view from beneath of the coarse branch structure of Catalpa speciosa. *Photograph by Peter Del Tredici.*

The two Catalpa speciosa *trees received as plants in 1886 from Robert Douglas of Waukegan, Illinois. The trees are now about fifty-five feet tall. Photograph by Peter Del Tredici.*

American chestnut, which unfortunately was not tested, was to be preferred because it allowed the spikes to be removed more easily than did white oak, when the time came to move or change the rails.

Yet even this clear statement of the facts seems to have gone unheeded, as John P. Brown of Chicago, editor of *Arboriculture*, continued to advocate in his journal the planting of catalpa for railroad ties well into the 1900s. A very high percentage of the early numbers of *Arboriculture* were devoted exclusively to the "wonders" of hardy catalpa. Brown's efforts, like Barney's twenty years earlier, no doubt greatly stimulated the planting of the tree.

Legitmate Uses for Catalpa

All of this is not to say that the widespread planting of *Catalpa speciosa* was a mistake to be regretted. To the contrary, the plant contributes significantly to the beauty and diversity of the countryside, whether in flower or in leaf. Belonging to a family of plants that is primarily tropical, the *Bignoniaceae*, it adds an exotic appearance to eastern and midwestern roadsides. Two stately specimens of *Catalpa speciosa* at the Arnold Arboretum (2776-A and 2776-B) show just how spectacular the tree can be when grown as a specimen. They were received in 1886, exactly one hundred years ago, as plants from the "Johnny Appleseed" of hardy catalpa, Robert Douglas of Waukegan, Illinois. Towering above the lilac collection, they are both about fifty-five feet tall with very straight trunks thirty-two and thirty-five inches in diameter, respectively. Dripping with long pods against the winter sky, they make a particularly dramatic impression. Nearby is a specimen of *Catalpa bignonioides* (12926-A) planted in 1891, that is forty-three feet tall, with a broad crown and a short trunk twenty inches in diameter.

The hardy catalpa can be a superb landscape plant *in the proper location*. It is not a good shade or street tree because of all the litter it drops. But in a parkland situation, where the tree can develop as a specimen, its showy flowers, distinctive foliage, and unique growth habit can add considerable interest to the landscape. In addition, its tolerance of poor, sandy soils, as well as of soils that are periodically inundated with water, makes the tree ideal for planting in habitats that have been badly disturbed or where spring flooding is a problem.

Catalpa also does well in cities. In downtown London, for example, *Catalpa bignonioides* is widely planted and seems to grow quite well. When I asked an English horticulturist why this was so, given that I hadn't seen it anywhere in the countryside, he replied that downtown London was the only place in England hot enough in summer for catalpa to grow. It's an odd twist of fate that a tree considered a weed by many in the United States should be a pampered prize in England.

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Peter Del Tredici, assistant plant propagator for the Arnold Arboretum, writes often on horticultural subjects for *Arnoldia* and *Horticulture* magazines. Not long ago, Theophrastus published his book, *St. George and the Pygmies*, a study of *Tsuga canadensis* 'Minuta'.

A Word about the Cover Artist and Her Work

Arnoldia is privileged to have for the cover of this issue an elegant watercolor painting of *Catalpa speciosa* by the distinguished botanical artist, Esther Heins of Marblehead, Massachusetts. Together with some sixty-seven other equally superb watercolors, this painting will be published during the spring of 1987 by Harry N. Abrams, Inc., of New York City under the title, *Flowering Trees and Shrubs*.

Educated at the Massachusetts College of Art and the School of Vision, Salzburg, Austria, Esther Heins studied painting with Ernest L. Major and Oskar Kokoshka. Her work has been displayed in many exhibitions, including three one-woman exhibitions. Paintings by her are part of the permanent collections of the Museum of Fine Arts, Boston; the Hunt Institute for Botanical Documentation, Pittsburgh; and the Boston Public Library. Previously, her work has been published by *Horticulture, Arnoldia, JAMA* (the journal of the American Medical Association), and the Hunt Institute, among others. *Arnoldia* is pleased again to share Mrs. Heins's work with its readers.

Corrections

Because of an editor's error, the captions for *Daphne odora* 'Ringmaster' and *D. odora* 'Zuiko Nishiki' (*Arnoldia*, Volume 45, Number 2, Spring 1985, page 14) were transposed. *Arnoldia* regrets the error.

Through an oversight, Theodore R. Dudley's name was absent from the list of American members of the 1980 Sino-American Botanical Expedition given on page 13 of *Arnoldia*, Volume 45, Number 4, Fall 1985. Dr. Dudley, Research Botanist at the U. S. National Arboretum, who was especially interested in Chinese species of *Ilex* and *Viburnum* during the Expedition, informs *Arnoldia* that the painting printed on page 16 of that issue and attributed to "an unknown artist" was in fact done by Xin Ke-jing of the Creation Group of the Bureau of Culture, En-shi Xian ("County"), Hubei province. *Arnoldia* thanks Dr. Dudley for having passed this information along.

Prunus maackii, the Friends's Plant Dividend for 1986

Gregory J. Waters

Friends of the Arnold Arboretum receive the exceptionally cold-hardy Amur chokecherry as a benefit of membership

All members of the Friends of the Arnold Arboretum will be receiving ready-to-plant seedlings of *Prunus maackii* in late April or early May, as this year's plant dividend. In mid-April, staff members and volunteers working in the Dana Greenhouses shipped the six- to twelve-inch seedlings by U.S. mail. Recipients who live farther north than Boston will be pleased to learn that the species is hardy to at least minus 35 degrees Fahrenheit. Unfortunately, *Prunus maackii* does not perform well south of Zone 6 owing to the stresses of summer heat.

The common name, Amur chokecherry, refers to the species's native habitat along the Amur River in northeastern China (Manchuria) and southeastern Soviet Union. *Prunus maackii* is native to parts of Korea as well. *The Flora of the U.S.S.R.* states that *Prunus maackii* occurs in the "[t]aiga, mixed forests, rare in conifer forests and even more rare in purely broad-leaved forests, often on mountain slopes, in illuminated sites, along streams, forest edges and clearings, and coarse rock taluses."

Its history at the Arnold Arboretum goes back 108 years, to 1878, when the Arboretum was in its infancy. During the summer of that year, the Arboretum's first director, Charles Sprague Sargent, and Asa Gray were actively consulting with Frederick Law Olmsted on the preliminary plans for incorporating the Arboretum into the City of Boston's park system. That year, plants of *Prunus maackii* arrived from the botanic garden in St. Petersburg (now called Leningrad). This was the first recorded introduction of the species into the United States. *Prunus maackii* was not introduced into Britain until 1910.

Though the Amur chokecherry produces small racemes of white flowers (see the back cover of this issue of *Arnoldia*) and pea-size dark-purple fruit, the main ornamental attraction is its bark. Golden brown and glossy, it peels off in thin strips when mature. Lit by afternoon sun or seen against a backdrop of snow, the beautiful bark of *Prunus maackii* is an unforgettable sight.

Few Friends of the Arboretum can have missed the prominent pondside planting of the species adjacent to the new Bradley Rose

A close-up glimpse of the shiny bark of Prunus maackii, *showing how it characteristically peels away in thin sheets. Photograph by Harrison L. Flint. From the Archives of the Arnold Arboretum.*

Two snow-covered specimens of Prunus maackii *in the Arnold Arboretum. Photograph by Albert W. Bussewitz. From the Archives of the Arnold Arboretum.*

Garden. These trees are descendants of seeds collected by the Russian botanist B. V. Skvortzov from a forest east of Harbin, Manchuria, on September 19, 1939. Skvortzov sent the seed to the United States Plant Introduction Station at Glenn Dale, Maryland, in January 1940, where they were assigned Plant Introduction Number 135617 and planted. In 1961, scion material from the Plant Introduction Station trees was sent to the Arnold Arboretum, where it was grafted onto *Prunus serrulata* rootstalk and given Accession Number 388-61. Vegetative cuttings from these grafted trees yielded the trees we have today. Because of their distinctive glossy bark, which can be viewed year round, they are among the most commented-upon trees in the Arboretum.

The Arboretum's records indicate that *Prunus maackii* can be propagated by seeds, cuttings, and grafts. (*See Alfred J. Fordham's detailed article on the propagation of* Prunus maackii *below.*) Perhaps the easiest method of propagation for the general gardener would be to take semi-hardwood stem cuttings in mid-July and to treat them with an 0.8 percent indolebutyric acid dip or with an equally strong powder. Placed in a rooting medium of equal parts of sand and perlite, and kept in the humid atmosphere of a mist bench or enclosed in a plastic bag, the cuttings should have roots within ten to twelve weeks.

Seedlings should be kept cool until they are planted outdoors, preferably in mid-May. They should be planted in sites with moderate to full sun, in well drained soil. Young trees should be staked for the first two or three years so that their shallow roots can become firmly established.

Pruning and controlling insects and diseases should be easy with the Amur chokecherry. During the early years, structural pruning performed in late winter corrects the tree's naturally small branching angles and improves its overall shape. Proper care and maintenance keep insect and disease problems to a minimum.

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Notes and Quotes on the History and Origins of the Amur Chokecherry (*Prunus maackii*)

Maackii, amurensis, ussuriensis—these and certain other specific epithets, or variants of them, appear in the scientific names of many specimens in the Living Collections of the Arnold Arboretum. There is even a genus *Maackia*, the type species of which is *Maackia amurensis*. All are linked by a story that combines plant exploration with the international intrigue and politics of a century and a quarter ago, intrigue and politics that led to the discovery, and eventually to the cultivation, of *Prunus maackii*, the Amur chokecherry. How? Perhaps the comments made in *Horticulture* magazine in 1912 by the Midwestern horticulturist, E. O. Orpet, give us the best excuse to explore the issues surrounding the origins of *Prunus maackii*. Orpet wrote as follows:

Prunus maackii

Surprises come to all of us who have eyes to see, and the other day when visiting Mr. William Constantine Egan at "Egandale," his estate in Highland Park, Illinois, by invitation to see his "Russian May Day" trees in full bloom, it was a revelation indeed, and yet a puzzle to explain how it is that so good a thing, with all the help Mr. Egan has given it in the way of publicity, should be practically unknown in cultivation, certainly unlisted in catalogues, and given only scant notice in Bailey's Cyclopedia.

The trees with Mr. Egan are rapid in growth, with perfect pendulous habit for a specimen or lawn tree, and they are in full bloom with the shad-bush, which most of us regard as the harbinger of the flowering trees. The whole tree was covered with the spikes of bloom, these being as large as and much more abundant than our *Prunus serotina*, and the sweet fragrance can be noticed many yards away. A very happy and instructive combination is obtained by the planting of *P. maackii*, *P. padus* and the native *P. serotina* in the same group, thus having the European, Russian, and American Bird Cherries, no two of which flower together. When asked as to seeds, Mr Egan said it was very hard to get as the birds carried them all off. There is compensation in this, however, for we noticed the young trees coming up spontaneously in the vicinity presumably from seed carried by birds.

It would appear from other cultivated trees of *P. maackii*, that it does not bloom for at least twelve years from seed; we find that this is so with specimens here in Lake Forest and in Lake Geneva, but after they do begin, it is a continual May Day feast, and we doubt not that in the future, when better known, *Prunus maackii* will figure in the landscape to a marked degree. The writer is free to confess personally that not in ten years has any tree or shrub made as great an impression at first sight, hence the present note.

The first week in November last, Mr. Dunbar pointed out in Highland Park, Rochester, N. Y., *Lonicera maackii* in fruit, bearing as profuse as we see it in *L. morrowii*, in August. There are few shrubs fruiting in November, and this had a very distinct decorative value. We have young plants now raised from a few seeds gathered at that time, but this again is a plant we do not find in catalogues; in other words it can't be bought.

It appears that there was once a *Maackia amurensis*, now reduced to *Cladrastis*. The three plants under note are from Mandschuria, and were described by Ruprecht. We are wondering who Maack was. Perhaps some one from the Arboretum can tell us.

In this particular year when we are all talking about hardiness or otherwise of all outdoor things, it is good to be able to report

> so favorably on a seemingly new tree, originally distributed by Prof. J. L. Budd of Ames, Iowa, and said to be the hardiest farthest north of all Cherries with a very marked horticultural value as a decorative tree.
>
> —Excerpted from *Horticulture*, Volume 15, Number 21 (May 25, 1912), page 755.

A Case of Misplaced Enthusiasm?

Messrs. Orpet and Egan, among others, would have been chagrined to read the following information in an article by Charles Sprague Sargent that was published in *Garden and Forest* in 1888. Discussing a very-early-flowering variety of *Prunus padus* (like *Prunus maackii* a bird cherry from Manchuria), Sargent reported that a specimen in the Arboretum's collections

> was raised from seed sent many years ago to the Arnold Arboretum from the St. Petersburg [Leningrad] garden as *Prunus Maackii*, a Manchurian Bird Cherry, with pubescent foliage and young branches, while those of this plant are quite glabrous and show no trace of the glandular dots which cover the under surface of the leaves of that species.

While they might have failed to see the by then decades-old *Garden and Forest* article, Orpet and Egan no doubt did see a much later one—which may also have been written by Sargent—in the *Bulletin of Popular Information* (now called *Arnoldia*), in 1917, though chances are they already knew the unhappy truth it revealed. In the later article, an anonymous author confesses, in describing a specimen of *Prunus padus* var. *commutata* in the Arboretum's collections, that

> The seed from which this plant was raised was sent from the Botanic Garden at Petrograd [Leningrad] in 1878, incorrectly as *Prunus Maackii*, under which name the young plants were distributed from the Arboretum, and as *Prunus Maackii* it is still cultivated and much esteemed in some Illinois gardens.

Maackia amurensis *var.* buergeri *in the Arnold Arboretum.* Left: *habit;* right: *close-up of leaves and an inflorescence.* Maackia *is one of the many plant taxa named after Richard K. Maak. Photograph by Herbert W. Gleason. From the Archives of the Arnold Arboretum.*

Opposite: *Drawing of the leaves and an inflorescence of* Prunus maackii. *From* Flora Sylvatica Koreana, *by Takenoshin Nakai (Part 5, 1916).*

The Arboretum's records on the seeds sent from Leningrad seem to be lost. In 1915, however, it did receive "Seed" of *Prunus padus* var. *commutata* from none other than E. O. Orpet of Lake Forest, Illinois. No doubt there had been an interesting exchange of letters between him and Sargent in the three years since his piece on "*Prunus maackii*" had appeared in *Horticulture*. The Arnold Arboretum did receive three authentic *plants* of *Prunus maackii* from Leningrad in 1878, however, one of which survived until 1946, when it had to be removed because it was in poor condition.

Fortunately, the two taxa can easily be distinguished from each other. The following chart should help expose any specimens of *Prunus padus* var. *commutata* still masquerading as *Prunus maackii*:

	Most Likely Time of Bloom	Length of Racemes	Flowers		Leaves
			Diameter	Number per Raceme	
Prunus maackii	Mid- to late May, after leaves appear	2 to 3 inches	⅓ inch	6 to 10	Midribs hairy beneath; glandular dots on lower surfaces
Prunus padus var. *commutata*	Early May, before leaves appear	3 to 6 inches	½ inch	10 to 40	Hairless; no dots on lower surfaces

The leaves of Prunus maackii. *Photograph from the Archives of the Arnold Arboretum.*

Richard Karlovich Maak

The Great Soviet Encyclopaedia states that Richard Karlovich Maak was "Born Aug. 23 (Sept. 9), 1825, in Arensburg, present-day Kingissepp, Estonian SSR; died Nov. 13 (25), 1886, in St. Petersburg." He was, the *Encyclopaedia* continues, a "Russian naturalist and explorer of Siberia and the Far East." (In English translation, the *Encyclopaedia* renders the surname "Maak," not "Maack" as most other sources do.)

"In 1853, Maak took part in the expedition which first described the orography, geology, and population of the basin of the Viliui, Olekma, and Chona rivers" the great work continues. "He studied the valleys of the Amur (1855-56) and Ussuri (1859) rivers." An account of Maak's work in the Amur valley, *Puteshestvie na Amur, sovershennoe po rasporiazheniiu Sibirskogo otdela Russkogo geograficheskogo obshcheskogo obshchestva v 1855 godu*, was published in St. Petersburg in 1859. The title is usually given in English as *Journey to Amur in 1855*. Here, at least in brief outline, is an answer to E. O. Orpet's query.

Emil Bretshneider, the Russian biographer, tells us more. Maak, he says,

> studied natural sciences at the St. Petersburg University, took his degree of Candidate, in 1849, and in 1852 was appointed Professor of Natural Sciences at the Gymnasium of Irkutsk. Subsequently he became Director of that Gymnasium, and from 1868 to 1879, he was Superintendent of all schools in Eastern Siberia. He died at St. Petersburg,

November 13, 1886.

Maak described his first expedition down the Amur and back in a book entitled: JOURNEY ON THE AMUR, IN 1855 (in Russian), published in 1859, accompanied with an Atlas containing maps, views and drawings of plants.

The expedition left Irkutsk in April 1855, and proceeded by the ordinary way to Nerchinsk. Here, at the discharging of the Nercha into the Shilka, they found a great raft prepared for them, on which they embarked on the 5th of May. Albazin, May 26, stay till 31st.—On August 8, the expedition arrived at the post Marinsk, near the Kidzi Lake and remained there till August 14. Then back up the Amur River, reached Aigun October 11, spent a month there. On November 12, started on horse back, for the Amur was frozen, following the river valley. Ust Strelka, December 30, Irkutsk January 16, 1856.

As on this river journey frequent stops were made, sometimes for several days, Maak had a favourable opportunity for making botanical and zoological collections. The plants gathered by him in the Amur valley, in 1855, were determined and described by Maximowicz in his Primitiae Florae Amurensis.

The Amur River

The Amur River (*Hei-lung Chiang* in Chinese) is a river of eastern Asia that forms the present border between the Soviet Union and China (Manchuria, or Heilongjiang). Flowing generally southeastward, the Amur is nearly 1,800 miles in length. (Counting the Shilka–Onon system, the Amur would be 2,700 miles in length.) It did not always form the frontier between the two countries, however. Before 1858, when China ceded all lands north of the Amur and east of the Ussuri rivers to Russia by the Treaty of Aigun, the Chinese claimed both of its banks. Russians had first reached the Amur area in the Seventeenth Century, but by the Treaty of Nerchinsk (1689) had yielded it to the Chinese. Russians began to colonize the area again in the Nineteenth Century. Richard Maak, the botanist, was part of that second wave.

Enter Perry McDonough Collins

Only a few months after Richard Maak explored the Amur River, an American, Perry McDonough Collins, having travelled the length of Russia eastward from Moscow, drifted down the Amur on a barge provided by Siberian officials, the first American to navigate the Amur from its source to its mouth. A businessman and promoter, Collins had managed to get himself appointed the official "American Commercial Agent to the Amoor River." Attracted by the potentialities he saw for American trade in the Amur region, he went there to see for himself, and on behalf of the United States government. Like other Americans of the time, Collins was afflicted with "Russian fever." Eventually, the era of good feeling between the United States and Russia would be capped by the sale of "Russian America" (Alaska) to the United States in 1867.

In an account of his travels, prepared for the United States Congress (*A Voyage Down the Amoor*, originally published in 1857, and reprinted by the University of Wisconsin Press in 1962 under the title, *Siberian Journey: Down the Amur to the Pacific, 1856–1857*), Collins captured a moment of change in czarist Russia's eastward expansion and development of Siberia. Fresh from the developing frontier of his own country, Collins saw Russian activities in the Amur region through approving eyes. "Siberia is comparatively a free country," he wrote.

> There are no landed proprietors, no serfdom. The land belongs to the Crown, and is given to the settlements or villages in the country or to individuals in cities. Public sentiment and speech are quite free also; in fact, the reins of government seem to set lightly on her people. The people are hardy and robust, accustomed, like our own frontiersmen, to

a rough and active life, have the rifle and use it well, as the mountains of furs and skins seen in the cities and market-towns fully attest.

Collins described the mighty Amur in terms any American could have understood:

> The river is truly a grand one, and since we passed the Zea, more and more resembling the Mississippi, and since we passed the Songahree, and now the Ousuree [Ussuri], in many places with its cut and crumbling shores, falling-in timber, and the muddiness of its waters, and its huge sandbars, the resemblance has become almost perfect.
>
> From the Songahree the Amoor is certainly a more considerable river in breadth than the Mississippi below the mouth of the Ohio. The expanse of water, the numerous islands, and the many navigable chutes, some of them thirty miles in extent, must give it more breadth than the Mississippi. As for distance, above the Ousuree the river is divided into two parts; one—the right—usually navigated, into which falls the Ousuree, deep, and about the size of the Ohio; the other, broad and filled with islands, bars, and chutes, certainly as large as the Mississippi above Memphis, and looking very like it.

Charles Vevier, who edited the 1962 reprinting of Collins's book, summarized the political situation of the Amur region during the 1850s in the following clear terms: "Economic opportunity in this unknown region . . . was grasped in a Russian fist which now, after some two hundred years of negotiation, had unclenched, spreading its fingers over the Amur region, the Ussuri River area east to the Pacific coast, Northern China, Sakhalin, and Japan." There was at least one benign result of Russia's thrust into eastern Asia, a flood of plant material new to botany and horticulture. Richard Maak alone discovered forty-two new taxa in the Amur and Ussuri river valleys on the two expeditions he made to the region during the 1850s, the first in 1855, the second in 1859. The genus *Maackia* was among the new taxa, as was the species *Prunus maackii*. It was the year after Maak's first expedition to "Amur-land" that China, in the city of Aigun, relinquished all claim to territory north of the Amur and east of the Ussuri. Two years later (1860), Russia established the town of Vladivostok at the southeasternmost extremity of its newly secured territory.

Professor Sargent & Son in Amur-land

Forty-three years later, Professor Charles Sprague Sargent, the first director of the Arnold Arboretum—accompanied by his son, A. Robeson Sargent, and the naturalist–writer, John Muir of California—travelled to the Amur region in search of plants. They left the United States on May 29, 1903, on a six-month around-the-world tour, arriving in Russia on August 1st and the Amur region a dozen days later. The journey went well for the most part until the travellers arrived in Manchuria and Siberia. There, they had to spend days at a time on hot, crowded trains, unable even to change their clothes. The food was abominable; at Harbin, Manchuria, Muir developed a severe case of food poisoning. These hardships, plus a profound difference of temperament between Muir and the elder Sargent that intensified during the trip, prompted Muir to strike out alone once the party had escaped Siberia and Manchuria. A newspaper interview with Robeson Sargent and private accounts of the trip by Muir follow.

Prof. Sargent Garners Rare Specimens of Eastern Flora

His Recent Expedition to Russia, and Through Siberia, Will Be of Vast Benefit to Plant Collection at Arnold Arboretum

Prof. Sargent, of the Arnold Arboretum, has just returned from a 6 mos.' tour of Russia and Siberia.

The journey was undertaken by Prof. Sargent for the purpose of securing an exhaustive collection of tree and plant specimens, and in this arduous task he was assisted by his son, A. R[obeson]. Sargent, the landscape architect.

More than 8000 bulbs, seeds and roots were the result of the expedition, and while it will require many months for development to reveal the exact value of the collection, the professor is sure that many rare specimens of eastern flora have been gathered and the success of this mission is a question beyond cavil.

The party left New York May 29, and entered the land of the czar Aug. 1.

Several weeks were devoted to the Crimea, where the younger Sargent was charmed with the landscape effects of the gardens attached to the imperial palace, pronouncing them surpassed only by the craft of the Italian landscape gardener.

"The most superb thing in nature that Russia had to offer," said he,

> *was the voluptuous floral display of Mt. Kasbek, a spur of the Caucasus range, where 10,000 ft. above the sea level the luxurious profusion of wild flowers was astounding.*

Perry McDonough Collins's map of Amur River basin as it was when he made his trip through the area in 1857. An American, Collins floated down the 1,800-mile waterway on a barge a year or two after the Russian botanist Richard K. Maak made the same trip on a raft, discovering, among other plants, Prunus maackii. *(Amur is spelled "Amoor" on Collins's map.) The Amur reminded Collins of the Mississippi, and its tributary the Ussuri ("Ousuree" on Collins's map), of the Ohio. China, by the Treaty of Aigun ("Igoon" here), ceded all lands north of the Amur and east of the Ussuri to Russia in 1858. (An "X" has been added to indicate the location of Haerbin, Manchuria, from which B. V. Skvortzov sent seeds of* Prunus maackii *to the U.S. Plant Introduction Station in 1940.) Map courtesy of the Boston Athenaeum.*

Every conceivable color was there to be found, and yet the blending was in such perfect harmony that it constituted a color scheme well worth cultivating in landscape gardening, and one scarcely creditable to accident alone.

My one ambition is to reproduce the effect in America.

We entered Siberia by way of the Chita branch of the railway and spent 28 nights upon the train, during 10 of which we did not remove our clothing, owing to the miserable sleeping car accommodations.

In Russia every traveler takes his bed clothing with him, and through ignorance of this custom we found ourselves in a sorry plight. Often where bedding could not be hired, we were compelled to drive the streets all night.

I was impressed with the vast forests and broad steppes of Siberia, and as we sped over the Armor R. R., the original one of the country, we passed many trains filled with Russian convicts. They were crowded into small box cars, lighted with tiny barred and grated windows.

At Harbin, in Manchuria, we found the Russian government was secretly mobilizing her troops, and everybody professed belief in the permanent occupancy of that country by the czar's minions. Harbin is a new town and tenanted by soldiers and Russian officials exclusively. The most interesting town in Manchuria is Kabavosk [*i.e., Khabarovsk*]*, a place of 5000 inhabitants and delightfully situated at the juncture of the Armor and Usari rivers.*

We expected to return from here to Harbin, where the Eastern China R. R. commences, but while en route thither a bridge went down with 40 passengers and we were compelled to retrace our steps.

Farming is quite primitive in Siberia and agricultural implements are most crude. Wooden plows are used and drawn by 12 yokes of oxen. I was pleased to see, however, that American implements of agriculture are beginning to be introduced into the country.

The soil is fertile and with proper cultivation would supply the world with wheat.

Vehicles with 2 wheels are employed exclusively and the ox is ubiquitous as a draught beast.

We had ample opportunity to study the people, for the Russian trader usually reaches the depot several days in advance of the departure of his train and there he sleeps and eats in the depot, carrying his food and bedding with him. They are all disgustedly dirty and wear shoes made of pelts and twisted twine. The beverage is invariably tea, which is drunk with block bread. The national intoxicant is voyaka, which is sold by the bottle, the law prohibiting its sale by the glass, and the purchaser gets gloriously drunk thereon. It seems to be made of pure alcohol.

Everybody smokes, the women using the cigarette and, though I am advised that universal discontent prevails, the people present an air of silent satisfaction.

The edifices are mostly block houses with thatched roofs.

Living is expensive, though railway fares are ridiculously cheap.

The better class of Russian women are the handsomest in the world, but the military officers do not present so fine an appearance as do those of the German and Austrian armies. . . .

Aside from the novelty and pleasure which the trip afforded, I feel that the benefit which will thereby accrue to the study of trees and plants is of incalculable value.

—*Boston Evening Record*,
December 29, 1903.

John Muir's accounts consist of a letter to his wife, Louisa ("Louie"), which he wrote in Vladivostok, and hastily scribbled entries in his diary. These give a vivid and decidedly more candid picture of the unhappy conditions under which the party travelled than did the newspaper account. Both the letter and diary excerpts are presented below with only minor editing.

Letter

Vladivostok Aug. 19, 1903

Dear Louie After many short stops here & there we are at last on the Pacific having crossed the whole vast breadth of Asia, & now you don't seem so dreadfully far. We arrived yesterday morning very tired having slept in our clothes the last 8 nights & the heat has been trying 80 to 90° in the cars. & miserable uneatable food at the stations most of the[m]. Here it is delightfully cool—but the food is very poor. I'm resting today while the Sargents are out botanizing. I suppose we will be here a few days longer. Then Sargent wants to [see] the Amour for a day or two, thence back to Harbin, thence to Muken & thence to Peking which will require 8 to 10 days more of rail riding of most wearisome sort, but with views of wonderful regions their rocks scenery flora people etc by way of compensation. I had made up my mind to leave the Sargents here

& go to Japan Shanghai, etc as I long for the cool sea. But Sargent advises very strongly against my going off alone & raises all sorts of objections, difficulty of arranging money matters etc. promises not to stay but a day or two in Pekin or hot, dusty Mukden (suggestive name) So I suppose Ill go on with him as far as Pekin or Shanghai—where I hope to hear from you once more. The whole trip has been exceedingly interesting far more so than anything I had read lead me to expect. And now dear wife & babes Heaven bless you. How glad Ill be to get home. Love to all. John Muir

Muir's diary is even more revealing than his letter.

Diary

Aug 12 . . . Mr Sargent & Son have decided to give up the voyage down the Amour on acct of missing todays boat, tho another sails in 4 or 5 days. Would go on alone but can't separate. . . .

Aug 19. Sargents out botanizing while I read & work & rest. Would like to leave for Japan etc but Sargent wishes to go with him to point on the Amour & thence to Mukden Pekin & Shanghai. 2 weeks more of miserable rail travel in very enfeebled condition but I suppose I'll get thro somehow & I will see more of Manchuria.

Aug 20. In house all day resting.

Aug 21. The sea air reviving. Hope to leave this eve 9. PM for Kabarovsk. . . .

Aug 28. 6 A.M. In broad flat mostly cultivated. At Harbin 7 a.m. Bar[ometer] 600 rainy Harbin is situated on river. Flat & muddy streets. When dry fill in ruts & sinkholes the story of sea of mud. Large Govermt buildings—intended for large town. like many others along the R.R. but Yankee enterprise sadly wanting or adventurous builders of homes. The whole country seems a Government camp. Drive to so-called garden restaurant 5 ms of the most horrible streets for holes basins pits ridges & peaks made chiefly of mud. Harbin on its large flat rain again and dark. Left Harbin at 2.30 for Mukden. Rain at 2.45 in rich rolling treeless prairie like country planted mostly to millet.

4:30 Bar 700. Same prairie sunflrs millet, melons etc. Still dark, rainy, extremly rich soils gl[acial] mud silt reformed in slow water—few clumps of trees on horizon mud adobe houses thatch roofs mud corall walls, some corn.
6 P M universal rain Bar 850 Dripping Chinamen herding cattle & horses here and there some with umbrellas. Nearly all cultivated or in pasture The country is flatter than 2 hrs ago. All looks like Illinois

29 aug. Bar 650, cldy. The same prairie & crops. All Chinese horses poor & sore. Groves & single trees here & there Willow poplar tillia [*Tilia*] or elm mostly not a stone to be seen Houses mud framework wood. The whole country beautiful in features of low swells & ravines with hills dotted with trees in dist. seems to have been cultivated every inch of it time immemorial No wildflrs in it only weeds by waysides & in pastures rose colored polygonum the showiest. Chinese here keep hogs wh they herd. The largest ever saw have enormous ears look like baby elephants.

We are running back to [Kungchuling]. 3 bridges said to be washed out ahead.—going back all the way to Harbin. Dont know how long may have to wait in that filthy place. Sargent seems pleased.

30 Aug. Still damp and cloudy & running wearily back thru millet fields to Karbin will probably get there this P.M. arrived at 10 a.m Stay here until 3 P M when we again go back 200 ms or so into first mtns to N of here to botanize. A day or so while waiting repairs on line to Port Arthur None knows when they will be completed.

Start at 3.40 PM rain hazy muggy weather. Bar 650 has stood so from when we turned back. At 6 P.M Bar 800 Many on train going this way via Vladivostok to Pt. Arthur, wish we were but of course Sargent wont & he has me in his power

Arive Aug. 31 at station in the mtns 1600 ft El at daybreak & in pouring rain, Crouch for a while back of brick wall then go to porch of restaurant where I lie on bench all day in terrible pain. indigestion after 3 mos of abominably cooked food. Start back to horrid Harbin at 4 or 5 P M. Arrive Sep 1, at 6 AM. After dreadful night of pain. I told S. that we wld probably be compelled to go via Vladivostok & Japan after all thus passing 5 times ovr part of road on acct of the broken bridges. He never seemed to think of me sick or well or of my studies only of his own. until he feared I might die on his hands and thus bother him—He was planning another botanical trip to some point on the Sungari, going by Stmr & leaving me alone at some hotel or lodging house. But fortunately learned the R R might not be opened for a Mo & that a stmr wld leave Vladivostock on the 3d or 4th. So back N we went again this Eve Sept 1.

Sep 2. Still alive. Morphin to stupify pain & brandy to hold life.

Sep 3 arrived at old quarters in Vladivostock at 7 AM. after most painful days of all my experience in this ○ Learn the steamer sails at 3 PM. today. Robeson [Sargent] loses his passport, & cant buy ticket or leave country. After big fuss went to Am consul & under his direction got out papers enabling him to leave—got off at 6 P.M. & now hope to get well.
Ate a little supper & suffer no pain.

Sep 4 glorious to be free from pain. Arrive at San Won [Wonsan] beautiful harbor on Korean coast leave at night . . .

From Korea, the party went to Japan and thence to China. At Shanghai, Muir and the Sargents went their separate ways.

The Sargent–Muir Trip in Context

Manchuria and Siberia, separated by the Amur and Ussuri rivers, increasingly became the scene of international rivalries between the time Maak and Collins, on the one hand, and the Sargents and Muir, on the other, travelled there. They also became the scene of intense botanical collecting. Frank N. Meyer, for instance, was in Siberia and Manchuria in late 1906 and early 1907. He was there again in late 1912 and early 1913. On both occasions he passed through Harbin and Mukden. During the first of those trips Meyer also travelled in northern Korea. On August 21, 1903, he collected a pyramidal wild cherry with bright-green foliage that Alfred Rehder of the Arnold Arboretum much later named *Prunus* ×*meyeri* in his honor. (Two days after Meyer made the collection, he recorded a killing frost.) Meyer reported seeing "Only two or three trees . . . during the whole trip through northern Korea and only two had a few seeds."

When he described *Prunus* ×*meyeri*, Rehder had suggested that it might actually be a hybrid. "*Prunus Meyeri* seems in all its characters intermediate between *P. Maackii* Rupr. and *P. Maximowiczii* Rupr.," he wrote in the *Journal of the Arnold Arboretum* in 1920, "and is probably a hybrid between these species, both of which grow in northern Korea and in the same regions, as specimens collected by Mr. [E. H.] Wilson on the Tumen–Yalu divide on two subsequent days show."

In 1928, the Russian botanist B. V. Skvortzov reported two forms of *Prunus maackii*, *Prunus maackii* forma *rotunda* and *Prunus maackii* forma *oblonga*, from northern Manchuria, in the *Lingnam Science Journal*. In 1939, from a forest near Hsiaoling, Manchuria (a town on the Trans-Siberian Railroad through which the Sargents and John Muir must have passed several times in their wanderings), Skvortzov collected seeds of *Prunus maackii*, which he sent to the U. S. Department of Agriculture and from which came the scions that produced the trees now growing in the Arnold Arboretum.

The Sargents and Muir travelled in Manchuria during a period of intense rivalry between Russia and Japan through which China was drawn to Russia (and Russia to China) in an alliance against Japan. As part of this process, Russia had begun to build the Trans-Siberian Railroad in 1891, to forge a link between Vladivostok and Russia proper; Russia was able to exact from China a concession that part of the line run through Manchuria in order to protect the Amur River frontier. The alliance between Russia and China was strengthened by Japan's victory over China in the Sino–Japanese War in 1895. Harbin (or Haerbin) owed its origin to the construction of the Manchurian section of the Trans-Siberian Railroad, the "Chinese Eastern Railway," over which the Sargents and Muir travelled. Before 1896, Harbin had been a minor fishing village and market town; thereafter, it became the construction center for the Chinese Eastern Railway. Another railroad (on which the Sargents and Muir also travelled) was built southward from Harbin to connect it with the Russian-developed city of Port Arthur (Lushun) on the Liaotung Peninsula in southern Manchuria. Largely Russian-built, Harbin became a base for Russian military operations in Manchuria during the Russo–Japanese War of 1904–05, which broke out soon after the Sargents and Muir were in the area. After the Russian Revolution of 1917, Harbin became a haven for Russian refugees; for a time, it was the largest Russian city outside the Soviet Union. Most likely B. V. Skvortzov was one of those refugees.

Summer Monsoons and *Prunus maackii*

The Sargent–Muir party chose a very poor time of year to travel in the Amur River region of Siberia and Manchuria, at least from John Muir's point of view. While they were there (mid-August through early September), the summer monsoon was at its height. On average, ten to sixty times more precipitation falls during the summer in the Amur region than during the winter. In the peak monsoon months of July, August, and September, 70 to 90 percent of a month's total may fall in only five or six days—up to 9.5 inches of it in a single day. A. A. Borisov, in *Climates of the U. S. S. R.*, reports that, "At Vladivostok 386 mm [15.3 inches] of precipitation, 65% of the annual total, fall from June to September, but only 28 mm (5%) fall in winter." Summer floods, some of them very destructive, are common. During the ripening and harvesting of grain crops, the excessive moisture affects the harvest adversely. Muir's "universal rain" seems an apt description. In the vicinity of Vladivostok, a coastal city, the summer monsoon usually lasts for four to four and one-half months, inland and northward for shorter periods of time. Contributing also to Muir's misery was the high humidity, which averages 88 percent during the summer. Winters, on the other hand, are sunny and dry in the Amur region; snow cover is thin and persists only in the northermost parts of the region. Autumns are warm and dry.

The climate of Harbin, which is only forty or so miles northwest of Xiaoling (Hsiaoling), the town where B. V. Skvortzov collected the seeds he sent to the U. S. Department of Agriculture in 1940, is similar to that of Winnipeg, Canada, as the following table shows:

Mean Daily Temperature, C

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Harbin	−20.1	−15.8	−6.0	5.8	14.0	19.8	23.3	21.6	14.3	5.7	−6.6	−16.7	3.3
Winnipeg	−17.7	−15.5	−7.9	3.3	11.3	16.5	20.2	18.9	12.8	6.2	−4.8	−12.9	2.5

While Harbin and Winnipeg receive similar amounts of precipitation (577.4 mm [about 23 inches] and 516.9 mm [about 20 inches] per year, respectively), the precipitation is more evenly distributed from month to month in Winnipeg than it is in Harbin. Winnipeg receives eight times more snow than does Harbin in an average winter (50 inches versus 6.7 inches).

Prunus maackii does best in moist, well drained soil—perhaps reflecting the soaking summer conditions of its native range. And, while very cold-hardy, it seems to be less frost resistant than *Prunus padus*, another early-blooming species. Also, it may not take to transplanting as well as some other species of tree, at least under certain conditions.

Acknowledgment

The text of the John Muir letter and of the quotations from John Muir's journal are published with the permission of the Muir–Hanna Trust, Holt–Atherton Center for Western Studies, University of the Pacific, Stockton, California.

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Propagation of *Prunus maackii*

Alfred J. Fordham

The records of the Arnold Arboretum reveal that *Prunus maackii* is easily propagated by any one of four routine methods

Prunus maackii can be propagated readily by seeds, cuttings, grafting, or budding. The records of the Arnold Arboretum show that early in 1961 we received fifteen scions of that species from the United States Plant Introduction Service, Glenn Dale, Maryland. At the time of year they arrived, grafting would have been the most appropriate method of propagating them. *Prunus avium*, commonly known as mazzard cherry, was listed as being a suitable rootstock for grafting *P. maackii* but was not available. We were able to get seedlings of *P. serrulata* (Oriental cherry), however; they proved to be excellent rootstocks.

To preserve the scions until we needed them, we placed them is a sealed polyethylene bag and stored them at 40 degrees Fahrenheit in a refrigerator. When it is handled in this way, woody-plant propagating material remains viable for many months. It should be inspected occasionally, however, to make certain it is not too wet or too dry, for either condition can cause it to deteriorate.

Whip-and-Tongue Grafting with Whole Rootstocks

As the name implies, a whole rootstock is the entire root system of a seedling. In autumn, before the ground freezes, seedlings are dug and placed in a deep frame, refrigerator, or cold-storage unit that is cold enough to keep them dormant, yet warm enough to prevent them from freezing, so that they will be available when they are needed.

In preparation for grafting, roots of the rootstocks were washed and trimmed to a uniform size. To accomplish grafting, the top of the seedling was removed, leaving about two inches of stem above the root system. Scions were about four inches long and contained three or four buds.

The stock and scion were joined by a whip-and-tongue grafting technique, making certain the cambial layers of each had as much contact as possible. The two components were then bound with rubber budding strips, which held them together with relentless tension.

Care after Grafting. When completed on March 29th, the grafts were placed in a medium of damp peatmoss on a greenhouse bench, making certain that the unions were well covered with peatmoss. Bottom heat of 70 degrees Fahrenheit was provided. This relatively high level of bottom heat leads to rapid callusing and growth.

By May 26th all grafts had succeeded, and the plants were in excellent growth. They next were transferred to one-gallon cans and placed on a greenhouse bench where they could be forced, to provide cutting wood for further propagation.

Propagation by Cuttings

By June 22nd, the growth had developed to a stage where it was ready to provide softwood cuttings. Twenty-six cuttings were taken, treated with a root-inducing substance containing eight milligrams of indolebutyric acid in a gram of talc. The cuttings were then placed under intermittent mist. By July 14th, twenty-one of them had developed excellent root systems and were potted. In the Boston area, softwood cuttings taken during about the third week of June and placed under mist should root in high percentages. Hardwood cuttings do not root.

Propagation by Seeds

The natural dispersal of cherry seeds is largely accomplished by birds. As fruits of *Prunus maackii* ripen, they soften, becoming shiny black and attractive to birds. Since birds have no teeth, they gulp their food; therefore, the hard-coated seeds pass unharmed throught their digestive systems and are scattered about the countryside in droppings. *Prunus maackii* fruits ripen around July 1st and must be watched carefully and collected before birds can get to them.

Nursery practice when dealing with *Prunus maackii* follows the chain of events as they occur in nature: the fruits are collected, their pulps removed, and the cleaned seeds then sown out-of-doors in prepared beds, where they are protected from rodents. The seeds of *Prunus maackii*, like those of many Temperate Zone woody plants, have dormancies—protective "barriers" that prevent them from germinating at times that would be unfavorable to the survival of the resulting seedlings. When the seeds are collected, cleaned, and sown without delay, seasonal changes overcome the barriers and germination occurs in spring.

An alternative, and simple, method of overcoming dormancy is to provide artificial "seasons." A polyethylene bag makes an ideal container for this purpose. The seeds are combined with a dampened medium of sand, peat moss, or such. The volume of the medium should not be more than three to four times that of the seeds. Keeping the bulk small is important, for at sowing time the entire content of the bag is sown. Twisting the top of the bag and binding it with a rubber band makes it vapor-proof for the full pretreatment period.

Propagating *Prunus maackii* by seed requires two stages, warm stratification and refrigeration. Warm stratification is provided by placing the container in a warm location, such as a windowsill, for four months. Full sun should be avoided as it could result in overheating. The container is then moved to a 40 degree Fahrenheit refrigerator for three months. Thus prepared, the seeds should germinate rapidly.

Propagation by Budding

Budding is an inexpensive way to propagate *Prunus maackii*, requiring neither the facilities nor skill, nor the meticulous aftercare, that grafting does. It is economical of propagating material, since only one bud is needed to produce a propagant.

To prepare for budding, line seedlings out in spring, spacing them about four inches apart in rows about twenty inches apart. They are ready for budding in the summer of their second growing season, when buds are inserted. The buds remain inserted until the next spring, when, before growth commences, the stocks are cut off just above the buds.

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Japanese Honeysuckle: From "One of the best" to Ruthless Pest

Richard A. Hardt

Slow to escape from cultivation when introduced, Japanese honeysuckle has become an aggressive and tenacious weed that should be used only with great caution

> Lonicera japonica—*flowers white changing to yellow, deliciously fragrant, borne in great profusion in the summer and occasionally in autumn. Grand for trellises and ground cover. One of the best.*
>
> —Biltmore Nursery Catalog, *Biltmore, North Carolina (1912), page 99.*

> Lonicera japonica . . . *a pernicious and dangerous weed, often overwhelming and strangling the native flora.*
>
> —Common Weeds of the United States, *by the Agricultural Research Service, U.S. Department of Agriculture (1971), page 358.*

> [*A*] *network of tangled cords that covers the ground wherever this ruthless invader gets a foot hold.*
>
> —*"The Japanese honeysuckle in the eastern United States," by E. F. Andrews,* Torreya, *Volume 19, Number 3 (March 1919), page 39.*

I was born and raised in the southern Piedmont of Maryland, where Japanese honeysuckle (*Lonicera japonica* Thunb.) is ubiquitous. At an early age I despised it for smothering my woodland clearings and have killed countless of its vines with a determined hatred. Yet I have always been delighted by the smell of its flowers on summer evenings and the taste of its nectar licked off a pulled stamen.

Introduced into the United States in 1806 as an ornamental, *Lonicera japonica* escaped from cultivation and eventually became naturalized throughout the eastern part of the country, where it is now an important component of the flora as far north as Massachusetts, Connecticut, southern New York, and Ohio. In the northern part of its range it is not the vigorous pest it is elsewhere because its early growth is killed by late spring frosts. Long Island and Cape Cod, where it is locally dominant, seem to be its northern limits as a pest. It is a serious pest as far west as Indiana and southern Illinois, however, becoming rarer westward and disappearing altogether in central Kansas. Japanese honeysuckle ranges southward to central Florida, being absent from the subtropical part of that state.

The commonly planted (and escaped) plant is *Lonicera japonica* 'Halliana', Hall's honeysuckle. Introduced by George Hall to Parsons's Nursery of Flushing, New York, in 1862, it differs from the species only in its more vigorous growth. In the eighth edition of *Gray's Manual of Botany*, Merritt Lyndon Fernald does not recognize it as a legitimate botanical variety. A common item in turn-of-the-century nursery catalogs, Hall's honeysuckle is still very much available in the trade.

Slow To Escape from Cultivation

It is difficult to pinpoint when *Lonicera japonica* began to escape from cultivation, but it apparently did so in the 1890s, becoming naturalized over most of its present range within thirty years. It may have escaped before 1890, however, but was uncommon and not recognized when encountered. Alvan Chapman did not list it in his *Flora of the Southern United States* (1884), nor did Asa Gray in the sixth edition of his *Manual of Botany* (1889). Nathaniel Lord Britton and Addison Brown gave the first evidence for its escape, in 1898, reporting *Lonicera japonica* as freely escaped from southern New York and Pennsylvania to North Carolina and West Virginia in their *Illustrated Flora of the Northern United States and Canada* (1896–1898). By 1903, it was reported from Florida and, in 1918, from Texas.

Why did it take more than eighty years for Japanese honeysuckle to escape?

Birds disseminate its seeds. Perhaps it took them some time to recognize honeysuckle berries as a source of food. The birds may even have had to develop a taste for the berries. Even today, when the berries are widely and dependably available, birds eat them sparingly.

On the other hand, Japanese honeysuckle may have spread slowly because there was little suitable habitat for it until the latter part of the Nineteenth Century. Cultivated land is not suitable for honeysuckle, and most mesic sites were under the plow in the early part of the century. After the Civil War, many farmers in the East abandoned their land. Abandoned fields, as they pass into the shrub stages of ecological succession, are ideal habitat for Japanese honeysuckle. A combination of these factors, and others, may best explain the long delay between the date of the species's introduction and the first reports of its escape.

A ban on honeysuckle at an early stage, coupled with a campaign to eradicate it, might have kept it within bounds, though there seems to be no precedent for success with this sort of effort. In any event, it is now too late to do anything about it. Japanese honeysuckle is a naturalized member of our flora.

Flowers of Lonicera japonica. *Photograph by Albert W. Bussewitz.*

A "most pernicious and dangerous weed"

Regardless of when it did, in fact, escape, Japanese honeysuckle quickly exhibited its darker side. By 1919, it had locally become a pest. E. F. Andrews, writing in the March 1919 issue of *Torreya*, reported that "it is no uncommon thing to see acres upon acres . . . buried under the rank growth of this aggressive invader." Government documents tell the same story: *The Eradication of Wild Honeysuckle*, by L. W. Kephart (1939); *Honeysuckle Is a Serious Problem*, by T. C. Nelson (1953); and the ominously titled, *Honeysuckle or Trees?*, by E. V. Brender and C. S. Hodges (1957). Animosity towards Japanese honeysuckle apparently developed rapidly. The usually dry and objective *Gray's Manual of Botany* (eighth edition), describes it as

> a most pernicious and dangerous weed, overwhelming and strangling the native flora and most difficult to eradicate, extensively planted and encouraged by those who do not value the rapidly destroyed indigenous vegetation. . . . (Unfortunately natzd. from Asia).


Leaves of Lonicera japonica *'Aureo-reticulata'. Photograph by Albert W. Bussewitz.*

Meanwhile, U. S. Department of Agriculture publications were recommending its use and suggesting planting methods. Nursery catalogs contained glowing accounts of it. But perhaps the most disturbing note came from Ernest H. Wilson's classic, *Aristocrats of the Garden* (page 67):

> Hall's semi-evergreen Japan Honeysuckle (*Lonicera japonica*, var. *Halliana*) needs no comment. . . .

On the contrary, "Japan Honeysuckle" requires considerable comment, discussion, and consideration.

Why is Japanese honeysuckle so vigorous and aggressive in the eastern United States? Let us consider these traits separately, defining "vigor" as a high growth rate and "aggression" as domination of other plants by direct competition. (Honeysuckle's aggression is, of course, dependent upon its vigor. Only a vigorous plant can be aggressive. But other botanical characteristics besides vigor make honeysuckle troublesome.)

Honeysuckle's growth rates are indeed high. One researcher has reported fifteen meters of growth on one plant in a single year. Such extensive vegetative growth is supported by an appropriately extensive root system. On an established Japanese honeysuckle plant, the roots may reach three meters across and one meter deep.

Honeysuckle is semi-evergreen, losing its leaves only in cold winters. It produces new leaves very early in the spring. As a result, it can begin active photosynthesis before competing trees and shrubs. Also, evergreen leaves can take advantage of warm, sunny winter days. The entire plant can make as much as two months of growth before most deciduous plants begin to grow. In Maryland, honeysuckle usually leafs out by March 15th, while the predominantly oak forests are leafless until May.

Another element of Japanese honeysuckle's aggression is its ability to reproduce rapidly by both vegetative and sexual means. The lateral branches that spread along the ground, root at the nodes in moist soil. Once this happens, the rooted branch is a new plant in a colony, able to survive if the original root crown is damaged or the branch cut. When a vigorous honeysuckle vine is cut, the root crown will respond with rapid resprouting. Lateral roots also can sprout, creating individuals independent of the original plant.

Ecological Relationships

The Japanese honeysuckle's fruit is a firm, black berry with few seeds. Birds disseminate the seeds, eating the berry and excreting the seeds. There is an ecologically self-reinforcing aspect to this manner of seed distribution: the bird ingests the berry and flies some distance before excreting the seeds. Chances are that the bird will deposit the seeds in an environment similar to that in which it found the berry, increasing the probability that the resulting seedlings will succeed. The consumers of honeysuckle berries—bluebirds, purple finches, white-throated sparrows, juncoes, robins, bobwhite quails—are birds of brushy areas, thickets, and forest openings. Birds of forest openings usually fly directly from one opening to another. Thus, while roosting, a bird will deposit seeds at the base of a tree that, if all goes well for one seed, will be climbed by a new honeysuckle vine.

Honeysuckle seedlings must have open conditions to succeed. Its small seeds contain little stored food and seedlings must begin photosynthesis soon after germinating. Dense grasslands are poor habitats for honeysuckle, however, because the honeysuckle vine cannot climb the grass blades to reach the full sunlight. If the seeds were to be deposited in a mature forest or in a grassland, the new honeysuckle vine would not be able to complete with its neighbors.

Honeysuckle occupies a special position in eastern landscapes not occupied by native vines. Its twining habit is well suited for climbing shrubs and saplings, a different "strategy" from those of native vines. Grapes (*Vitis* spp.) climb by tendrils, which are effective for holding onto tree branches, while Virginia-creeper (*Parthenocissus quinquefolia*) climbs by adhesive discs on tendrils, which allow it to climb tree trunks that would be too large to twine around. Poison-ivy (*Rhus radicans*) climbs in the same manner as Virginia-creeper, but does so with modified aerial roots.

These vines have climbing strategies well suited for forest environments: they are adapted for climbing the branches and trunks of mature trees. Bittersweet (*Celastrus scandens*) is more like honeysuckle in that it, too, climbs by twining, but it does so much more "lazily" than honeysuckle, making fewer circuits per length of stem than the honeysuckle. As a result, bittersweet cannot support as much weight and does not climb as high as honeysuckle does. Nor can it produce a dense, sunlight-blocking canopy above a sapling, since it does not hold tightly enough to support the weight.

Honeysuckle can climb any object that is thin enough. It cannot twine around mature tree trunks, but it wraps itself around saplings with ease. It grows up and past a sapling, blocking the sunlight to its host. Deprived of light, the sapling dies, and the weight of the vine causes the dead stem to collapse, leaving only a hummock of honeysuckle. Its twining is equally effective on shrubs. In mature forests, honeysuckle may twine upon other vines such as grape, Virginia-creeper, and posion-ivy, that have successfully climbed mature trees.

Forest openings contain herbs, shrubs, and saplings, many of which are attractive to both man and wildlife. Vigorous growths of honeysuckle can smother them, replacing a diverse flora with a monotonous one. In the Piedmont of Maryland, flowering dogwood (*Cornus florida*), black cherry (*Prunus serotina*), tulip-poplar (*Liriodendron tulipifera*), and brambles (*Rubus* spp.) are very common constituents of forest openings and edges and have much higher wildlife value than honeysuckle.

All of the regions in which Japanese honeysuckle has become naturalized were once forested. Honeysuckle can block the return of forest to landscapes that originally were forested, producing what ecologists call a disclimax or disturbance climax. Plant succession can be "frozen" at the honeysuckle disclimax.

Costs and Benefits

In human terms, Japanese honeysuckle has both costs and benefits. The costs are due to its vigor, aggressiveness, rapid dispersal, and tenacity. A pest in forest management because of its impact on forest regeneration, honeysuckle prevents both the natural and artificial regeneration of forest lands.

Professionals tend to see only one side of the plant—either its virtues or its vices. Nurserymen and landscapers cultivate and plant it, foresters try to eradicate it. Landscaping professionals must understand the character and potential problems of this plant before using it. Planted in the right situation it does no harm, but very few situations are right. Under most conditions, honeysuckle will have a damaging and uncontrollable impact on its environment. It should be used only after careful and thorough consideration.

In the South, foresters generally practice even-age management on pines (*i.e.*, cutting and restocking large, continuous blocks of forest at the same time), which opens an area to direct sunlight and reduces competition for moisture, allowing honeysuckle to take over and making effective restocking with trees impossible. If honeysuckle is not present, the trees may have a chance to become sufficiently established to shade the ground, making the site less attractive to honeysuckle. However, if honeysuckle is present in a forest stand when the trees are cut, the honeysuckle may grow rapidly, preventing the return of the forest. Often, foresters will not cut certain forests for fear that honeysuckle will take over.

While a luxuriant growth of honeysuckle in a woodland is visually unpleasant, a tended and pruned vine of honeysuckle clothing an arbor or fence can be very attractive. The sweetly fragant flowers open pure white and fade to a soft yellow. In full sun, with regular pruning, honeysuckle is far more floriferous than in the woodlands, where most honeysuckle vines are devoid of flowers. It is very easy to transplant and is a vigorous and carefree flowerer. This, of course, is one of the reasons it is such a pest outside of the garden.

Honeysuckle can provide a dense mat of vines that will climb over banks and thus is useful for stabilizing roadbanks, controlling erosion, and revegetating terrain. Rooted cuttings grow readily and quickly produce a cover, completely arresting soil erosion. The same qualities that make it a pest under one set of circumstances make it a valued plant under another set of circumstances.

Honeysuckle's value to wildlife must be carefully evaluated since it suppresses many of the plants that have the highest food value to wildlife. It holds its berries through the winter, usually well above the ground, providing a dependable food source during a critical period. Songbirds and gamebirds do eat small quantities of its berries. Deer eat its leaves. The tangled vines do provide superlative cover for birds, mice, and, particularly, cottontail rabbits. Honeysuckle has been suggested for use as a managed source of nutritious browse in the heavily manipulated southern pine plantations.

Japanese honeysuckle can also strongly affect historic sites. One survey of historic sites around Washington, D. C., noted that honeysuckle had damaged wooden and masonry structures, forcing apart stonewalls and producing dry rot in wooden walls. More importantly, it may produce an uncontrollable, historically inappropritate landscape. The study found that along the Potomac Canal in Washington, D. C., honeysuckle was threatening "visitors' understanding and appreciation of the site."

Design Considerations

A luxuriant growth of Japanese honeysuckle is aesthetically objectionable for three reasons: it lacks discernible form, it creates no line, and it suppresses aesthetically pleasing vegetation. "Form" can be defined as the three-dimensional mass of an object. Japanese honeysuckle is loose and rangy, forming hummocks over strangled saplings and reaching in all directions. It is impossible to perceive limits to its mass; it is amorphous. Its growth creates no visual points, no visual line (for a line is a series of points). The most commonly perceived visual line of a plant lies along its stem, from the root collar to the leaves. A dense growth of honeysuckle hides its source, presenting a façade of leaves or tangled vine stem. It can establish no "rhythm" without points, no pattern without lines. If a growth of honeysuckle were translated into sound, it would be noise. As noise disrupts music, honeysuckle disrupts an aesthetically pleasing landscape. Instead of a thicket or young forest, it produces a tangle of amorphous vegetation. Forest openings and edges usually are characterized by a richness of plant elements and structures, but Japanese honeysuckle succeeds in creating a landscape of only one element.

On balance the costs of Japanese honeysuckle outweigh the benefits. Other, less invasive plants can be used to control erosion and as ornamental vines. Of course, it would be impossible to make Japanese honeysuckle disappear; it is a permanent part of our flora. It can only be controlled.

Controlling Honeysuckle

A number of measures are used routinely to control weeds: chemicals, mechanical cultivation, hand labor, fire, biological control, and competition. Chemicals have been developed to kill honeysuckle. They usually kill broad-leaf plants on contact without affecting conifers. In southern pine plantations, these chemicals may be the most effective control measure. Unfortunately, honeysuckle is also present in hardwood areas, in which the chemicals would also kill desired saplings and shrubs.

Mechanical cultivation eliminates Japanese honeysuckle. As a result, the species is absent from cultivated cropland. In woods and thickets, mechanical cultivation is not possible because it kills the trees and shrubs you want. Hand labor would eliminate the honeysuckle without destroying the trees and shrubs, but its high cost makes this method completely impractical.

Fire often is used to control weeds in southern pine plantations and can also be used to control honeysuckle in pine forests, though the vine is likely to resprout from the roots. A light fire does not kill the pine trees but does kill seedlings, shrubs, and most hardwood trees. Therefore, fire can be used before planting, to clear out honeysuckle and

Lonicera japonica *'Halliana' covering a wall at Hener Castle, England. Photograph by Donald Wyman. From the Archives of the Arnold Arboretum.*

give seedlings a slight headstart.

Biological control—the deliberate use of a disease or animal to control a weed—has been used successfully on several invasive exotics. In Australia, the prickly-pear cactus has been controlled by an introduced moth (*Cactoblastis cactorum*) that feeds on the cactus. St. Johnswort (*Hypericum perforatum*), a weed of rangelands in the western United States, has been controlled by two introduced beetles. Unfortunately, there appear to be no disease-producing organisms that have any serious effect on Japanese honeysuckle in the United States, nor are there any insects in the United States that do anything more than nibble its leaves occasionally. This freedom from diseases and insects is a major reason for honeysuckle's high vigor. Nonetheless, biological control represents the best potential for controlling Japanese honeysuckle and is deserving of research.

Ecological competition is a natural phenomenon. Competition for light by trees reduces the vigor of honeysuckle. When its vigor is sufficiently reduced, it is no longer a pest. It is a lion without teeth. Unfortunately, human activity usually leads to the removal of trees, eliminating the competition for light.

Because it is such a problem, ought it not to be illegal to plant Japanese honeysuckle? Indeed, it is highly inadvisable to plant the species near woodlands if it cannot be controlled, but in the garden, tended and pruned around an arbor, it does no harm. There is already so much wild honeysuckle that garden plants could not significantly affect the overall seed supply.

Japanese honeysuckle has some virtues and many vices. When I was a child in the woods of Maryland, it was rope and string, perfume and ambrosia to me. Though I have spent many a day ripping it out of the earth with my bare hands, I have never wished that Japanese honeysuckle had never been.

Richard A. Hardt is a student in the Graduate School of Design, Harvard University. During the summer of 1985, he was a horticultural intern with the Arnold Arboretum.

Botanical Gold: Exploring the Treasures of the Harvard University Herbaria

Caroline J. Swartz

Faculty and staff of the combined Harvard herbaria invite Friends of the Arnold Arboretum and other special guests to an open house in May

On Thursday, May 8, 1986, from 5:30 to 8:30 p.m., the combined Harvard University Herbaria (HUH) will offer a unique opportunity to visit behind the scenes of one of the world's richest botanical resources. Friends of the Arnold Arboretum, Friends of the Farlow Herbarium, members of the New England Botanical Club, and members of the Harvard community are cordially invited to come and talk with Herbaria faculty and staff members about their research, botanical exploration, and particular areas of study. Guests will have a special opportunity to examine specimens of plants collected by botanists between the late 1700s and the present and to see records of historic plant expeditions that date from the opening of the American West and the United States's first ventures into world exploration, to recent expeditions to all parts of the globe. This special evening will provide an opportunity to see why these rich collections are so important to researchers around the world in the identification, classification, and study of the evolution and distribution of plants.

The Combined Herbaria

The HUH building houses the combined Arnold Arboretum–Gray herbaria and libraries, the Farlow Herbarium and Library of Cryptogamic Botany, the Oakes Ames Orchid Herbarium and Library, the Economic Botany Herbarium and Library, and the New England Botanical Club Herbarium and Library. Associated with these collections are rich archival materials documenting the work of past researchers and the history of the collections. With over 4.5 million specimens of plants, the Harvard Herbaria comprise the fifth-largest such collection in the world and the largest university-associated collection of its kind anywhere; their associated libraries contain 224,000 items, constituting one of the world's leading resources for systematic botany. Together, the specimens, books, and historical documents form the foundation of modern botanical research and hold a wealth of information about the whole history of botany. The accompanying article gives details on the various herbaria's and libraries's holdings.

The rich accumulation of material, particularly the herbarium sheets of pressed and dried plant specimens, document a significant portion of the world's roughly 400,000 kinds of plants and fungi. These collections were begun in 1842 by Asa Gray, the first Fisher Professor of Natural History at Harvard University. In the mid- to late 1800s, Gray received specimens from many government- and privately-sponsored expeditions to little-known parts of the expanding West, and to many other parts of the world. He described and identified these plants, accumulating a large number of specimens, now of great scientific and historical interest. Gray's personal herbarium, containing over 200,000 plant specimens, and his collections of botanical texts were bequeathed to Harvard; they form the basis of the herbaria's rich collections.

Connected to the HUH building is the Farlow Reference Library and Herbarium of Cryptogamic Botany. William Gilson Farlow, a one-time assistant to Gray and first professor of cryptogamic botany (the study of lower plants) in North America, appointed in 1874, endowed his personal collections at his death in 1919. His collections contained mosses, fungi, lichens, and algae.

The Arnold Arboretum, established in 1872 by its first director, Charles Sprague Sargent, supports a substantial herbarium in addition to its Living Collections. Sargent donated his personal plant collection and library to the Arboretum, but during his years as its director he made every effort to support field expeditions, primarily to eastern Asia, where such collectors as E. H. Wilson were strongly encouraged to collect herbarium specimens in addition to living plants and seeds. Sargent's training under Gray helped him to understand the great value an herbarium would have in the Arboretum's pursuit of botanical knowledge.

To this day, botanists at the Harvard University Herbaria still travel to distant lands to carry out fieldwork and bring back thousands of plants specimens and seeds for the herbaria and for the Living Collections of the Arboretum. It is through the integrated use of the herbarium, library, and Living Collections that botanical knowledge will continue to be advanced. Says Peter Stevens, Professor of Biology and Curator of the combined Arnold–Gray Herbaria, "By studying all the species in one family, how they are classified, how they relate to one another, or, in some cases, do not relate to one another, one begins to understand that correct classification is the basis for all sound evolutionary ideas." Only in the herbarium can one study simultaneously all the species of a family, or of a genus.

The Oakes Ames Orchid Herbarium is the world's largest herbarium devoted to a single plant family. As with so many of the other collections of the HUH, the orchid herbarium owes its existence to the early efforts of a single person, in this case, Professor Oakes Ames.

An Invitation To Attend

Come visit us, then, and follow an "explorer's map" through the HUH building. On display will be records from the early days of botanical exploration in the American West and in other parts of the world; specimens prepared by Henry David Thoreau in his treks around New England; herbarium specimens collected by Ernest ("Chinese") Wilson and Joseph Rock in remote areas of China; early accounts and checks signed by Asa Gray; and material relating to more recent botanical expeditions to distant parts of the earth. Staff members will reveal how plant specimens are prepared, from the time they are collected in the field, through the mounting process, up to the time they are added to the collection and made available for scientific research.

Herbaria staff members, faculty, and graduate students will be on hand to describe the plants and documents on display and to convey through slide shows, photographs, and exhibits the kinds of research that are based on these collections. We encourage you to take advantage of this unique behind-the-scenes opportunity to visit one of the world's richest botanical treasures and to learn about another aspect of botany at Harvard University.

Discover what plants are used for food and medicine in other parts of the world. Learn how plants make food, through demonstrations of photosynthesis. Explore the fascinating beauty and biological importance of fern spores through fantastic photographs taken with the scanning electron microscope. Gather insights on the difficulties that explorers faced in the early American West, and on some of the difficulties they faced in dealing with a famous Harvard professor!

Hosts for the Evening

The following are some of the staff members who will be present during the open house, and their areas of interest and expertise:

☐ **Raymond L. Angelo**, Curator of the New England Botanical Club (NEBC) Herbarium: Thoreau's botanical contributions and the role of the NEBC Herbarium.

☐ **Peter S. Ashton**, Professor and Director of the Arnold Arboretum: tropical forests of southeast Asia.

☐ **Jean R. Boise**, Research Bibliographer: the Loculoascomycetes.

☐ **Allan J. Bornstein**, Postdoctoral Herbarium Intern: the Piperaceae (pepper family).

☐ **David E. Boufford**, Curatorial Taxonomist: current botanical exploration in the People's Republic of China.

☐ **Michael A. Canoso**, Manager of the Systematic Collections, and **Walter T. Kittredge**, Curatorial Assistant: organization, function, and workings of a major research herbarium.

☐ **Zepur Elmayan** and **Edith Hollender**, Preparators: mounting of herbarium specimens.

☐ **Leslie A. Garay**, Curator of the Oakes Ames Orchid Herbarium, and **Herman R. Sweet**, Research Associate: orchids of the world.

☐ **Ida Hay**, Curatorial Associate, and **Emily**

Two herbarium sheets from the Herbarium of the Arnold Arboretum. The sheet on the left is a specimen of Cornus kousa, *a dogwood native to Japan and Korea, that on the right a specimen of a related species,* Cornus florida, *the flowering dogwood of eastern North America. Visitors at the Herbaria open house on May 8th will be able to discuss such interesting similarities between the eastern Asian and eastern North American floras with faculty and staff, as well as other botanical topics. Photograph by Joseph Wrinn. Courtesy of* The Harvard University Gazette.

W. Wood, Curatorial Assistant: pressing and drying herbarium specimens in the field.

☐ **Richard A. Howard**, Professor and former Director of the Arnold Arboretum: West Indian floras and exploration in the Caribbean.

☐ **Hsiu-Ying Hu**, Botanist: food and medicinal plants of China.

☐ **Geraldine C. Kaye**, Librarian: fungi and other cryptogams in the Farlow Herbarium.

☐ **David C. Michener**, Research Taxonomist and Curatorial Administrator: the Wood Laboratory; sectioning wood for microscopic study.

☐ **Donald H. Pfister**, Professor, Curator of the Farlow Library and Herbarium, and Director of the Harvard University Herbaria: Discomycetes, early mycological literature.

☐ **Bernice G. Schubert**, Lecturer and Curator: *Dioscorea* (the yam) and *Desmodium* (beggar's ticks; legume family).

☐ **Elizabeth A. Shaw**, Bibliographer and Research Taxonomist: botanical exploration in the early American West.

☐ **Otto T. Solbrig**, Mangelsdorf Professor of Natural Science and past Director of the Gray Herbarium: photosynthesis.

☐ **Stephen A. Spongberg**, Horticultural Taxonomist: the early botanical exploration of China.

☐ **Peter F. Stevens**, Professor and Curator, and **Barbara A. Callahan**, Librarian: the development of systematic botany as displayed through botanical illustrations.

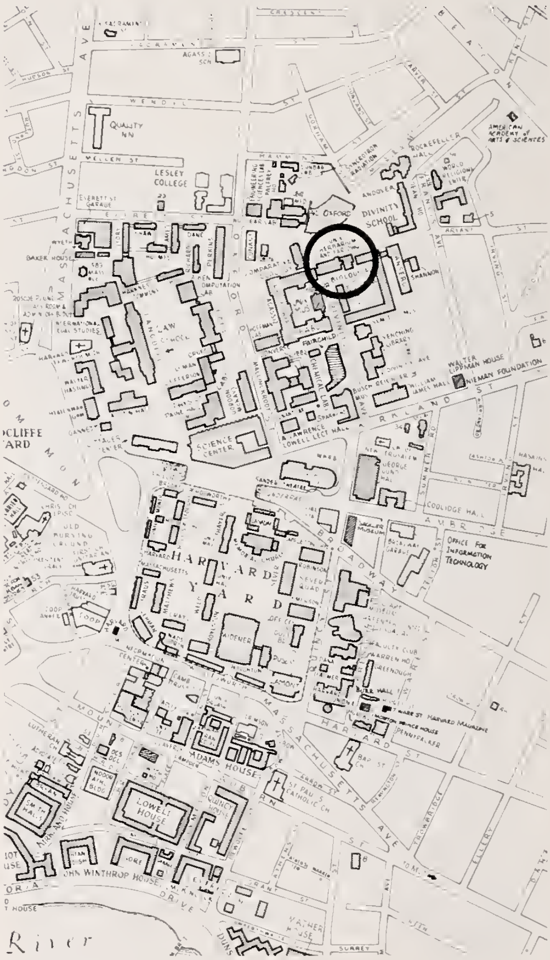
☐ **Rolla M. Tryon, Jr.**, Professor and Curator, and **Alice F. Tryon**, Associate Curator: the world of ferns and fern spores, scanning electron micrographs.

☐ **Carroll E. Wood, Jr.**, Professor and Curator, and **Ihsan A. Al-Shehbaz**, Research Associate: the flora of the southeastern United States.

To Attend

Friends of the Arboretum will find free parking in the Andover lot, which is located behind the HUH building. They should enter from Oxford Street. (See the accompanying map.)

Complimentary hors d'oeuvres will be served.



Caroline J. Swartz is membership coordinator of the Friends of the Arnold Arboretum. A graduate of Connecticut College, she has a special interest in Chinese language and culture.

A + AAH + AMES + ECON + FH + GH + NEBC = "HUH": Systematic Botany at Harvard

Harvard's diverse herbaria and their associated libraries make up one of the world's greatest centers for research in systematic botany

The rich and diverse botanical collections housed in the Harvard University Herbaria building at 22 Divinity Avenue and in the adjacent Farlow Herbarium are world-renowned. Botanists working at the cutting edge of plant systematics converge from around the world to consult specimens of vascular plants, mosses, liverworts, algae, fungi, and lichens maintained in Harvard's half-dozen specialized herbaria. Designated "HUH" among systematic botanists at Harvard, the combined Harvard University Herbaria consist of the Herbarium of the Arnold Arboretum (designated "A"), the Oakes Ames Orchid Herbarium ("AMES"), the Economic Herbarium of Oakes Ames ("ECON"), the Gray Herbarium ("GH"), the Farlow Herbarium of Cryptogamic Botany ("FH") (actually housed in an adjacent, connected building), the Gray Herbarium ("GH"), and the Herbarium of the New England Botanical Club ("NEBC").

The Harvard University Herbaria (HUH) Building

The Harvard University Herbaria building, completed in 1954, is located at the end of Divinity Avenue in Cambridge, in the center of the Harvard complex devoted to the natural sciences. It houses the Oakes Ames Orchid Herbarium, the herbarium and library of the Gray Herbarium (formerly maintained at the "old Gray" on the Botanic Garden site on Garden Street), part of the library and herbarium of the Arnold Arboretum, and, since 1985, the Economic Botany Herbarium. The library and herbarium of the New England Botanical Club are also located in the building.

The Libraries. Comparable in depth and comprehensiveness to the collections of the Royal Botanic Gardens, Kew, and the Komarov Botanical Institute, Leningrad, the combined libraries of the Arnold Arboretum, the Gray Herbarium, the Farlow Herbarium, the Economic Botany Herbarium, and the Oakes Ames Orchid Herbarium are particularly rich in early botanical literature. These collections greatly facilitate research in systematic and evolutionary botany. All have grown from the research collections of their founder–scientists. This fact is easily sensed when one uses a volume that was originally owned and annotated by Charles Sprague Sargent, Oakes Ames, William Gilson Farlow, or Asa Gray.

The Arnold Arboretum's library now has over 90,000 books and pamphlets and some 11,000 microforms, the Gray library over 62,000 books and pamphlets and an archive collection of many thousands of items. Together, the archives of the two institutions are basic source material critical to the study of the development of evolutionary philosophy and the plant sciences in North America.

☐ **The Arnold Arboretum Herbarium (A).** The Arnold Arboretum Herbarium was established by Charles Sprague Sargent in 1879, when he resigned his directorship of the Harvard Botanic Garden in order to devote full time to the Arboretum. It contains important collections from all over the globe and complements the Gray Herbarium (see below), inasmuch as it is especially rich in materials from eastern Asia, particularly China, the Philippines, western Malesia, and Papuasia. The large and important contributions of E. H. Wilson, J. F. Rock, G. Forest, and the New Guinea collections of L. J. Brass are prominent among the Arboretum's 1,154,000 specimens housed in Cambridge. Its herbarium of cultivated plants in Jamaica Plain ("AAH") includes over 174,200 sheets and is the largest collection of its kind in the world.

To supplement its herbarium collections, the Arboretum maintains an extensive vouchered wood collection of some 30,000 specimens and 45,000 prepared microscope slides of wood, pollen, seeds, etc., and an important fruit and seed collection.

☐ **The Orchid Herbarium of Oakes Ames (AMES).** The Orchid Herbarium of Oakes Ames was founded in 1899 by Professor Oakes Ames, the Harvard Botanical Museum's second director. It is the largest herbarium in the world devoted to a single family. Originally a private institution, it was intended to be a working tool to facilitate the identification of orchid species and the preparation of orchid floras. In developing his herbarium, Ames emphasized from the very beginning the accumulation of scientific information in every conceivable manner, rather than solely the storing of dried specimens. Consequently, the collection of nearly 130,000 sheets is very rich not only in type specimens, but also in records and transcripts of holotypes from institutions located throughout the world. There are also a spirit collection of 3,000 plants and flowers and 25,000 slides of dissected orchid flowers. Its specimens, drawings of floral details, color plates, paintings, and descriptions make AMES a unique and indispensable tool in taxonomy. In 1939, Ames formally presented his Orchid Herbarium, together with his orchid library, which now consists of 5,000 books and pamphlets, to the Botanical Museum. In 1957, all of the orchid specimens of the Gray Herbarium and of the Arnold Arboretum's herbarium were integrated with those of AMES for an indefinite duration.

Housed in the Herbaria building, AMES contains some 10,000 type specimens or type collections of species. One of its unique holdings is a set of life-size drawings of types, together with drawings of floral details of types of orchids described by Rudolf Schlechter, which were prepared under his personal supervision. The actual type specimens from which these were made were destroyed in Berlin during World War II. AMES is exceptionally complete in material from the Philippines, Malesia, Mexico, Central America, South America, and China.

☐ **The Economic Herbarium (ECON).** The Economic Herbarium of Oakes Ames, housed until recently in the Botanical Museum, consists of 45,000 specimens of economically important plants, especially from South America, and includes extensive collections of such genera as *Zea* (maize), *Hevea* (rubber), and *Cinchona* (quinine).

☐ **The Farlow Library and Herbarium (FH).** The Farlow Reference Library and Herbarium of Cryptogamic Botany is housed in the former Divinity School Library, built in 1886; it is connected to the HUH building on the west and the Biological Laboratories on the east. Stemming from the extensive herbarium and library of William Gilson Farlow, who joined the Harvard faculty in 1874 and endowed the collections at his death in 1919, the herbarium now includes 1,125,000 accessions of bryophytes, fungi, lichens, and algae; the library has holdings of over 60,000 items. Included within the collections are the M. A. Curtis collection of fungi and William Starling Sullivant's herbarium of mosses, both of which Farlow brought to Harvard. The nearly quarter of a million specimens of types and authentic specimens in FH indicate the richness and importance of the collection for systematic and evolutionary studies.

☐ **The Gray Herbarium (GH).** The collections of the Gray Herbarium date from 1842, when Asa Gray was appointed Director of the Harvard Botanic Garden and Fisher Pro-

Two preserved specimens of marine algae from the Farlow Herbarium. On the left is Padina pavonica, *a brown alga that lives in warm marine waters worldwide. On the right is* Heterosiphonia coccinea, *a yellow-green, or yellow-golden, marine alga. These are only two of the one and a quarter million specimens of mosses, algae, fungi, and lichens in the Farlow's world-renowned collections. Courtesy Farlow Library and Herbarium.*

fessor of Natural History. Although systematic botanical studies were initiated in 1807, when the Botanic Garden was established by W. D. Peck, the Herbarium was established by Asa Gray and grew steadily because of his research and that of his colleagues and successors. Today, the Gray Herbarium numbers 1,823,300 specimens. The collections of the early explorers are prominent. Worldwide in scope, GH is especially rich in North American materials and includes early collections from western North America and Mexico and the types and collections of Gray, Sereno Watson, B. L. Robinson, and M. L. Fernald.

□ **Herbarium of the New England Botanical Club (NEBC).** The 250,000 specimens in the Herbarium of the New England Botanical Club were collected totally within New England by knowledgeable amateurs, Harvard professors, and others. Serving to document the flora of the region, its specimens are also a rich resource for research on rare and endangered species. In concentrating on such a small area, NEBC makes it possible to study genetic variability from one population of a species to another.

The Botanical Museum

Although officially founded in 1888 when the University named Professor George Lincoln Goodale its first director, the collections of the Botanical Museum dated from 1858, when Asa Gray began to assemble a collection of "vegetable products, etc." that were augmented by plant materials of economic importance sent to him by his friend, William Jackson Hooker. The Economic Herbarium (ECON) is now housed in the HUH building (see above). The Botanical Museum's library has a notable collection of some 32,000 titles that has grown largely from the research collections of Oakes Ames and George Lincoln Goodale.

BOTANY: THE STATE OF THE ART

Listening to Thirsty Plants

John W. Einset

The ingenious application of acoustic devices enables botanists to study the water economy of woody plants

Martin H. Zimmermann, the late Charles Bullard Professor at Harvard University and Director of the Harvard Forest from 1970 to 1984, was a recognized expert on the water economy of plants, especially trees. Among his many contributions to science was the introduction of the term *hydraulic architecture*, a term that describes the way in which plants use their structures to regulate water flow. In fact, a major goal of Professor Zimmermann's research involved detailed descriptions of hydraulic architecture in plants, a task he approached with ingenuity, often using techniques he had developed himself.

As so often happens in scientific research, one of the best ways of understanding a process is to study what happens when it is disrupted. For example, if one is interested in how water moves through a plant, one can ask what happens when water is no longer supplied. The immediate consequence, of course, is that the overall water content of the plant begins to decrease as a result of continued evaporation (*transpiration*) from leaves in the absence of a corresponding uptake of water by its roots. As further drying occurs, the pores (*stomates*) on leaves usually close, thus minimizing additional water loss. Then the stem begins to contract under the tension caused by the evaporation of water from within it. Eventually, dehydration of the stem results in *cavitation* within individual vessels (water-conducting "pipelines") of the xylem as air bubbles replace water. At this stage, flow within the plant ceases because cavitated vessels can no longer transport water. Some plants, in fact, are damaged beyond recovery by cavitation since they are incapable of refilling air-plugged xylem even when water again becomes plentiful.

Sabotage by Bubbles of Air

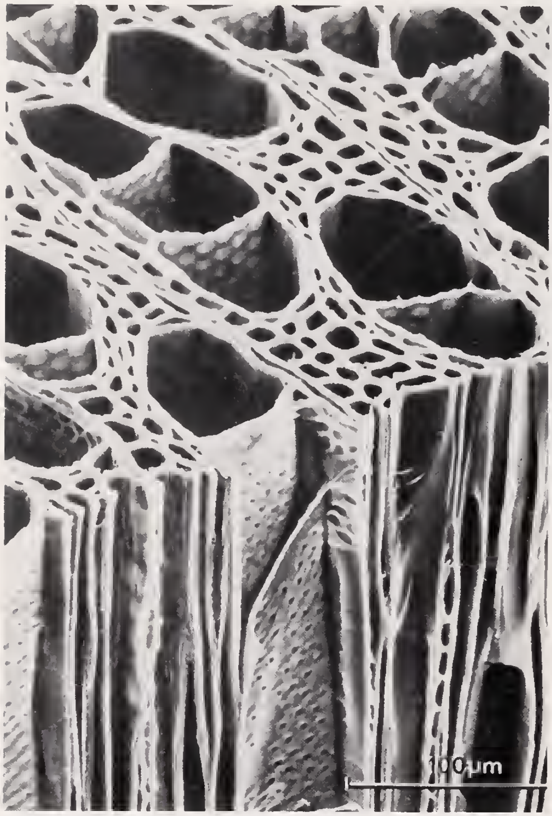
According to a widely held theory, elaborated in large part by Martin Zimmermann, cavitation is initiated when a tiny bubble of air penetrates a water-containing xylem vessel from an adjacent, dry vessel element—a process known as *air seeding*. Negative hydrostatic pressure within the vessel then causes the bubble to expand quickly and fill the contents of the cell. While the air-seeding hypothesis has not been proven conclusively, it is generally considered to be the best current explanation for cavitation. At the very least, Zimmermann's theory focusses interest on this important phenomenon and stimulates research that could lead to new technology. If cavitation can be better understood, perhaps it can be avoided by breeding plants

Dr. Martin H. Zimmermann, the late Director of the Harvard Forest in Petersham, Massachusetts. Photograph by Regula Zimmermann. Courtesy of the Harvard Forest.

with more effective mechanisms for preventing it. Or, improved procedures might be developed to reverse cavitation once it has occurred.

If the crucial event that sparks cavitation actually is the appearance of an air bubble, the obvious strategy for stopping cavitation is to prevent air from moving between cells. In plants suffering a moderate degree of water stress, this normally is accomplished by the cellulosic cell walls between adjacent elements. An illustration of the principle involved can be obtained by trying to plunge a fresh tea bag directly into hot water. The low permeability of the wet, cellulosic paper causes the tea bag initially to float on the surface of the water until air has diffused out of the bag. The same phenomenon is exploited in life-saving when a shirt or pillow case is used to improvise an emergency flotation device. In these cases, wet fabric impedes the diffusion of the entrapped air.

The relative permeability to air, of a plant cell wall or of any other wet barrier for that matter, can be calculated from physical laws based on the size of the pores it contains: the smaller the pore size, the greater the pressure difference required to push air through it. Given an average pore diameter of about 0.2 micrometer (approximately one ten millionth of an inch) in plant cell walls, the pressure differential necessary for air to move from one cell to another is about 10 to 1. In other words, one can expect air seeding to occur in trees as soon as vessel tensions reach values of minus 10 atmospheres and less.



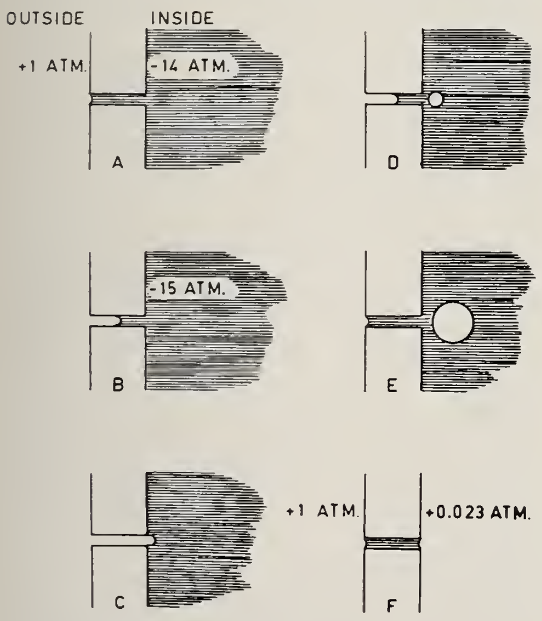
*A scanning electron microscope picture, highly magnified, of poplar (*Populus grandidentata*) wood showing the three-dimensional structure of xylem tissue and individual vessels (the large columnar cells with conspicuous pores on their lateral walls) making up the water-transporting system. Courtesy of Springer-Verlag.*

Acoustic Emission: The Sound of Cavitation

Using microscopic techniques coupled with cinematography, Ann M. Lewis (a student at the Harvard Forest) has determined that the lapse of time from the first appearance of an air bubble in a vessel until the end of the cavitation event is less than 1/124 second. The rapidity of this process probably accounts for one of the most important aspects of cavitation—namely, the production of a weak but detectable noise as vessel walls vibrate in response to the air bubble's explosive expansion.

Studies of the "acoustic emissions" (AEs) accompanying cavitations have recently become an especially active area for scientific investigation. At the University of Toronto in Canada, for example, Professor Melvin Tyree has adapted the sensitive acoustic devices used in mechanical engineering to the study of AEs in white cedar (*Thuja occidentalis*) and hemlock (*Tsuga canadensis*) trees. Tyree clamps a noise detector onto the stem of a tree and then monitors AEs as the tree becomes more and more dehydrated. Each signal the detector picks up is processed with the aid of a computer, which analyzes harmonic frequency, duration, and intensity. By doing this, Tyree can exclude interfering signals caused by extraneous (*i.e.*, noncavitation) noises.

This sophisticated instrumentation has already made it possible to prove that individual AEs correspond to single cavitations occurring in the wood of trees; thus, a small (4-mm-diameter, 10-mm-length) block of hemlock wood, for example, contains about one million tracheids (tracheids, rather than vessel elements, are the water-conducting cells of gymnosperms) and produces approximately that number of AEs upon complete dehydration. The technology also makes it possible to measure the potential of different water-transporting systems to recover from cavitation. This can be accomplished by monitoring AEs during the dehydration of a wood sample, then rewetting the sample to its maximum extent and determining the total number of AEs obtained during a second dehydration treatment. Presumably, the difference in AE totals is the number of cells that cavitated beyond recovery during the initial dehydration. Alternatively, AE technolgy can be used to determine the types of cells that are most prone to cavitation, inasmuch as the harmonic frequency of an AE is apparently related to a cell's dimensions. Evidence to date confirms Zimmermann's theory that large vessels, and thus "ring-porous" trees such as oaks and elms, are more likely to cavitate than small vessels,



M. H. Zimmermann's diagram of the stages involved in cavitation by air seeding. Each panel indicates the status of an air-filled vessel or tracheid (outside) and an adjacent vessel or tracheid (inside) undergoing cavitation. A *through* C *show the effect of progressively negative xylem pressures in causing air movement through a small pore in the cell wall. In* D, *an air bubble has appeared within the water-containing cell, while* E *and* F *indicate the explosive expansion of this bubble that results in cavitation and, significantly, in the acoustic emission. Courtesy of Springer-Verlag.*

and thus "diffuse-porous" trees such as maples.

Practical Applications

Of course, the greatest value of listening to thirsty plants ultimately will be improved understanding of water flow and the mechanisms by which plants prevent damage associated with dehydration. When one considers that water utilization is one of the major factors determining plant growth and survival as well as plant distribution in the environment, it is easy to appreciate how even small advances in scientific knowledge about the water economy of plants can have profound practical consequences.

Martin Zimmermann's book *Xylem Structure and the Ascent of Sap* was dedicated to the memory of Godfrey Lowell Cabot, who in 1937 established the Maria Moors Cabot Foundation for Botanical Research at Harvard University. In the dedication of the book, Professor Zimmermann describes his first meeting with Cabot in the mid-1950s, an occasion that he took advantage of to explain his latest scientific findings in great detail:

> When I had finished, he surprised me with the sudden question, "How can you improve the growth of trees?" This caught me completely unprepared, because I had never thought about practical applications. After what seemed to me a rather painful silence I ventured that it would be useful to learn more about how trees function and grow. He seemed to be quite satisfied with this answer. Little did I guess that trees would be holding me under their spell for so many years!

John W. Einset, associate professor of biology in Harvard University, directs the Arnold Arboretum's Laboratory of Comparative Physiology. In May, he will teach "Tissue-Culture Propagation Methods: An Introduction to a New Branch of Plant Science," a special class limited to Friends of the Arnold Arboretum.

BOOKS

The Butterfly Garden, by Mathew Tekulsky. Harvard and Boston, Massachusetts: The Harvard Common Press, 1985. vi + 144 pages. $8.95 (paper), $16.95 (cloth).

How To Attract Butterflies to Your Garden, by Nick Rossi. Saddle River, New Jersey: The Butterfly Garden, undated. 16 pages. $14.95 (paper). [Part of the "Home Garden Butterfly Kit," which includes also ten packets of seeds.]

Butterflies East of the Great Plains: An Illustrated Natural History, by Paul A. Opler and George O. Krizek. Baltimore and London: The Johns Hopkins University Press, 1984. 294 pages; 324 color photographs. $49.50.

DAVID C. MICHENER

For over fifteen years I have been striving to turn a wooded city lot into a haven for butterflies, birds, and salamanders. Fifty dump-truck loads of wood chips, untold bags of leaves, numerous rotting logs, and a rerouting of the storm drains have delighted the salamanders, extirpated whatever remained of the rear lawn, and started the final phase of controlling the already successful "butterfly meadow." I confess that I didn't know a thing about butterflies before starting; everything I learned I learned by making mistakes. But there is an easier way. If you are interested in butterfly gardening, preferably without making the kinds of mistakes I did and without needing fifty loads of wood chips, you might consider reading a book. There are three possibilities that I know of, and a fourth on its way.

The trick to successful butterfly gardening, it seems, is to realize that (1) butterflies come from caterpillars, (2) most caterpillars are quite particular about what species of plants they will feed upon, and (3) female butterflies will seek out the right species of plants on which to lay their eggs, ensuring thereby that the caterpillars will have food. Good butterfly gardens provide sacrificial food plants for the caterpillars as well as flowering plants for the adults. *How To Attract Butterflies to Your Garden*, by Nick Rossi, does not address this central issue. Instead, $14.95 gets you ten packets of seeds (an $8.90 value at my local hardware store) and a sixteen-page booklet that is long on enthusiasm for butterflies but short on information about plants and gardening. The three sections on attracting adult butterflies account for only thirty-three lines of text. I recommend that you buy your own seeds after spending $8.95 on Mathew Tekulsky's *The Butterfly Garden*. Here is a straightforward and well organized introductory book. It has already helped me understand what makes a garden "work" from the perspective of a butterfly.

Tekulsky's fourth chapter, "Getting Started," cuts to the core of the issue—the need to get the butterfly's entire life cycle to occur in your garden. Subsequent chapters, on larval food plants and nectar sources, and the various appendixes form the "gardening" core of the book. Here are lists of plants to use, notes on how to attract the fifty most-common species of butterfly in North America, nursery and seed sources of the plants, and the addresses of both butterfly-fancier and gardening organizations.

Since *The Butterfly Garden* is intended for use by gardeners throughout continental North America, much of the region-specific information has to be extracted from the text and appendixes; but the information is there. I found the author's familiarity with Californian butterflies and plants helpful in illustrating several points, though the specifics were not always germane to butterfly gardening in New England. Chapters on butterfly biology, the rearing of butterflies, and conservation round the book out. If you are thinking about attracting butterflies to your garden, start with this book and then use your imagination.

Compulsive butterfly gardeners (*mea culpa*) will pay the small ransom needed to purchase *Butterflies East of the Great Plains*, whereas others may prefer to wine and dine their local librarians until the book is purchased. *Butterflies East of the Great Plains* is a stunning tour de force and is destined to be the classic reference for decades to come. Every species of butterfly known to occur or to stray into the eastern United States is presented. (Canada is excluded.) The text is accented by 324 color photographs of the butterflies in nature. For every butterfly species, the etymology of the Latin name, the geographic range (usually shown through exquisite maps), the habitat, the life history, and the adult and larval food plants are presented and discussed. The last subjects are a gold mine for butterfly gardeners. Enjoyable hours can be spent scanning the maps for your home area and then reading the text to find out what plants you will need to attract the flying lovelies. If the illustrations make you realize that you simply cannot live without pipe vine swallowtails gracing your yard, the text will inform you that you must have *Aristolochia* in the garden, while the range maps tell you whether the species lives in your area. If the plant material is sometimes unfamiliar to you (both Latin and common names are provided), use any good garden dictionary to find out about the plants.

Butterflies East of the Great Plains is the only tome I know of that provides the essential information on the butterflies of a given area, listing their critical food and nectar plants. If I have any qualms about recommending this book to the reader, it is that the binding may not be up to the long-term use the book will receive.

All three of the titles reviewed here will be available for inspection at the "Sky Gardening" symposium scheduled for May 31st. Among the attractions of the symposium will be an annotated list of the butterflies native to eastern Massachusetts and their larvae's food plants. The complete program for the symposium is given on page 48.

David C. Michener, a research taxonomist at the Arnold Arboretum, is responsible for the Living Collections Verification Project. Before coming to the Arboretum he was a graduate student in botany at the Rancho Santa Ana Botanic Garden in Claremont, California. He has long been interested in gardening for birds and butterflies. On May 31st, he will speak at "Sky Gardening: A Symposium on Butterflies, Birds, and the Horticultural Habitat." For details about the symposium, see the current issue of *Arnoldia*'s "New England Horticultural Calendar."

From The Butterfly Garden.

Saturday, May 31, 1986
8:30 am - 3:00 pm

Sky Gardening

Birds, Butterflies and the Horticultural Habitat

Birds, butterflies, and moths animate the garden. They choose seasonal territories based on the presence of certain plants. The selection of trees, shrubs, and perennials attractive to specific fauna and the effective juxtaposition of these plants in the garden is the focus of this Spring Symposium. Speakers will address the habitat needs of birds, butterflies, and moths, and how these needs can be met through the selection of garden material; annotated lists of plants will be presented. Field observation on the grounds of the Arnold Arboretum will allow participants to see mature specimens of selected plants. Sky Gardening is designed for advanced amateur gardeners; bird, butterfly, and moth enthusiasts; landscape designers; and garden center professionals.

Program

8:30 - 9:00	**Registration**
9:00 - 9:10	**Welcome and Introduction.** Nan Sinton & David Michener
9:10 - 9:50	**Understanding New England Butterflies.** Jo Brewer
9:50 - 10:15	**Moths in Your Garden.** David Winter
10:15 - 10:55	**Birds on the Blossom: attracting birds with plants.** Al Bussewitz
10:55 - 11:10	Coffee Break
11:10 - 11:50	**The Horticultural Habitat.** Michael Dathe
11:50 - 12:30	**Food Plants for our Region: caterpillar cuisine and berries for birds.** David Michener
12:30 - 12:45	**Summary** David Michener
12:45 - 1:30	Box lunch with the speakers.
1:30 - 3:00	**Observational Walks.**

The Observational Walks of plant material in the Arboretum will follow unpaved paths and will climb a hill — come comfortably dressed for the weather.

Summer 1986

arnoldia

The Magazine of the Arnold Arboretum

LILIUM GRAYI.

Vol. 46 No. 3 Summer 1986

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PLANT CONSERVATION: PART I

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

Subscriptions are $12.00 per calendar year domestic, $15.00 per calendar year foreign, payable in advance. Single copies are $3.50. *All remittances must be in U.S. dollars, by check drawn on a U.S. bank or by international money order.* Send subscription orders, remittances, change-of-address notices, and all other subscription-related communications to: *Arnoldia,* The Arnold Arboretum, The Arborway, Jamaica Plain, MA 02130-2795.

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Front cover: Lilium grayi Sereno Watson, the roan, or Gray's, lily, a potentially endangered species native to Virginia, North Carolina, and Tennessee. Asa Gray discovered this rare lily on Roan Mountain, North Carolina, in 1840. From *Flora and Sylva*, Volume 1 (1903). (See page 2.) *Opposite*: A Kamsa Indian student of Native folklore holding the flower and leaves of one of the potent medicinal and hallucinogenic solanaceous plants of the Valley of Sibundoy, Colombia. Photograph by Richard Evans Schultes. In the Fall issue of *Arnoldia*, Professor Schultes will emphasize the importance of preserving lore about the uses of Amazonian plants. *This page*: Bird-foot violets (*Viola pedata* L), photographed by Herbert Wendell Gleason in Concord, Massachusetts, on May 26, 1900. Used through the courtesy of Heather C. Conover and Nick Mills. (See page 59.) *Inside back cover*: John Muir resting in the Sierra Nevada. Photograph from the Archives of the Arnold Arboretum. (See page 61.) *Back cover*: A giant *xianmu* (*Burretiodendron hsienmu*) tree in Longrui Reserve, Guangxi, China. Photograph by Dr. Wang Xianpu. Conservation of *xianmu* will be discussed in the Fall issue of *Arnoldia*.

E. Faxon del. Picart fr.

GORDONIA ALTAMAHA, Sarg.

Saving the Rarest

Donald A. Falk
Francis R. Thibodeau

By cultivating endangered native plants a nationwide network of botanical gardens and arboreta hopes to produce stock that can be used to reestablish endangered plants in the wild once their natural habitats have been rehabilitated

Like many desert plants, *Agave arizonica* was in serious decline during the 1960s. By the middle of the decade it had been reduced to two known localities with only a handful of plants. Despite attempts to protect the remaining individuals, the species—which tends to grow in populations of very low densities—continued to suffer from grazing and collecting and was apparently on the road to extinction. In 1968, staff members of the Desert Botanical Garden in Phoenix, Arizona, took an interest in the species. Working primarily with bulbils and tissue cultures, they managed to establish a cultivated stand from which scores of plants have since been propagated for distribution and replanting in the wild. The Garden has also played a key role in public education and has worked cooperatively with the national Fish and Wildlife Service to help locate and manage the remaining wild populations. Thirty-one clonal populations are now known from a one hundred-square-mile area. *Agave arizonica* was officially listed as a protected endangered species in 1984, which should enhance its chances for recovery.

A dramatic intervention, perhaps, but not so unusual as one might think, for in recent years botanical gardens and arboreta in the United States and abroad have become increasingly active in protecting and conserving native species of plants. Conservation is rapidly becoming a mission of many gardens and arboreta, alongside their traditional missions of display, research, and education. In coming decades, botanical gardens and arboreta should become vital for the conservation and understanding of the world's rarest plants.

The Problem of Extinction

The tragic extinction of species worldwide, which is primarily a consequence of widespread destruction of habitat in the Tropics, is now well recognized (Myers, 1979). Human-induced extinction of species is not limited to the Tropics, however, but is happening in every nation on earth. In the United States alone at least three thousand species of higher plants are believed to be endangered or threatened with extinction, roughly fifteen percent of the nation's entire flora (Prance and Elias, 1977; Ayensu and DeFilipps, 1978). Agencies of the Federal Government charged with protecting these species—most notably the Office of Endan-

Opposite: *Drawing of* Franklinia alatamaha *Marsh., Franklinia, or the Franklin tree, by Charles Edward Faxon (1846–1918). Franklinia is believed to be extinct in the wild but is widely cultivated in botanical gardens and elsewhere. Many drawings by Faxon, both previously published and unpublished, appear in this issue of* Arnoldia. *Most are from materials in the Archives of the Arnold Arboretum.*

gered Species in the Fish and Wildlife Service—operate on severely limited budgets and simply do not have the means to evaluate the status of the thousands of plant taxa that have been proposed under the terms of the Endangered Species Act (Anonymous, 1984*a*). Moreover, very few taxa—one hundred as of this writing—have survived the administrative procedure for officially listing a taxon as "endangered" under the provisions of the Act (Anonymous, 1984*b*), though they may have such status under state laws. In fact, however, plants do not receive the same degree of protection that animals do because the law regards them as part of the property on which they grow and hence may be privately owned. Thus, under the current formulation of the Act, the sale and interstate transport of endangered plants is restricted, but the destruction or taking of wild individuals from private land technically is not. The Act's primary effect is to prevent the use of Federal funds for projects that would destroy or alter the habitats of endangered taxa. In this context, when the presence of rare plants might hold up commercial-development projects, it is not unusual for wild populations of rare plants to be destroyed before anyone can protect their habitats permanently. Other Federal agencies (such as the Forest Service, Park Service, and Bureau of Land Management) cooperate with the Office of Endangered Species by law—but they, too, have competing demands for their budgets and for the land they control, especially since Congress is not uniformly friendly to the protection of endangered species when there is a conflict. Outside of the Federal Government, a single private conservation organization—The Nature Conservancy—has been almost solely responsible for the vast majority of natural-habitat acquisition in the nation. The Conservancy has managed to protect more than two million acres of prime natural habitat in over three thousand locations across the country.

Meanwhile, extinction accelerates. Commercial, industrial, and agricultural "development" continues to destroy tens of thousands of acres yearly; much of this land is logged, mined, or converted for recreational uses, even though it technically remains "protected" under the jurisdiction of a Federal or state agency, such as the Bureau of Land Management. Other sources of danger are more subtle but no less insidious. Elias (1977) estimates that twenty-two percent of the flora of the United States consists of naturalized species, many of which (*Lythrum salicaria*, the common purple loose-

Calochortus obispoensis *Lemmon, the San Luis mariposa, a candidate for legal protection under the Endangered Species Act. Further information on wild populations of this species is needed before it can be officially listed, however. This drawing, by C. E. Faxon, is from the Archives of the Arnold Arboretum.*

strife, for example) compete with native plants and may literally crowd them out of existence. Native species have suffered from such introduced diseases as Dutch elm disease and chestnut blight, against which they have no resistance.

In the face of such multifarious threats to species diversity, it is essential that every available resource be mobilized. In recent years, botanical gardens and arboreta have become important new members of the conservation community. Although their enormous potential to intervene in species extinction has only begun to be realized, there are many hopeful signs that they will be increasingly active in the preservation of endangered plant species.

Iris tenuis *S. Wats., the Clackamas iris, drawn by C. E. Faxon. Native to northwestern Oregon, this species is no longer a candidate for listing under the Endangered Species Act because it has "proven to be more abundant or widespread than was previously believed and/or [is] not subject to any identifiable threat." Taxa of this type are said by the Fish and Wildlife Service to be in "Category 3C."*

The Increasing Importance of Botanical Gardens and Arboreta

Recently, Dr. Peter Ashton, Director of the Arnold Arboretum, noted that botanical gardens and arboreta should view themselves as "basic resources" in conservation and research. He notes (Ashton, 1984) that

> botanic gardens have an opportunity, indeed an obligation which is open to them alone, to bridge between the traditional concerns of systematic biology and the returning needs of agriculture, forestry, and medicine for the exploration and conservation of biological diversity.

Others—Schultes (1983), Lucas (1984), and Synge and Townsend (1979), for example—have similarly noted the potential importance of gardens for research on and conservation of endangered species. The roles gardens and arboreta can play are by and large extensions of their traditional areas of expertise in plant collecting, propagation, cultivation, and research. A sampling of activity in United States botanical gardens illustrates the diverse functions that gardens are already developing as they concentrate increasingly on work with endangered native plants.

Cultivating Rare and Endangered Plants

Where botanical gardens truly excel is in the propagation and cultivation of plants. Gardens and arboreta in this country have had many decades of experience in propagating and cultivating rare and fastidious species. Although they traditionally have applied their skills primarily to horticultural varieties and exotics, many gardens and arboreta have begun turning their skills to the conservation of rare native taxa (Huckins, 1983). For instance, a recent survey of botanical gardens and arboreta in the United States revealed that at least sixty-eight of them are currently raising some regionally or nationally rare native taxa. It is an encouraging sign that these institutions are dispersed among all regions of the continental United States and Hawaii and that they include many of the newer, smaller gardens as well as the more established institutions. Yet despite these encouraging signs, fewer than one in ten of the taxa that are endangered in this country are in cultivation anywhere (Brumback, 1981).

Elliottia racemosa *Muhlenb. ex Elliott, the Georgia plume, a member of the Ericaceae. A deciduous shrub that reaches twenty feet in height, this is the only species in the genus. It is native to eastern Georgia and southern South Carolina. The Fish and Wildlife Service has placed* Elliottia racemosa *in Category 3C. The drawing, which is by C. E. Faxon, is from the Archives of the Arnold Arboretum.*

There are a few bright spots on the map. Among the largest collections in the continental United States is that of the North Carolina Botanical Garden in Chapel Hill, which maintains in cultivation thirty-eight protected taxa, including three Federally listed species and candidates for listing such as *Shortia galacifolia.* Another significant collection is that of the Garden in the Woods in Framingham, Massachusetts, which currently has more than two hundred fifty specimens of plants representing eighteen regionally or nationally endangered taxa. The Desert Botanical Garden in Phoenix, Arizona, cultivates thirty rare native taxa, seventeen of which are either listed or proposed for listing on the Federal Government's "List of Endangered Plant Species." Rancho Santa Ana Botanic Garden in Claremont, California, conserves upwards of one hundred rare or threatened native plants, including major collections of *Arctostaphylos* (manzanita), *Ceanothus,* and *Dudleya* (live-forever). In Hawaii, the Waimea Arboretum currently cultivates over three hundred taxa that are rare or endemic to the Hawaiian Islands. Other gardens that cultivate threatened or endangered species include the State Arboretum of Utah in Salt Lake City; Bok Tower Gardens in Lake Wales, Florida; the Denver Botanic Gardens; the University of Nebraska Statewide Arboretum; and the San Antonio Botanical Center.

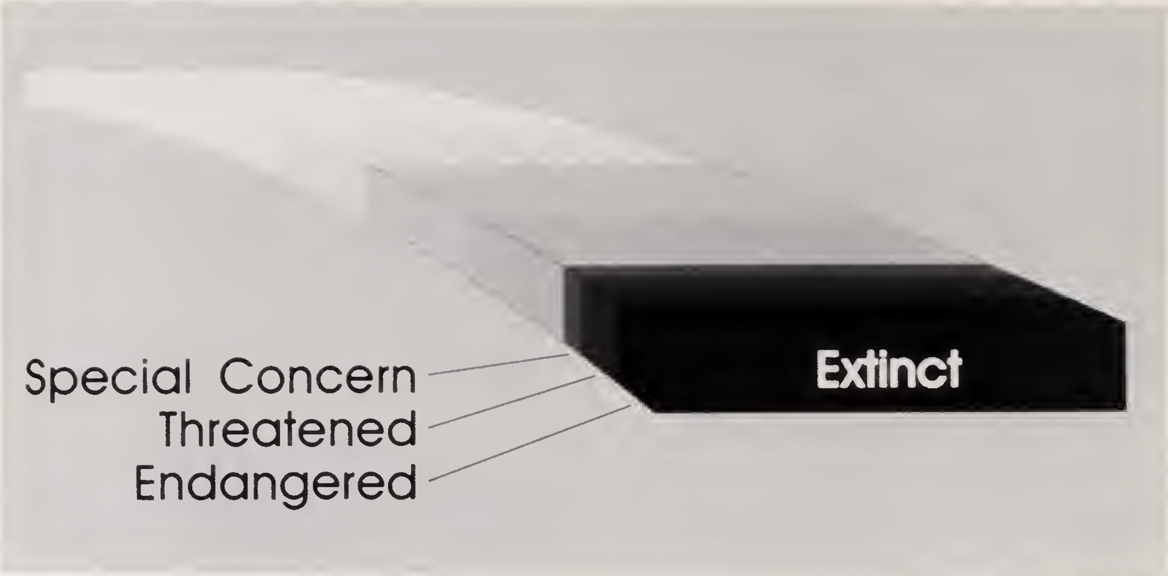
Numbers are not the whole picture, of course; in some cases, botanical gardens are actually growing the last living individuals of a species that has been extirpated from the wild. The Fairchild Tropical Garden in Miami maintains specimens of *Goetzia elegans* from Puerto Rico, a species that has been reduced to one plant in the wild. The plant appears to be self-incompatible, so the plants at the Garden (which were propagated from root cuttings) may soon be the only remaining living individuals of the species. The Fairchild also cultivates *Amyris balsaminifera,* a plant once found in the subtropical hummocks of southern Florida. All of the wild United States populations have disappeared, though the species is still relatively common in Central America and South America.

Franklinia

The best known example of the cultivation of a species no longer found in the wild is, of course, *Franklinia alatamaha.* The species was observed by John and William Bartram along the Alatamaha River in Georgia in 1765 but never elsewhere. The last person to see the plant in the wild, Dr. Moses Marshall, revisited the site in 1790 and found *Franklinia* to be locally plentiful over an area of two to three acres. It has not been seen in the wild since and is presumed to have been extirpated. It has found an alternative niche, however, as a cultivated ornamental and is now widely grown. All living specimens are descendants of the material collected in 1790 by Marshall (Barnhart, 1933; Harper and Leeds, 1937).

Predictably, some of the most successful work with endangered species has been done by gardens that have given native plants high priority in their accessions and collections policies. The staff of the Garden in the Woods in Massachusetts, for example, is able to maintain the Garden's collection of rare species as part of an overall accessions policy that emphasizes native plants of the Northeast, particularly New England. The Garden's collection currently includes populations of *Trollius laxus* (spreading globeflower), *Helonias bullata* (swamp pink), *Sabatia kennedyana* (Plymouth gentian), and several unusual species of *Sarracenia* (pitcher plants). The Garden also maintains species from other regions, such as *Echinacea tennesseensis* (Tennessee coneflower) and *Shortia galacifolia* (Oconee bells).

Camassia cusickii *S. Wats., a species native to northeastern Oregon and to Idaho. It is in Category 3C. Drawing by C. E. Faxon.*



A diagram illustrating the several categories of rare (and extinct) plants.

Another excellent example of commitment to threatened native plants is the new Transition Zone Horticultural Institute in Flagstaff, Arizona, which operates The Arboretum at Flagstaff. The Institute's charter specifically commits the Arboretum to the cultivation and conservation of rare and endangered taxa from its region whenever possible. As a result, the Institute has been able to acquire a collection that includes several endangered species of *Pediocactus, Cowania,* and *Sclerocactus.*

Waimea Arboretum and Botanical Garden in Hawaii has stated in its accessions policy that a "primary role" will be to cultivate endangered plant species and to distribute them widely. It is committed to working with national and international conservation efforts. Another important Hawaiian garden is the Pacific Tropical Botanical Garden, which has been chartered by the United States Congress to work toward the conservation of endangered plants. Other larger and more established institutions, such as the Missouri Botanical Garden in St. Louis, have recognized conservation as a priority and are beginning to integrate endangered species into their permanent collections.

A particular application of the skill of gardens in cultivation is the transplanting of wild plants into a cultivated setting as part of an emergency "plant-rescue" program. The plant-rescue program at the North Carolina Botanical Garden has operated for over fifteen years and is among the oldest in the country, sending staff and volunteers to dozens of sites threatened with imminent destruction. The program is designed to preserve plants when all attempts to protect their habitats have failed. One recent series of expeditions managed to transplant over twenty-five hundred plants of *Shortia galacifolia* from a site slated for recreational development—ironically, the construction of a hiking path—by a power company. An excursion to another, isolated *Shortia* site was also successful even though the team had to be ferried to the site by motorboat. Other collecting trips have yielded living material of *Camassia scilloides, Trillium pusillum,* and *Kalmia cuneata.* Plants are transported either bare-rooted or in blocks of soil and are reestablished in the Garden. In every case, collectors obtained permission from the landowner to enter a site and to remove plants. Efforts to secure permanent protection for plants in their natural habitats continue.

Rescue operations are not always successful, even when arrangements seem secure. For instance, the Berry Botanic Garden was scheduled to collect seeds and plants from the largest remaining population of *Lomatium bradshawii,* which was situated in a city park in Eugene, Oregon. Unfortunately, the Parks Department's grounds crew was not informed of the arrangement and mowed the entire population before the fruits ripened.

Species that are rare in the wild are not necessarily difficult to raise in cultivation. Many are rare simply because their poor abilities to compete restrict them to a narrow range of habitat types in the wild. If the necessary habitat is threatened, then the species is threatened. An example is *Sabatia kennedyana* (Plymouth gentian), which grows on the sandy margins of ponds on Cape Cod, Massachusetts. Given the proper conditions under cultivation and unimpeded by other species, the plant thrives. A recent transplant experiment in England revealed that, of a group of very rare plants, only a third were unusually difficult to raise, while another third were actually weedy (Cranston and Valentine, 1983)!

C. E. Faxon's drawing of Cypripedium californicum *A. Gray, the California lady's-slipper. Native to California and Oregon,* Cypripedium californicum *is also in Category 3C.*

Horticultural Value

Genetic conservation is not the only reason for raising endangered plants. Many of them are stunningly beautiful as well. While some endangered taxa are not especially attractive, Dr. Linda R. McMahan of the Center for Plant Conservation (formerly of the World Wildlife Fund–U.S.) estimates that fully two-thirds of the endangered species native to the United States belong to genera of proven horticultural merit. Among them are endangered lilies, larkspurs, orchids, roses, rhododendrons, heathers, asters, columbines, violets, meadowbeauties, phloxes, daisies, sunflowers, and gentians, as well as oaks, hollies, birches, pines, cypresses, and many cacti.

With a few notable exceptions, the color and form of native species in the garden tend to be subtle and understated rather than showy. One would not pit *Hydrastis canadensis* (goldenseal) against the latest generation of Holland's tulips, for instance. Consequently, in botanical gardens the most successful horticultural applications often are those that integrate plantings of native species into their natural settings. At the Garden in the Woods, for example, naturalistic plantings are maintained in a diversity of habitats, including acid- and limestone-woodland, pine-barren, meadow, bog, and pond environments. Another example is the United States National Arboretum in Washington, D.C., where over twenty nationally rare species are grown in Fern Valley, which is maintained as a natural woodland. Similarly, the Holden Arboretum in Mentor, Ohio, works with some thirty-six endangered plants in seventeen representative habitat plantings, including woodland, stream- or marsh-border, prairie, and wet-meadow plantings. The North Carolina Botanical Garden maintains collections in several habitat types typical of the southeastern mountains and coastal plain. The Desert Botanical Garden in Phoenix integrates its rare-species plantings into a variety of Sonoran Desert habitat types, including a shallow alkaline plain and a rocky outcrop, where the plants are kept alongside other species associated with them in the wild. In these settings, native plants (including those that are endangered) can be best appreciated for their natural aesthetic virtues.

Seed Storage

Besides raising plants in greenhouses and out-of-doors, botanical gardens can maintain living plant material in storage facilities, such as low-temperature seed banks. An example is the Rare and Endangered Seed Bank at the Berry Botanic Garden in Portland, Oregon. Initiated in 1982, the Seed Bank currently includes seeds of over one hundred rare and endangered species found in Oregon. Curator Julie Kierstead observes that the goal is "to preserve a representative genetic sample of each endangered species in Oregon as insurance against extinction of the species in the wild." Collecting for the facility is done by Garden staff and volunteers, and emphasizes species that are clearly endangered in the wild but that have not yet been accorded formal protection under the Endangered Species Act. Specimens are stored at minus 18 Celsius (0 Fahrenheit) in sealed glass vials in which the relative humidity is kept below five percent. Among the plants currently in storage are species of *Lomatium, Arabis, Astragalus, Lewisia,* and *Lilium*. Viability trials are conducted periodically to determine how long the seeds remain alive, and their rates of germination. Because many specimens may be kept easily, seed storage provides perhaps the simplest means for gardens to maintain ade-

Lonicera hirsuta *Eat., the hairy honeysuckle, which ranges from Quebec to Pennsylvania and west to Nebraska. It is listed as endangered in Massachusetts by the Massachusetts Division of Fisheries and Wildlife but does not appear on the Federal list. Drawing by C. E. Faxon.*

quate populations of plants, making it possible to preserve a greater cross-section of the genetic diversity of each species. The cost per species can be quite low also, especially if the garden is able to use an existing facility that has been made available for the purpose.

The United States Department of Agriculture, which operates the largest seed-storage facilities in the United States, has begun to work on the conservation of seeds of endangered American plants. The Department's interest arises in part because many native species belong to genera with important food, fiber, oil, or horticultural species. But the Department's mandate is even broader than this, encompassing conservation work through the Forest Service and the Agricultural Research Service. The National Plant Germplasm System, which includes the National Seed Storage Laboratory in Fort Collins, Colorado, along with several other facilities nationwide, is now conducting trial storage of rare species through the Center for Plant Conservation. Readers interested in details about current seed-storage work should refer to the review article by Holden and Williams (1984).

Research

In its 1978 report, *Conservation of Germplasm Resources,* the National Research Council of the National Academy of Sciences concluded that one of the most important facets of a botanic garden's involvement with endangered plant species is the opportunity to perform significant research (Committee on Germplasm Resources, 1978). Many of the rarest and most unusual species in the United States are virtually unstudied beyond basic botanical description, because of the difficulty of working with populations in the wild. It is hardly possible to study thoroughly a species's biochemistry, for instance, when there are only a dozen individuals left in the wild. Dr. Thomas S. Elias of Rancho Santa Ana Botanic Garden observes (Elias, 1977) that "the threatened and endangered species are one of the poorest-known assemblages of plants in the U.S. Little is known about their natural history, their reproductive mechanisms or their life cycles." As a response to this problem, he suggests that botanic gardens and arboreta can play a major role in the preservation of endangered species by assuming "a leadership role in the study of the natural history and life cycle of such endangered plant groups as the cacti, orchids, cycads, some of the attractive wild flowers, and others."

Rhododendron maximum *L., the great laurel, or rosebay, a species listed in Massachusetts as threatened. Like* Lonicera hirsuta, *it does not appear on the Federal list. Drawing by C. E. Faxon.*

Only recently has the role of experimental cultivation in relation to habitat conservation been recognized in the United States. Frequently, habitat managers have to base recovery and management plans on inadequate data about the species in their care. Consequently, the wild populations of a species may continue to decline, despite continued efforts at preservation. Particularly in the case of very rare species, research is further hindered by the inaccessibility of the populations and by the necessity to avoid damaging any of the wild individuals. Dr. Robert E. Cook, Director of Cornell Plantations at Cornell University in Ithaca, New York, explains (Cook, 1984):

> Many recovery plans fail to place sufficient emphasis on critical components of the natural history of all life stages of a species. Furthermore, because individuals of endangered species are rare and irreplaceable, experimental manipulations are seldom feasible, and recovery procedures cannot be tested. We believe that the preservation of endangered plants depends upon an understanding of the population biology of each species.

By bringing plants into cultivation, a garden may then propagate a large number of expendable individuals that can be subjected to types of experimental treatment never desirable—or even possible—in the wild. Gardens can thus make a valuable contribution to species management, especially by providing data on environmental tolerances, growth requirements, physiology, and life histories. When coupled with field studies of population dynamics, pollinators, and associated species in the wild, for example, the data can begin to suggest the best line of management. Garden-based *ex situ* research is increasingly being joined with fieldwork at institutions such as Cornell and the Center for Conservation Biology at Stanford, to provide a solid scientific footing for conservation.

Many gardens, of course, are already participating in research on the biology of endangered plants. In many cases, simply attempting to cultivate a species will require research, since so few of the plants have ever been cultivated. The normal range of factors that can be manipulated—soil composition, moisture, pH, sunlight, fertilization, stratification, and so on—constitutes an important contribution to understanding the biology of the species. As William E. Brumback, propagator at the Garden in the Woods, observes (Brumback, 1983):

Monardella leucocephala *A. Gray, the Merced monardella, which was native to Merced and Stanislaus counties in California but which now appears to be extinct in the wild. The Fish and Wildlife Service has placed* Monardella leucocephala *in Category 1, which means that enough information is available to justify giving it immediate protection under the Endangered Species Act. This drawing is by Adel Hagar of the Center for Plant Conservation and is used with her permission.*

Propagation research can provide important insights into a species' behavior in the wild. For instance, what might account for a species' ease of propagation and cultivation in the controlled environment of a botanical garden while the wild populations continue to decline? For each species, the answer lies in the long-term study of the species' biology; but propagation research can supply valuable information regarding the potential success of the species under "ideal" conditions in the wild.

A notable example of such research is currently being conducted by Brian Parsons and Tom Yates at the Holden Arboretum on *Trollius laxus* (spreading globeflower) under contract to the Ohio Department of Natural Resources (ODNR). Holden is investigating the cultural requirements of the species in the Arboretum. ODNR is using their recommendations to manage the remaining wild populations of *Trollius* in Ohio. Similarly, the Transition Zone Horticultural Institute in Flagstaff, Arizona, and Cornell Plantations, among other gardens, are working under contract with the Fish and Wildlife Service to help develop more accurate and effective "recovery plans" for an increasing number of endangered species.

Oreonana purpurascens *Shevock & Constance, the purple mountain parsley. Endemic to Tulare County, California, this species is in Category 2*—i.e., *it is a candidate for protection under the terms of the Endangered Species Act, but more information about it will be required before it can be proposed for listing. This drawing was done by Amy Eisenberg and is used with her permission. Copyright © 1981 by Amy Eisenberg.*

Conservation of Habitat and Reintroduction: Closing the Circle

In the long run success in the gardens will be a hollow victory if it does not enhance efforts to conserve species in their native habitats. Many of the instances cited in this article are the result of close cooperation among botanical gardens and agencies that manage natural habitats. Much of the cooperation naturally revolves around the gardens's ability to perform or assist in research. By learning more about plants in cultivation, habitat managers can make more-informed choices about populations in the wild.

Trifolium bolanderi *A. Gray, Bolander's clover, a rare clover known only from a few scattered localities from Yosemite National Park south to Sierra National Forest, California. Like* Oreonana purpurascens, Trifolium bolanderi *is in Category 2. Drawing by Amy Eisenberg. Copyright © 1981 by Amy Eisenberg. Used through the courtesy of the artist.*

One area where gardens have been particularly active is in the reconstruction of habitat types and the reconstruction of damaged habitats. An instance is the Prairie Restoration Project at the University of Wisconsin. The Project, directed by Dr. William Jordan, has included both scientific study and experimental re-creation of northern-prairie types. The University also publishes *Restoration and Management Notes,* a semiannual journal devoted to the reconstruction of damaged habitats. A recent instance of a garden's role involved the restoration of a population of *Hudsonia tomentosa* that had been nearly destroyed by off-road vehicles on land in Vermont owned by The Nature Conservancy. The Conservancy arranged for the propagation in a commercial greenhouse of cuttings taken from the site. The resulting material was rooted and then transplanted in the original location, thus helping to reestablish the population.

Conclusion

Plant extinction is a complex phenomenon, sharing the same kind of interaction between economic and biological processes that is characteristic of all critical environmental issues. The conservation of species cannot realistically be divorced from the national conservation strategy. It will require the full range of resources available to prevent species extinction from reaching massive proportions in this country. The stakes are too high for us to allow plants of unique biological character, potential economic utility, and rare beauty to be lost. Professor Richard Evans Schultes of the Harvard Botanical Museum recently noted that, "A massive effort is urgently needed to ensure the survival of endangered species" (Schultes, 1983). It is a hopeful sign that the considerable resources of botanical gardens and arboreta are being mobilized to this purpose.

Brodiaea insignis *(Jeps.) Niehaus, the Kaweah brodiaea, which is native to California. It is in the Fish and Wildlife Service's Category 1. Drawing by Amy Eisenberg. Copyright © 1980 by Amy Eisenberg. Used through the courtesy of the artist.*

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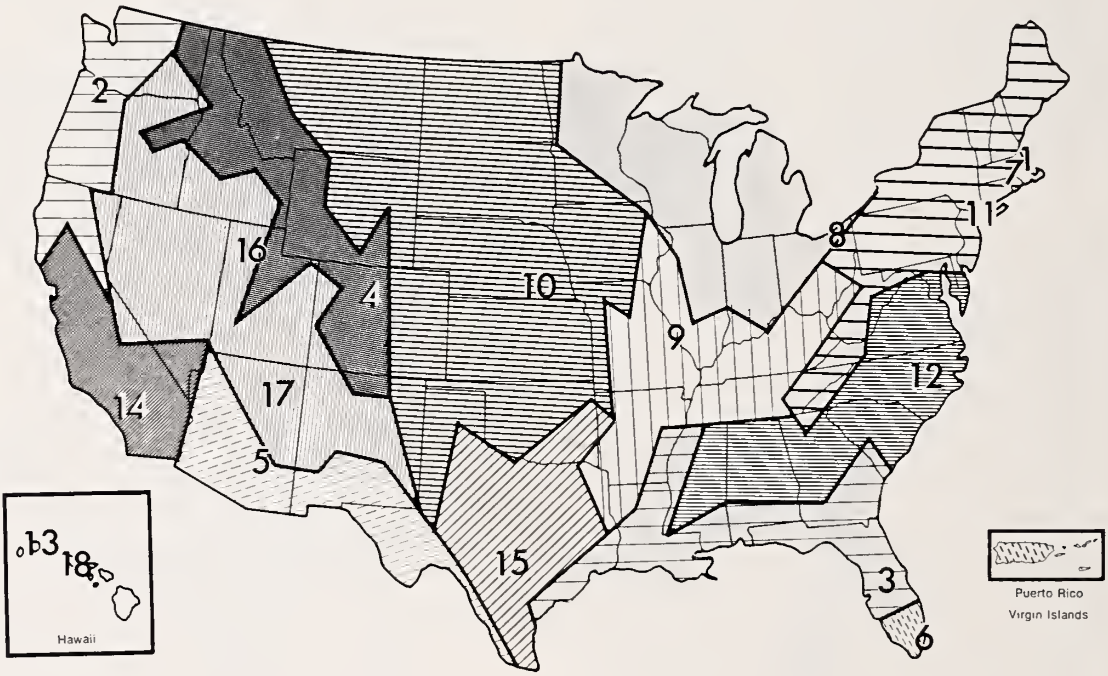
Donald A. Falk and Francis R. Thibodeau, Director of Administration and Director of Science, respectively, of The Center for Plant Conservation, cofounded the Center in 1984.



Regions established by the Center for Plant Conservation on the basis of the major biogeographic regions of the United States. Several cooperating arboreta and botanical gardens (eighteen in all) work with the Center, concentrating on species native to their respective regions. The cooperating institutions are the Arnold Arboretum ("1" on the map), Berry Botanic Garden (2), Bok Tower Gardens (3), Denver Botanic Gardens (4), Desert Botanical Garden (5), Fairchild Tropical Garden (6), Garden in the Woods (7), Holden Arboretum (8), Missouri Botanical Garden (9), Nebraska Statewide Arboretum (10), New York Botanical Garden (11), North Carolina Botanical Garden (12), Pacific Tropical Botanical Garden (13), Rancho Santa Ana Botanic Garden (14), San Antonio Botanical Gardens (15), State Arboretum of Utah (16), The Arboretum at Flagstaff (17), and Waimea Arboretum and Botanical Garden (18).

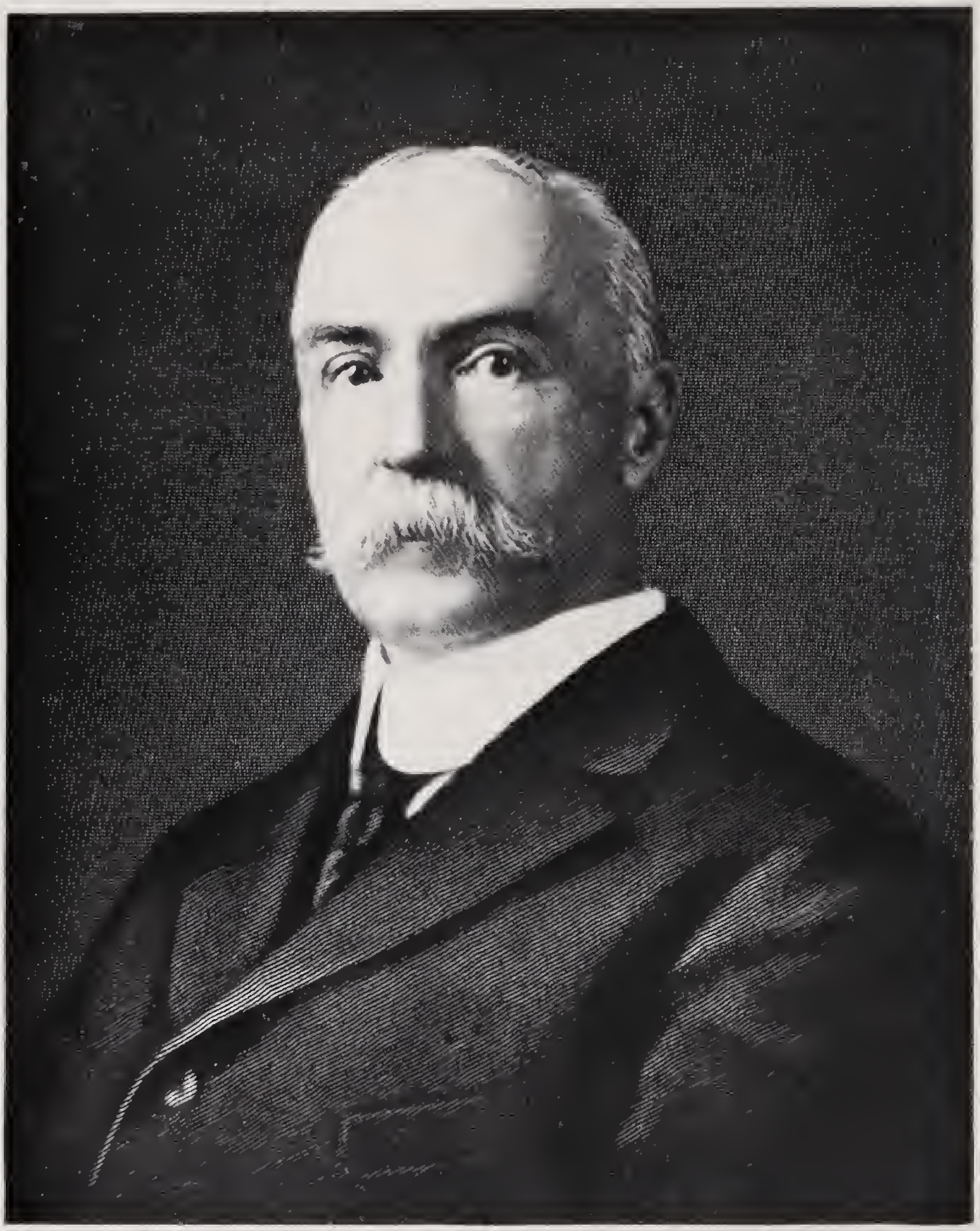
The Center for Plant Conservation

Donald A. Falk and Francis R. Thibodeau direct the Center for Plant Conservation, the first national organization devoted specifically to the conservation and study of endangered plants. Founded in 1984, the Center operates as a cooperative network consisting of eighteen leading botanical gardens and arboreta in the United States, as well as seed-storage facilities of the United States Department of Agriculture (see map on facing page). The institutions are committed to cultivating endangered species in their respective regions; some have been actively working with endangered species for years. In addition to the participating gardens, the Center is guided by a scientific Advisory Council consisting of eminent scientists and conservationists from the Smithsonian Institution, the Office of Endangered Species, the World Wildlife Fund (WWF), the International Union for Conservation of Nature and Natural Resources (IUCN), and The Nature Conservancy. The Center's offices are located at the Arnold Arboretum in Jamaica Plain, Massachusetts.

The Center's primary objective is to acquire a comprehensive national collection of United States endangered plants in the selected regional gardens, arboreta, and storage facilities. Accessions are determined with an endangered-species data base, which allows threatened plants in the wild to be assessed and prioritized for collection. The species targeted for collection are both critically endangered in the wild and not currently in cultivation in a garden or arboretum. Over a period of years, the Center will establish a network of regional collections that will be carefully maintained and documented at each member institution. Over time, these collections should prove to be of great value to both the scientific and conservation communities. In addition, the Center holds research that enhances habitat management as an important goal, particularly in relation to the development of biological information to be used in recovery and management plans for species in their wild habitats. Finally, the Center is committed to broadening public awareness and support of biological conservation through exhibits and teaching in the member gardens. It hopes to serve as an example for international conservation through the development of a strong national program, and to cooperate with efforts such as those sponsored by IUCN and WWF.

In order to guarantee the permanence of the National Collection, the Center has established a Permanent Preservation Fund, which will be used to ensure the ongoing curation in the participating gardens. The Fund offers an opportunity for adding a species to the Collection in the donor's name.

For further information about the Permanent Preservation Fund and the work of the Center for Plant Conservation, please contact the Center's office at the Arnold Arboretum, Jamaica Plain, Massachusetts 02130-2795, or at (617) 524-6988.



C. E. Faxon

Charles Edward Faxon, *delineavit*

Many of the drawings in this issue of *Arnoldia* were done by C. E. Faxon (1845–1918), a self-taught artist who for thirty-six years worked at the Arnold Arboretum, running the Library and Herbarium and drawing plants for various botanical publications. From 1882 to 1902, for example, he prepared seven hundred forty-four plates for Charles Sprague Sargent's classic *Silva of North America*. The acclaim that was heaped on the *Silva* owed as much to Faxon's drawings as to Sargent's text.

When Faxon died in 1918, Sargent wrote the following words, which are excerpted from an article published in *Rhodora*, the journal of the New England Botanical Club:

> As a child Charles Faxon taught himself to draw, using as his model the studies of landscape and of trees published by J. D. Harding, an English artist, in his *Lessons on Trees* and other books which in their time were influential in increasing the love of drawing. By the time he was fifteen years old Charles Faxon was able to make excellent copies in color of some of Audubon's birds, and during the summers made successful pencil and water color sketches of the scenery of northern New England.
>
> What Faxon learned from schools was in the Jamaica Plain public schools and the Lawrence Scientific School at Cambridge, from which he was graduated as a civil engineer in 1867. At Cambridge he was noted for skill in mechanical drawing. Later he became deeply interested in English literature and taught himself to read nearly all the modern European languages.
>
> Faxon lived always in Jamaica Plain and did not care to travel except in western and northern New England where he spent a few weeks every spring and autumn, his last journey to northern New Hampshire having been in the autumn before he died. Berkshire County, Massachusetts, was a favorite field of the Faxons and they knew its flora well, as they did that of the Green Mountains of Vermont and of all northern New Hampshire. Outside of New England Faxon traveled little and never crossed the continent.
>
> From 1879 to 1884 Faxon was an instructor of botany in the Bussey Institution of Harvard College. He was a Fellow of the American

The drawings of ferns scattered through the text of this article were made by C. E. Faxon for D. C. Eaton's Ferns of North America *(1879–80). They are, in the order of their appearance,* Pellaea atropurpurea *(L.) Link, the purple cliffbrake (of special concern in Massachusetts);* Asplenium montanum *Willd., the mountain spleenwort (threatened in Massachusetts); and* Woodsia glabella *R. Br., the smooth woodsia (endangered in Massachusetts).*

Academy of Arts and Sciences, and in 1897 Harvard conferred on him an Honorary Master of Arts degree.

During the 70's Professor D. C. Eaton was preparing an illustrated work on the Ferns of North America and the Faxons, who were interested in Ferns, had opportunities for collecting northern material for him. This led to an invitation to Charles Faxon to make some of the colored drawings for Eaton's book. The first of these, that of *Aspidium Goldianum* Hook., was published in June 1879, and is plate xl, of volume i. The remaining plates of this volume and all those of volume ii. were drawn by Faxon.

Professor Spencer F. Baird, one of whose earlier papers was a catalogue of the trees and shrubs of Cumberland County, Pennsylvania, was anxious that the Smithsonian Institution should publish a Silva of North America, and as early as 1849 Isaac Sprague began to make colored drawings of the flowers and fruits of trees under the direction of Asa Gray who was to prepare a North American Silva for the national Government. This plan was dropped at the end of a few years, but in 1882 I accepted Professor Baird's invitation to undertake the preparation of a Silva of North America to be published by the Smithsonian Institution, and I asked Charles Faxon to join the Arboretum staff to take charge of the herbarium and library, and to make the drawings for the new Silva. He came to the Arboretum on May 12th of that year and remained in

charge of the herbarium and library until his death, seeing them grow from insignificance to considerable importance; and much of the value and success of the Arboretum is due to the admirable manner in which he managed his departments.

Faxon began at once the drawings for The Silva, but at the end of a few months it was found that at the rate the Smithsonian Institution was willing to pay for the work it would take at least seventy-five years to complete it, and another arrangement was made for the publication of the book. Under the new arrangement Faxon made such good progress with the drawings that it was possible to begin publishing the first volume in 1891, and the last of his seven hundred and forty-four Silva plates appeared just twenty-one years after he began making the first drawing.

To illustrate some of the Guatemala plants described by John Donnell Smith, Faxon made thirty-four drawings which were published in *The Botanical Gazette* between 1888 and 1894. In this set of drawings are found some of the best examples of Faxon's work.

In the ten volumes of *Garden and Forest* (1888–1898) are published two hundred and eighty-five of Faxon's drawings. Among them are eight drawings of insects and their destructive work. Among the plants there is a large variety of subjects, including trees, shrubs, herbaceous plants and Ferns. Many previously undescribed species and one genus are found among these drawings. Among them, too, will be found the first illustrations of several plants which have now become common in gardens, and the only illustrations which have been published of many rare and interesting North American shrubs. Among these drawings are figures of thirteen North American species of Aster, Irises, Phloxes, Barberries, and a number of Japanese trees and shrubs. Seventeen of these illustrations of Japanese trees were reproduced in Sargent's *Forest Flora of Japan*.

In the two volumes of *Trees and Shrubs* (1902–1913) two hundred of Faxon's drawings are published. They illustrate new or little

Quercus macrocarpa *Michx., the bur, or mossy-cup, oak, a species "of special concern" in Massachusetts.* Top: *Faxon's sketches from living specimens.* Bottom: *Engraved print. Both from the Archives of the Arnold Arboretum.*

known ligneous plants, including two previously undescribed genera, *Faxonanthus* in honor of Edwin Faxon, and *Grypocarpa*, and one hundred and three previously undescribed species, principally from North America, Mexico, Central America, China and Japan.

In 1905 six hundred and forty-two of Faxon's drawings were published in Sargent's *Manual of the Trees of North America*, and in the last year of his life he was at work on some additional drawings for a new edition of this work. Between 1899 and 1913 thirteen of Faxon's drawings were published in *Rhodora*, and three of his drawings of Ferns will be found in the *Bulletin of the Torrey Botanical Club*. During thirty-four years, from 1879 to 1913, nineteen hundred and twenty-five of Faxon's drawings were published.

Lilium grayi *S. Wats., the roan lily, by C. E. Faxon. Original drawing in the Archives of the Arnold Arboretum.*

C. E. Faxon's drawing of Crataegus berberifolia *Torrey & Gray, a hawthorn from eastern Texas and western Louisiana that is in the Fish and Wildlife Service's Category 2. The drawing was published as Plate 179 in Sargent's* Silva of North America.

In his drawings Faxon united accuracy with graceful composition and softness of outline. He worked with a sure hand and great rapidity, and few botanical draftsmen have produced more. Certainly none of them have drawn the flowers, fruits and leaves of as many trees. Among the very few who in all time have excelled in the art of botanical draftsmanship Faxon's position is secure, and his name will live with those of the great masters of his art as long as plants are studied.

—Excerpted from *Rhodora*, Volume 20, Number 235 (July 1918), pages 117–112.

To the Arks with Rabbitbane: Plant Conservation at the Arnold Arboretum

Robert G. Nicholson

New and old propagation data from the Arboretum's records are proving valuable in the Arboretum's recent work with rare and endangered native plants

The Arnold Arboretum in Boston is the great dendrological Noah's Ark in this country. It contains almost all the trees, American and foreign, which will grow in that region.

—*Trees Worth Knowing*, by Julia Ellen Rogers (1923), page xiv.

In the fall of 1985, the Center for Plant Conservation (CPC) funded the first fieldwork done on its behalf by a staff member of the Arnold Arboretum, asking me, the newly appointed curator, to examine populations of a number of species listed by the Federal Government as rare, endangered, or threatened. Even species in the lower categories—the potentially endangered species—were to receive attention because any additional data on populations is always helpful for determining their actual status.

I visited thirty sites in North Carolina, Tennessee, and Georgia for the Center. In some instances, I collected propagating material as the first step in the process of amassing a genetically diverse, representative sampling of each species from a variety of populations. I also collected seeds from the general flora, preparing three hundred packets of them for exchanging with foreign botanical gardens, and testing them at the Arboretum's Dana Greenhouses as well. I processed the seeds according to the Arboretum's standard procedures. Interestingly, since the Arboretum had tested most of the species at one time or another, I already knew whether a specific treatment would be successful or unsuccessful.

Conradina verticillata, the Upland Rabbitbane

During the fall of 1985, I travelled to the Clear Fork River on the Cumberland Plateau to seek *Conradina verticillata* in its natural habitat and to assess the health of any population I might find. *Conradina verticillata*, the upland rabbitbane, is a low-growing woody shrublet that reaches only about nine inches in height. It forms spreading clumps, or colonies, since its branches can root when they touch the soil. Its lanceolate leaves are bright green; when crushed, they smell like rosemary. The intense fragrance released is responsible for one of the plant's local names—rabbitbane—since rabbits dislike it. (Having seen the damage rabbits can do to our nurseries in winter, I am beginning to wonder whether an infusion of *Conradina*, sprayed in the fall, would make an effective barrier to nibbling.) It is a candidate for endangered status.

Rabbitbane blooms in late May, its flowers ranging in color from white to rose purple. Two-lipped, and one-half inch wide and high, the flowers are borne prolifically on the stalks in axillary clusters. The blossoms are such that *Conradina* eventually may infiltrate its way into horticulture. A pleasing plant of fine texture, it is well suited for rock gardens, perennial borders, and even for use as a groundcover in full sun. It probably is hardy to 0 Fahrenheit, although it hasn't received extensive hardiness trials.

Brought to the attention of the botanical world by Harry M. Jennison, a botanist at the University of Tennessee, as recently as 1933, *Conradina* is a genus of shrubs in the Lamiaceae (the mint family) (Jennison, 1933). It numbers only four species, three of which range over the Gulf Coast region of Alabama and Florida. The fourth species, a rare endemic, is found much farther inland, in a few counties of Kentucky and Tennessee. Jennison first found *Conradina verticillata* as "Relict colonies in sandy banks along the Clear Fork River, Fentress and Morgan counties," Tennessee. He realized the elusive nature of his discovery, for he reported that "considerable exploring in this vicinity . . . as well as in similar habitats in the region has failed to turn up other stations where this endemic grows." Alerted to its existence, other botanists began finding it, however. Paul Somers, the state botanist of Tennessee, tells me that some forty stands of it are now known; they vary in size from a few plants to massive clumps.

In 1935, Professor E. Lucy Braun of the University of Cincinnati found the upland rabbitbane on the South Fork of the Cumberland River, in McCreary County, Kentucky, some fifty miles downstream of Jennison's station. She warned that it might be eradicated by flooding caused by the newly constructed Wolf Creek Dam. Marc Evans, state botanist of Kentucky, tells me that Braun's original stands were indeed wiped out but that others have since been found along the river. These stands suffer from trampling by canoeists, however, since the gravel bars on which they grow make appealing spots for resting and camping.

Rabbitbane Discovered

After an afternoon's search along the trailless and tangled undergrowth of the Clear Fork River, I spotted a sand bar on the opposite shore. Remembering that Jennison had described it as growing on "sandy banks," I decided to cross over. Hopping from rock to rock, I soon reached the other side and immediately found a small stand of rabbitbane. Half a dozen plants, growing in full sun, formed small, one-foot-wide clumps in the sandy gravel. Studying the immediate vicinity, I discovered that the plants would be under water during flood stages, since a line of flotsam clearly showed the river's high-water mark a full fifteen feet beyond the stand of rabbitbane.

The records of the Arnold Arboretum indicate that rabbitbane is very easy to propagate. Cuttings taken in fall or spring rooted to the extent of 90 to 100 percent under mist or under polyethylene humidity chambers. Such cuttings transplant well and grow out strongly. It was a relief finally to encounter a plant with the proper respect for both modern propagating techniques and hard-working propagators.

Rabbitbane's ease of propagation means two things: first, that propagating material can be collected in the wild without altering the composition of a stand of plants; second, that large numbers of propagules can be produced easily, making the plant's reintroduction into the wild an easy process, should the need to do so arise.

At present, reintroduction of plants of rabbitbane to some sparse stands in Kentucky is being considered. The support of CPC, coupled with the Arnold Arboretum's prowess at propagating plants, could make it possible to do so.

Invaluable Data Already Exist

As Julia Ellen Rogers noted, the Arnold Arboretum has become a kind of "Noah's Ark" for woody plants, as have other, similar institutions. While the metaphor may be somewhat far-fetched, it does hint at a key issue in plant conservation—namely, that only a few special people get early-enough warning of catastrophe in the making. Botanists and horticulturists at botanical gardens and arboreta are rapidly realizing that the knowledge they and their predecessors have accumulated over many decades can be directly applied to preserving the growing number of rare, threatened, and endangered species in the native flora of the United States.

Reference

Jennison, H. M. 1933. A new species of *Conradina* from Tennessee. *Journal of the Elisha Mitchell Science Society* **48**: 268–269.

Robert G. Nicholson is a widely travelled member of the Arnold Arboretum's grounds staff. He has written several articles for *Arnoldia* and other horticultural publications.

Professors Gray and Sargent Pursue Shortia

Almost from its inception the Arnold Arboretum has had a strong interest in and concern for plant conservation, whether of entire forests or of individual species. Charles Sprague Sargent, its first Director, was intimately involved in establishing the nation's earliest policies on forest preservation, for example. A number of species in the Arboretum's Living Collections are rare, endangered, or even extinct in the wild, here or abroad. *Buckleya distichophylla* (Nutt.) Torrey, the oldest documented cultivated plant in the Arboretum, is native to North Carolina, Tennessee, and Virginia. The Fish and Wildlife Service is now studying and accumulating data on the abundance and vulnerability of that species, to determine whether to list it formally as endangered or threatened; data the Service already has suggest that doing so would be "appropriate."

Another species, *Neviusia alabamensis* A. Gray, a native of Alabama, Arkansas, Mississippi, Missouri, and Tennessee, is also under study for possible listing. In 1876, the Arnold Arboretum acquired a cutting of this species from a plant in the Harvard Botanic Garden, in Cambridge (specimen 430 in the Arboretum's inventory); another cutting was established at "Holm Lea," Sargent's estate in Brookline. Sargent sent a living plant of it to J. D. Hooker at Kew, in 1879. "*Neviusia* is one of the rarest plants of the United States," Hooker wrote in *Curtis's Botanical Magazine* in 1885, "being, in so far as hitherto known, confined to the State of Alabama, and there to some shaded cliffs near Tuscaloosa, where it was discovered by the Rev. R. D. Nevius, after whom [Asa] Gray named the genus." (As indicated above, the species has since been found in four other southern states.)

Interesting as these two cases may be, the case of *Shortia galacifolia* is even more interesting perhaps, since its advent and earliest years in the annals of botany where shrouded in mystery.

Shortia, "perhaps the most interesting plant in North America"

Shortia galacifolia Torrey & Gray, commonly called Oconee bells, little coltsfoot, or simply Shortia, is a rare plant that occurs

Neviusia alabamensis *A. Gray. From* Curtis's Botanical Magazine *for 1885.*

C. E. Faxon's drawing of Shortia galacifolia, *first published in* Garden and Forest *in 1888. It accompanied Sargent's account, "The Story of Shortia." This is the original drawing, which is preserved in the Archives of the Arnold Arboretum.*

in mountainous areas from Virginia to Georgia. A small evergreen, woody plant of up to eight inches in height, it is the sole species of *Shortia* native to North America; eight or ten other species occur in eastern Asia. Asa Gray pronounced it "perhaps the most interesting plant in North America."

In its most recent *Review of Plant Taxa for Listing as Endangered or Threatened Species*, the Fish and Wildlife Service assigns *Shortia galacifolia* to Category 2—"taxa for which information now in possession of the Service indicates that proposing to list them as endangered or threatened species is possibly appropriate, but for which substantial data on biological vulnerability and threat(s) are not currently known or on file to support the immediate preparation of rules" [!].

Shortia has an intriguing history somewhat reminiscent of the histories of Franklinia and Bartram's ixia (*Sphenostigma coelestinum*). André Michaux collected a specimen of Shortia in the mountains of Carolina in 1787 but did not describe it. Asa Gray came across Michaux's specimen while working in Paris in 1839; three years later he and John Torrey described it as a new genus, in the *American Journal of Science and Arts*. For decades Gray and others assiduously sought additional specimens of *Shortia galacifolia*, but to absolutely no avail. Finally, the species was rediscovered in North Carolina, in 1877; in 1886, Charles Sprague Sargent and Frank Ellis Boynton, a North Carolina botanist, even were able to find the type locality. But let Professor Sargent himself tell the story:

The Story of Shortia.

Our illustration upon page [27] represents one of the rarest and most interesting plants of North America. It is interesting from the peculiar structure of its delicate flowers, its botanical relationship, and the geographical distribution of the small family to which it belongs, which, as now [in 1888] defined, consists of but half a dozen genera and only nine species, which are all, excepting the two species of Diapensia, confined to eastern North America and eastern Asia.

The great interest of our Shortia, however, is found in the history of this plant during the past century, and in the fact that among all the plants studied and described and classified by Asa Gray, this little herb most excited his interest. American botanists never think of the man whom they all delight to look upon as their master and to remember as their friend without thinking, too, of this humble little plant, which properly occupied a conspicuous place upon the gift which a few years before his death they brought to him with words of affection and encouragement.

Professor Gray was in Europe in 1839, and in examining the herbarium of the elder Michaux, preserved in the Museum at Paris, found an unnamed specimen of a plant, with the habit of Pyrola and the foliage of Galax, of which only the leaves and a single fruit were preserved, and which had been collected, the label stated, in the "*Hautes montagnes de Carolinie.*" This specimen at once arrested his attention; and after his return, two years later, from his first botanical journey into the Carolina mountains, where he had

Drawing of the type specimen of Shortia galacifolia *A. Gray in the Michaux Herbarium, Paris.*

Buckleya distichophylla *Torr.* Top: *C. E. Faxon's sketches from living material.* Bottom: *The engraved print. From originals and proofs in the Archives of the Arnold Arboretum.*

searched in vain for Michaux's plant, he ventured to describe it, and to point out its probable affinities upon the strength of the scanty material in the Michaux herbarium, dedicating it to Dr. C. W. Short, the author of a catalogue of the plants of Kentucky, and fifty years ago an astute observer and capital collector of western plants, which he distributed with an unstinted hand among the principal herbaria of the United States and Europe.

Nothing more was seen of Shortia for a long time, although no botanist ever visited the mountains of Carolina (and the number after 1866 was considerable), without carrying a special commission from Cambridge to bring back a specimen of Michaux's little plant, in which Dr. Gray's interest became stronger than ever when, in studying in 1858 a collection of Maximowicz's Japanese plants, he recognized in that botanist's *Scizocodon uniflorus* another species of Shortia almost identical with the Carolina plant. The Japanese specimens, curiously enough, were in the same condition—that is, although the calyx and pistil of the flower were preserved, there was no trace of either corolla or stamens.

These specimens, while they confirmed the validity of the genus, threw no light upon the Carolina plant, which botanists now hunted for more assiduously than ever. The keenest-eyed plant-hunters looked for it in vain year after year in all the region in which Michaux was supposed to have traveled; and the search was almost given up as hopeless, when in May, 1877, Shortia was found accidentally by a youth, G. M. Hyams, upon the banks of the Catawba River, near the town of Marion, in McDowell County, North Carolina, at a considerable distance from the high mountains to which Michaux's label assigned the plant. The new specimen fell into the hands of the young man's father, a professed herbalist. His knowledge of botany, however, was not great; and it was not until the following year that he discovered, with the aid of a correspondent, what a treasure he had.

These new specimens made when the plant was in flower confirmed at once Professor Gray's original ideas of the proper relationship of his genus, and enabled him to complete its characters and remodel the family to which it belonged.

There seemed to be nothing more left to say about Shortia. It was figured and described and discussed, and even introduced sparingly into cultivation, although its stay in gardens was a short one; while the enterprising discoverer reaped a rich harvest during a year or two by selling plants (and, it is to be feared, by exterminating them) for herbarium specimens, at extravagant prices. Professor Gray, however, clung to the belief that Michaux's label could be depended upon, and that the real home of Shortia was in the high mountains. He regarded the station upon the Catawba as an outlying post, to which he suggested the plant might have been washed down, and still believed that it was to be found about the head-waters of the streams flowing eastward from the high Black Mountain range. This region was again carefully examined, but without result, and the search for Shortia was practically abandoned.

There is still, however, another short chapter to relate in the history of this little plant. I visited, two years ago, in the autumn of 1886, the mountain region of North and South Carolina, which lies about the head-waters of the Keowee River, the great eastern fork of the Savannah, for the purpose of gaining, if possible, some insight into the origin of *Magnolia cordata*, a species which was first described in Michaux's North American Flora, but had not been seen anywhere growing wild during the present century, although preserved and generally disseminated in gardens. Michaux left Augusta, Georgia, towards the end of November, 1788, for the purpose of securing a supply of roots of what he called at that time *Magnolia cordata*. This was not, as I was afterwards able to show, the *Magnolia cordata* of the Flora, founded long afterwards in Paris by Richard upon a specimen of *M. acuminata*, but the *M. Fraseri*, a species which had been discovered a few years earlier by the younger Bartram, the first botanist who explored the Carolina mountains. Michaux, in spite of a serious attack of fever, reached the head-waters of the Keowee on the 9th of December, and although weakened by sickness and hunger, and seriously impeded by the intense cold which he encountered in this elevated region, proceeded to explore the neighboring high mountains in search of a supply of young Magnolia trees for his Charleston nurseries. On the day of his arrival he noted in his journal that he had discovered what he called a *"Nouvel Arbuste a. f. dentelés rampant sur la Montagne."* I had taken occasion before undertaking this journey to examine the manuscript diary kept by Michaux during his stay in America, preserved in the library of the American Philosophical Society; and I had noted the directions he had written down with much detail for finding his *"Arbuste"*—which evidently had interested him, as it is the only plant which he mentioned in the whole diary in this way—in the hope of identifying his plant, which, as this region had not been visited again by any botanist, might prove something new, or at least imperfectly known. The idea that the plant might be Shortia was hardly entertained. It did not seem possible that Michaux, under any circumstances, could have mistaken Shortia for a shrub; and Dr. Gray, who had examined the diary either just before or immediately after his first journey to Carolina, if he noticed this entry at all, certainly never associated it in any way with the plant which he wanted to find more than all others. Had he done so he would have visited, or sent some of his correspondents to visit, the head-waters of the Savannah, a region which, for some reason, never attracted his attention, although it was by this route, following the old Indian trail from the coast to the Cherokee country, that all the early botanists penetrated to the mountains.

It was possible, with the aid of the journal, to find, without much trouble, the spot where Michaux had camped in December, 1788, and to race his footsteps upon the different excursions which he made into the mountains from this camp. The two torrents which he described, as descending in a rough and tumultuous course from the high mountains to form the Keowee, are now known as the Toxoway and the Horse-pasture. The little fertile plain which Michaux found at the junction of these two streams still exists, as does the footpath, since trodden by the feet of many moonshiners, which led from the right bank of the river a hundred paces below the junction of the two streams into the mountain facing the north. It was by the side of this path that Michaux, just 100 years ago this month, discovered this *"Arbuste,"* with denticulate leaves, and here, ninety-eight years later, I found Shortia.

The evidence seems conclusive that the two plants are one and the same, or, if it was not in this exact locality that Michaux gathered the specimen preserved in the Paris Museum, it was in this immediate neighborhood, where Shortia is now known through the subsequent explorations of Mr. F. H. Boynton, of Highlands, North Carolina, to be abundant.

Mr. Faxon's drawing shows so clearly the habit and structure of Shortia, which, moreover, has been frequently described in purely technical journals of botany, that nothing further upon these subjects need be written now. Its nearest American allies are *Galax aphylla*, a beautiful evergreen herb, with tall, erect racemes of small pure white flowers, peculiar to the wooded slopes of the southern Alleghany Mountains, and the familiar Pixie (*Pixidanthera barbata*) of the New Jersey Pine barrens. There is in Japan one species of Shortia (*S. uniflora*), and possibly two, as there exists a rude portrait in an old work upon Japanese botany, in which what is evidently another species of Shortia, almost identical with the American plant, is represented. In Japan, too, are two species of the nearly related Schizocodon, while in Thibet occurs Berneuxia, of the same family of *Diapensiaceæ*, of which the type is Diapensia, with two species, one widely distributed in boreal regions and the other confined to the Himalayas.

—Excerpted from *Garden and Forest*, Volume 1, Number 43 (December 19, 1888), pages 506 and 507.

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Endangered Plants at the Garden in the Woods: Problems and Possibilities

William E. Brumback

The special difficulties of raising endangered nonwoody species in a botanic garden evoke information on how to preserve the same species in their natural habitats

As members of the recently formed Center for Plant Conservation (CPC), the Arnold Arboretum and the Garden in the Woods (the botanic garden of the New England Wild Flower Society) face similar challenges in their attempts to propagate and raise endangered plant species. It should be made clear from the beginning, however, that raising endangered plants in a botanic garden ("*ex situ* conservation") is not a substitue for protecting them in their natural habitats ("*in situ* preservation"). Botanic gardens must not find themselves in the predicament zoos are in—holding collections of creatures that can no longer exist in the wild because their habitats are gone. Rather, botanic gardens should emphasize to their visitors that preserving its habitat is the single most important way to preserve a species, and that the role of a botanic garden is to complement, not to substitue for, preserving plants in the wild.

Yet both gardens can play significant roles by conducting research on the reproductive biology and potential of endangered plants, as well as by creating valuable reserve collections that could be used for reintroduction should wildlife biologists ever deem it necessary to do so. However, I feel that our most important role is educating the public to the fact that plants are endangered. In the long run, it is the public who will determine our nation's policies with respect to endangered species; by informing their visitors about endangered plants and the reasons why they are endangered (overwhelmingly because of disturbance by man), gardens will be serving the cause of conservation.

The Problems and the Challenges

But what are the problems both gardens will face in holding collections of endangered plants? The biggest problem will be to select and maintain in perpetuity the widest possible degree of genetic variability of each species. We will be attempting to preserve their genetic integrity for an indefinite period of time, so that the plants growing in our collections twenty, fifty, or a hundred years hence will be essentially the same genetically as the plants in the wild.

In practice, this may not be totally possible to do. In the first place, any sample of seeds collected from the wild, even with the most judicious sampling, will not contain all of the genetic variability inherent in a species throughout its entire range. However, we should be able to capture a very high proportion of the variability since it has been shown (Primack, 1980) that even small populations of rare plants contain a great deal of genetic variability.

It is after the seeds have been collected that the real problems arise. We must then germinate 100 percent of the seeds so that none of the genetic variability is lost; otherwise, we will select for those seedlings that can survive under our cultural conditions, which may be quite different from those in the wild.

Realizing that some loss is likely to occur, CPC has wisely arranged to have a large portion of the collected seeds stored in a seed bank under cold, dry conditions, which will maintain the viability of most seeds for long periods of time.

Siting the New Species

Once the plants are grown to proper size, they will be placed in the collections. Exactly where they are placed will be a matter for some consideration. They should, of course, be planted where they will have the best chance of surviving and, if possible, where they will be available to visitors. However, there are other factors to consider. To reduce the chance of hybridization, endangered plants ideally should be located far from other species that might hybridize with them. Because there may be similar (or, in fact, identical) species already present in the garden's collection, hybridization may occur, meaning that seedlings growing near the endangered species could be very different from the parent plants.

With woody species, the focus of the Arnold Arboretum's collections, it should be possible to collect any seedlings that persist so as to maintain the genetic integrity of the collection. With the herbaceous species that make up the bulk of the collection at the Garden in the Woods, the process of collecting seedlings will be similar, but much greater vigilance will be required of us because the seedlings will become mature plants quickly and may then be indistinguishable in morphology from their parents.

One way around this problem would be to remove the flowers before seeds are set, but the seeds are a valuable source of research material, and we would like to avoid the laborious maintenance task of removing flowers. Another possiblity would be to maintain only material of a species from a single wild source. This might mean having to remove plants if the same species, already present in the Garden in the Woods, were not as well documented as the new CPC material.

The Tennessee Coneflower

Surprisingly, some endangered species are proving easy to cultivate. *Echinacea tennesseensis,* the Tennessee coneflower, has proven very successful under cultivation. In the wild, it grows over limestone, in openings in the cedar glades of Tennessee, where the soil is too thin to support trees. In the wild, it is a low plant, but in rich soil at the Garden in the Woods it becomes much more robust.

Other species may not be so easy to cultivate, particularly the native terrestrial orchids and plants that are semiparasitic or sapro-

Echinacea tennesseensis *(Beadle) Small, the Tennessee purple coneflower, a species that has been formally listed as endangered by the Fish and Wildlife Service, under the terms of the Endangered Species Act. It is endemic to Tennessee. Photograph by Robert K. Gardner of the North Carolina Botanical Garden. Courtesy of the Center for Plant Conservation.*

phytic. Furthermore, because they would have to be maintained and continually repropagated for the Garden's collection, annual and biennial species probably can be conserved best in seed banks.

Information Applicable to *In Situ* Preservation

One aspect of the cultivation of endangered species in botanic gardens that is valuable to wildlife managers is the information generated by the successful propagation and cultivation of a species. If we are able to raise an endangered plant in the controlled environment of a botanic garden, questions arise for the botanist monitoring the same species in decline in the wild. Is the decline of the species due solely to destruction of its habitat, or has the habitat been changed, allowing stronger competitors to get a foothold? Perhaps the pollination and dispersal mechanisms are not successful, or the conditions necessary for the establishment of seedlings are no longer present. It is very possible that we may raise more questions for biologists than we answer.

But we can also provide valuable information on species biology. For instance, *Helonias bullata*, the swamp pink, is an attractive member of the lily family that grows in open, wet places, primarily in the eastern United States. In May, it sends up a flower spike that resembles a pink drumstick on a two-foot stalk. Plants grow slowly into large clumps. Plants of *Helonias bullata* at the Garden in the Woods set copious amounts of seeds. Research has taught us that germination drops off sharply if the seeds are allowed to dry out after they have been collected, although some of them may germinate as many as nine months after collection. It has also taught us that the seeds should not be covered with the germination medium after sowing and that the best germination was achieved by placing each flat of freshly sown seeds in a tray of water. Seedlings appear approximately three weeks after sowing and resent any disturbance until they have attained a reasonable size. The plants need three to five growing seasons to mature, and some may not bloom for several years more.

This information could give valuable clues to a wildlife biologist who is following *Helonias bullata*. If a wild population declines, perhaps it is because water levels have been changed so that seedlings receive too little or too much moisture. Perhaps other disturbances make it difficult for seedlings to develop. Furthermore, because we know that plants need a relatively long period of time to mature, this information may hold implications for a population of only one or two blooming plants and a few seedlings.

Thus, by working with an endangered plant in a botanic garden we can help biologists manage wild populations. Furthermore, we have developed the techniques to propagate a particular genotype for return to the wild should that be deemed advisable, and have built up a reserve collection in case of catastrophe.

This year we will be collecting seeds for the CPC collection from various species throughout New England. We hope that the resulting new plants will become permanent additions to the Garden in the Woods and that we will be able to admire them and to learn more about endangered species in general.

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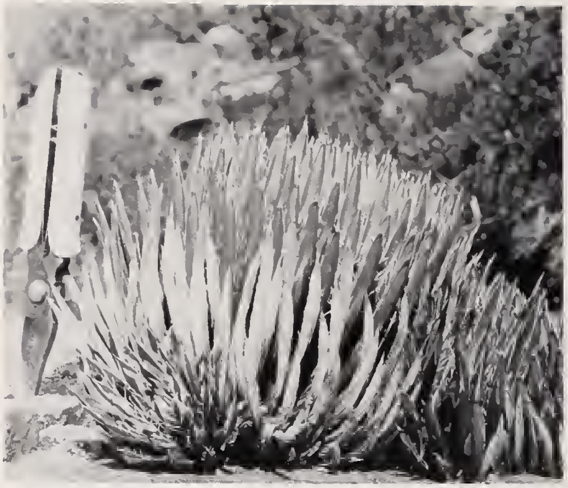


At the Edge of Extinction: Useful Plants of the Border States of the United States and Mexico

Gary Paul Nabhan
Ruth Greenhouse
Wendy Hodgson

One in ten of five hundred wild relatives of New World crop plants are threatened or endangered in the border region of the United States and Mexico, yet little is being done to protect them

Most people who care about and study plants could easily cite reasons why endangered plants should be protected, reasons having little or nothing to do with potential gains from the plants's products (ornamental flowers, gums, resins, and so on) or from their ecological functions (the prevention of soil erosion, fixation of atmospheric nitrogen, and provision of habitat for wildlife, for example.) Such considerations are far less important than the intrinsic right of a species to exist (Callicott, 1986); in fact, laws dealing with endangered species usually exclude the use of economic or aesthetic criteria for determining whether a rare or threatened plant deserves legal protection.

Nevertheless, many lay people would like to know how currently endangered plants were used in the past and how they might be used in the future. Conservationists often hint at such uses when they argue that taxpayers ought to subsidize the protection of endangered species (Myers, 1983; Farnsworth and Soejarto, 1985). Unfortunately, their arguments have very often been far-fetched appeals that do not match the actual economic potential of endangered species.

One platitude offered by the mass media holds that a given endangered species may yield the hidden cure for cancer or other dread diseases. If we should lose that species, they argue, we may unwittingly lose a miracle drug it is "programmed" to produce. This argument assumes that (1) medical researchers seek a single panacea that could cure all kinds of cancer and (2), of the thousands of species already screened by pharmacologists and the hundreds of thousands of common species that remain, none are more likely than a species bordering on extinction is to yield the miracle drug. In short, the proponents of plant conservation have been vague and at times misleading in their responses to questions about the impor-

Opposite*: Four agaves native to the Borderlands region of the United States and Mexico. They are among the eighty or more wild relatives of crop plants from the Borderlands region that already have been or may yet be officially listed for protection under the Endangered Species Act because they are considered to be rare, vulnerable, or actually threatened.*

Agave parviflora *Torr. (top left) is in Category 2 (*i.e., *is under study for possible listing), while both* Agave mckelveyana *Gentry (top right) and* Agave utahensis *var.* kaibabensis *(McKelv.) Breit. (bottom left) are in Category 3C (*i.e., *are currently not subject to threat).* Agave cf. havardiana *Trel. (bottom right) has not been listed by the Fish and Wildlife Service.*

*The photographs were taken in Arizona and Texas by Susan Delano McKelvey of the Arnold Arboretum during the 1920s and 1930s as follows:—*Agave parviflora*: Sierra Parajito, Arizona, 1930;* Agave mckelveyana*: Sierra Ancha, Arizona, 1929 (the type locality of the species);* Agave utahensis *var.* kaibabensis*: Kaibab National Forest, Arizona, 1934 (the type locality of the species); and* Agave cf. havardiana*: Miller's Ranch, near Limpia Creek, Jeff Davis County, Texas, 1931. Photographs from the Archives of the Arnold Arboretum.*

tance of endangered plants to human beings.

Fortunately, there are meaningful responses to such questions. Before their habitats came under attack, a number of endangered species provided American Indian peoples with food, fiber, medicine, or ceremonial materials; some still are important in Indian (or "Native American") cultures. Species (or other taxa) needed for healing and ceremony may continue to be available under the legal sanction of the Indian Freedom of Religion Act. Plant breeders are now using an additional set of wild species, some endangered, others closely related but more abundant, as donors of genes to species of crop plants in the same respective genera. While the improvement of crop plants through the use of "wild" genes usually proceeds slowly, by a series of small increments rather than in large steps, the improvements gained do increase the resistance of modern crops to pests, diseases, and stress and also enhance the nutritive value of the crops (Prescott–Allen and Prescott–Allen, 1983). The following discussion therefore offers examples of rare or threatened plants that (1) have a long history of use by people and/or (2) are being considered by plant breeders as potential sources of genes for crop improvement. The discussion focusses on species that are native to the "Borderlands"—the border states of California, Arizona, New Mexico, and Texas in the United States and Baja California Norte, Sonora, Chihuahua, Nuevo León, Coahuila, and Tamaulipas in Mexico, which have a common history of land and plant use.

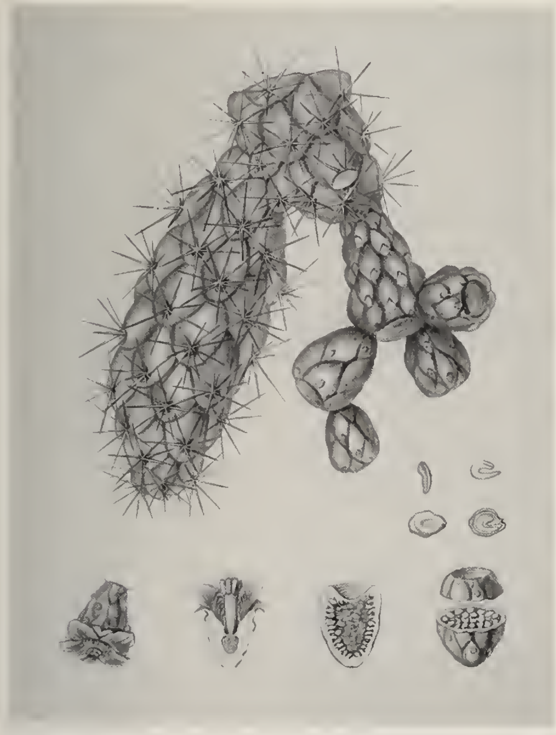
Ethnobotanical Uses

To determine whether any of the rare or endangered plants in the border states ever contributed to the well-being of the human inhabitants of those states, we consulted several compendia of ethnobotanical data, including Altschul (1973), Burlage (1968), Clarke (1977), Hodgson (1982), and Yankovsky (1936). We also drew upon detailed botanical ethnographies of Native cultures of this desertic and mountainous region. Among the cultures described were those of the Apache (Gallagher, 1977), Cahuilla (Bean and Saubel, 1972), and Seri (Felger and Moser, 1985). The results, summarized in Table 1, indicate that over forty rare, threatened, or endangered species were historically used directly for food, clothing, medicine, or other purposes. These forty-odd species belong to twenty-seven genera, which are indicated by ○s in Table 1. A further one hundred twenty-seven genera that contain species at risk (indicated by +s) were also used. Thus, one hundred fifty-four genera of plants used by Native Americans in either prehistoric or historic times contain species that now are at risk in the ten border states of the United States and Mexico. No fewer than one hundred fifteen genera were used directly as medicines or indirectly in ceremonies for healing, fertility, or protection.

What is the significance of such numbers? They suggest that a staggering diversity of plants now facing extinction belong to genera that played major roles in feeding and healing early Americans. Because few early ethnographic sources reliably identified plants to the level of species, it is difficult to be sure that particular species now threatened or endangered were routinely used in historic times. Because of this uncertainty, we have had to present and analyze data at the level of genus. Nonetheless, when we find that most species in a genus such as *Arctostaphylos*, *Opuntia*, or *Rubus* were used for food, we can confidently assume that the rare species in those genera were also comestible and probably were eaten whenever they were encountered.

Did such use endanger these plants? Of the twenty-eight genera for which we know that particular species now at risk definitely were utilized, a few such as *Agave*, *Echinocactus*, *Calochortus*, *Dudleya*, and *Triteleiopsis*, could have suffered if they had been used intensively. Others, such as plants that bear berries, grains, or achenes, probably were not dramatically affected by harvesting itself. On the contrary, in the overwhelming majority of cases, recent destruction or degradation of habitat has more severely threatened these plants than did localized overharvesting in historic times.

In several instances Native Americans have protected or favored rare species in habitats that were modified by man. For example, *Helianthus anomalus*, a wild sunflower, is protected in Hopi Indian sand-dune fields, where its flowers are harvested for ceremonial purposes (Nabhan and Reichhardt,



Opuntia fulgida *Engelm., the jumping cholla, a cactus common in the Sonoran Desert and a potential crop plant for arid lands. In coastal Sonora, Mexico, the Seri Indians harvest fruit from specific stands and individual plants of* Opuntia fulgida *that consistently bear fruit several times larger than usual. Fruit size appears to be genetically controlled. Drawing by C. E. Faxon.*

C. E. Faxon's drawing of Triteleiopsis palmeri *(S. Wats.) Hoover, the blue sand lily of Mexico and extreme southwestern Arizona. At one time this species was in Category 1 but later was placed in Category 3C as more information became available. Though common in Baja California, it is not common in Arizona, where it receives protection under the terms of the Arizona Native Plant Law (because it is a member of the Liliaceae). Native peoples of the Borderlands area use it for food. First published, in* Garden and Forest *magazine, in 1889 (the year the species was described), this drawing is from the Archives of the Arnold Arboretum.*

Table 1 Native American Uses of Genera Containing Plant Species At Risk in the U.S./Mexico Borderlands

o: Evidence exists that Native Americans of the Borderlands have used one or more threatened or endangered species in the genus for the indicated purpose.

+: Evidence exists that Native Americans of the Borderlands have used one or more species in the genus for the indicated purpose, but none that they used any of the threatened or endangered species belonging to the genus that occur there.

Genus	Common Name of Genus	Tannin, Glues, Dyes, Paints	Wood, Construction, or Tools	Cosmetic or Soap	Medicine or Ceremonial Healing	Clothing or Adornment	Food or Beverage
Abronia Juss.	Sand verbena			+			
Acacia Mill.	Acacia	+		+		+	+
Acer L.	Maple, ash	+		+	+	+	+
Agave L.	Century plant	o	o	+	o	+	
Allium L.	Onion	+		+			
Ambrosia L.	Bursage			+			
Amoreuxia Moç. & Sessé	Yellowshow	+	+				
Amorpha L.	False indigo			+			+
Andrachne L.	Maidenbush			+			
Anemone L.	Anemone			+			
Aquilegia L.	Columbine	o		+			
Arctostaphylos Adans.	Manzanita	o		o		+	
Arenaria L.	Sandwort			+			
Argemone L.	Prickle poppy			+			
Asclepias L.	Milkweed	+	+	+	+		
Aster L.	Aster	+		+	+		
Astragalus L.	Milkvetch	+					
Atriplex L.	Saltbush	+		+	+	+	
Baccharis L.	Desert broom			+	+	+	
Boerhavia L.	Spiderling	+					
Bouteloua Lag.	Grama	+					
Brickellia Rafin.	Brickellbush			+	+		
Brodiaea Sm.	Blue dicks	+					
Caesalpinia L.	Bird of paradise	+		+			
Calliandra Benth.	Fairyduster			+			
Calochortus Pursh	Mariposa lily	+					
Camissonia Link	Evening primrose	+			+		
Cardamine L.	Bittercress			+			
Cardiospermum L.	Balloonvine		+				
Carex L.	Sedge			+			
Cassia L.	Senna	+		+			+
Castilleja Mutis	Paintbrush			+			+
Caulanthus S. Wats.	Squaw cabbage	+					
Ceanothus L.	Wild lilac			+			
Celtis L.	Hackberry	+				+	
Cereus Mill.	Night-blooming cereus	o		o	o		
Chrysothamnus Nutt.	Rabbitbrush			+			
Cirsium Mill.	Thistle	+		+			
Citharexylum Mill.	Mission fiddleweed	o		+			
Colubrina L. Rich. ex Brongn.	Snakewood	+			+	+	+
Condalia Cav.	Graythorn	+		+	+		

Genus	Common Name of Genus	Tannin, Glues, Dyes, Paints	Wood, Construction, or Tools	Cosmetic or Soap	Medicine or Ceremonial Healing	Clothing or Adornment	Food or Beverage
Conyza Less.	Horseweed			+			
Cowania D. Don.	Cliffrose					+	+
Crataegus L.	Hawthorn	o				+	
Croton L.	Croton			+		+	+
Cryptantha Lehm.	Hidden flower			+			
Cucurbita L.	Gourd	+		+	o	o	
Cymopterus Rafin.	Corkwing	+					
Cyperus L.	Flatsedge	+					
Dalea L. ex Juss.	Prairie clover	+		+			
Desmodium Desv.	Tick-trefoil			+			
Draba L.	Draba			+			
Dudleya Britton & Rose	Live-forever	o		+			
Echinocactus Link & Otto	Barrel cactus	o		+			
Echinocereus Engelm.	Hedgehog	o		o			
Eleocharis R. Br.	Water chestnut	+					
Epilobium L.	Fireweed	+		+			
Erigeron L.	Fleabane			+			
Eriogonum Michx.	Buckwheat	+		+		+	
Errazurizia Phil.	Errazurizia		+				
Eryngium L.	Rattlesnake master			+			
Eysenhardtia Kunth	Kidneywood					o	
Ferocactus Britton & Rose	Barrel cactus	o		+			
Frankenia L.	Frankenia			+			
Gaillardia Foug.	Blanket flower			+			
Galium L.	Bedstraw	+					
Gaura L.	Gaura			+			
Gilia Ruiz & Pavón	Gilia			+			
Gossypium L.	Cotton	+	+	+			
Grindelia Willd.	Gumweed			+			
Hedeoma Pers.	Oregano	o		o			
Helianthus L.	Sunflower	+		+			+
Hibiscus L.	Rose mallow	+		+			
Hoffmanseggia Cav.	Hog potato	+					
Hymenoxys Cass.	Bitterweed			+			+
Ipomoea L.	Morning-glory	+		+			
Iresine P. Br.	Bloodleaf			+			
Juglans L.	Walnut	o				o	o
Justicia L.	Hummingbirdbush	+		+			
Kallstroemia Scop.	Caltrop			+			
Lechea Kalm ex L.	Pinweed			+			
Lepidium L.	Peppergrass	+					

Genus	Common Name of Genus	Tannin, Glues, Dyes, Paints	Wood, Construction, or Tools	Cosmetic or Soap	Medicine or Ceremonial Healing	Clothing or Adornment	Food or Beverage
Lesquerella S. Wats.	Bladderpod	+		+			
Lobelia L.	Lobelia			+			
Lomatium Rafin.	Cow-parsnip	+		+			
Lonicera L.	Honeysuckle	+		+			
Lycium L.	Wolfberry	+	+				
Machaeranthera Nees	Spiny-aster			+			
Magnolia L.	Magnolia			+			
Mahonia Nutt.	Mountain grape	o					o
Mammillaria Haw.	Fishhook cactus	o					
Manihot Mill.	Cassava	+		+	+		
Matelea Aubl.	Matelea	+					
Mentzelia L.	Stickleaf	+		+			
Mimosa L.	Mimosa	+		+		+	+
Mimulus L.	Monkeyflower	+		+			
Monardella Benth.	Monardella	o					
Muhlenbergia Schreb.	Muhly	+					
Nolina Michx.	Beargrass	+	+				
Notholaena R. Br.	Cloakfern			+			
Oenothera L.	Evening primrose			+	+		
Opuntia Mill.	Prickly pear, cholla	o		+			
Osmorhiza Rafin.	Sweetroot			+			
Ostrya Scop.	Hop hornbeam			+		+	
Panicum L.	Panicgrass	o					
Pectis L.	Chinchweed	+		+			
Penstemon Mitch.	Beardtongue	+		+			
Perideridia Rchb.	Squaw root	o		o			
Phacelia Juss.	Phacelia			+			
Phaseolus L.	Bean	+		+			+
Pholisma Nutt. ex Hook.	Sandfood	o					
Phyllanthus L.	Leaf-flower			+			
Pinus L.	Pine	+	+	+	+	+	+
Polygala L.	Milkwort			+			
Polygonum L.	Smartweed	+		+			
Porophyllum Guett.	Poreleaf	+		+		+	
Proboscidea Schmidel	Devil's claw	+	+	+	+	+	
Prunus L.	Plum, cherry	+		+			+
Psoralea L.	Scurfpea	o		+			+
Quercus L.	Oak	+		+		+	+
Rhus L.	Sumac	o		+		+	+
Ribes L.	Gooseberry	+		+			
Rorippa Scop.	Watercress	+					

Genus	Common Name of Genus	Tannin, Glues, Dyes, Paints	Wood, Construction, or Tools	Cosmetic or Soap	Medicine or Ceremonial Healing	Clothing or Adornment	Food or Beverage
Rosa L.	Rose	o		+			
Rubus L.	Blackberry	+		+			
Rumex L.	Dock	+		+			
Sabal Adans.	Palmetto	+	+			+	
Salix L.	Willow			+	+	+	
Salvia L.	Sage, chia	+		+	+		
Scutellaria L.	Skullcap			+			
Sedum L.	Stonecrop			+			
Selaginella Beauv.	Resurrection plant	+		+			
Senecio L.	Groundsel			+			
Silene L.	Catchfly	+		+	+		
Solanum L.	Nightshade, potato	+		+			+
Sphaeralcea St.-Hil.	Globe mallow			+			
Spigelia L.	Pinkroot			+			
Stephanomeria Nutt.	Wire lettuce					+	
Styrax L.	Snowbell			+			
Symphoricarpos Duh.	Snowberry	+		+			
Talinum Adans.	Flameflower	+		+			
Taxodium L. Rich.	Bald cypress			o			
Thalictrum L.	Meadowrue	+		+			
Thelypodium Endl.	Thelypody			+			
Trifolium L.	Clover	+		+			
Triteleiopsis Hoover	Blue sand lily	o					
Vaccinium L.	Blueberry	o		+		+	
Valeriana L.	Valerian	+		+			
Valerianella Mill.	Little valerian	+					
Verbena L.	Verbena			+			
Viguiera HBK	Goldeneye			+			
Yucca L.	Yucca	+	+	+	+	+	
Zanthoxylum L.	Tickletongue			+			
Zizania Gron. ex L.	Wild rice	+					

1983). In a recent excellent study by Housley (1975, and *in press*), *Opuntia imbricata* and the rare *Opuntia whipplei* var. *viridiflora* were shown to be highly associated with Pueblo Indian habitation sites in northern New Mexico. Similarly, *Agave murpheyi* in Arizona and Sonora is found almost exclusively around prehistoric ruins or contemporary O'odham Indian villages. Either by tolerating or directly propagating these species, Native Americans have conserved the plants's gene pools.

Potential Uses as Genetic Resources

In addition to their long history of direct use for food and other purposes, many plants of the Borderlands are now considered to be useful indirectly, as potential genetic resources. Some genera that contain crop-plant species also contain cross-compatible wild taxa that are capable of "donating" their genes through conventional breeding or new, biotechnological, methods. The wild taxa are said to be part of the same "gene pool" as the crop-plant species. Geneticists are now using the wild taxa on an unprecedented scale.

Roughly five hundred wild species of plants in twenty-eight genera native to the border states of the United States and Mexico are "crop relatives" (Nabhan, 1986). Not all of the five hundred will eventually be found able to exchange genes with crops by currently available techniques, but about 5 percent already have been artificially crossed with their closest domesticated kin. In some cases the results have already proven to have been worth the effort and cost. Sunflowers, strawberries, chile peppers, cotton, and cherries have already benefitted from controlled interbreeding with related species from the wilds of the Borderlands. Genes for disease

Richard Pentewa, a Hopi farmer, and Karen L. Reichhardt, a botanist with Native Seeds/SEARCH, pose in a field of Helianthus anomalus *Blake. This rare wild sunflower is protected in Hopi fields and is used ceremonially. Photograph by Gary Paul Nabhan.*

Table 2 Wild Relatives of Crop Plants At Risk in the Borderlands of the United States and Mexico

Genus	Name(s) of Crop(s)	Number of Species: At Risk	Number of Species: Proposed or Listed as Threatened or Endangered	Already Used in Breeding?
Agave L.	Sisal, tequila, henequen, pulque	17	4	Yes
Crataegus L.	Hawthorn	3	2	Not known
Gossypium L.	Cotton	1	–	Not known
Helianthus L.	Sunflower, sunchoke	11	4	Yes
Iva L.	Sumpweed	1	–	No
Macroptilium (Benth.) Urb.	Siratro	1	–	No
Manihot Mill.	Cassava	2	1	Not known
Opuntia Mill.	Prickly pear	10	9	No
Panicum L.	Sonoran millet	1	–	No
Phaseolus L.	Bean, lima, tepary	3	–	Yes
Proboscidea Schmidel	Devil's claw	2	–	No
Prunus L.	Cherry, plum	2	–	Yes
Ribes L.	Currant	7	1	Not known
Rubus L.	Blackberry	4	1	Not known
Salvia L.	Chia, sage	8	3	No
Solanum L.	Potato	5	1	Yes
Vaccinium L.	Blueberry, cranberry	2	–	Yes
Zizania Gron. ex L.	Wild rice	1	1	No

resistance, pest deterrence, drought tolerance, salt exclusion, nutritive quality, and cold hardiness have been found in the relatives of other crops, among them beans, cassava, sisal, grains, potatoes, and blueberries. Though not obvious in grocery stores, wild genes nevertheless are there—within produce. More genes are sure to follow.

The Southwest is, perhaps, the richest source of crop relatives in the United States. Northern Mexico, because of its vegetational history, is even richer. Yet more than eighty taxa of crop relatives in this binational region are at risk (Table 2) because of both their natural rarity and direct threats from human beings and their livestock. By conservative estimate, 10 to 15 percent of the wild congeners of crops in the border states of the two countries should eventually be put on official lists of threatened and endangered species.

The habitats of these plants are being destroyed through conversion to agriculture and through the development of water resources by dams and the pumping of groundwater. Ironically, the agriculture being made possible through the destruction of habitat someday may need the traits for hardiness borne in genes of the wild plants it is displacing.

It is disconcerting to realize that the habitats of the few threatened crop relatives found in parks and nature sanctuaries of the United States are not necessarily being managed so as to favor the threatened species. Many of these species are "disturbance-adapted" and, therefore, components of pioneer ecosystems. The suppression of fire, prevention of floods, and abandonment of small-scale Native agriculture actually cause populations of these plants to wane.

At present, few threatened crop relatives or ethnobotanical resource plants are cultivated by botanical gardens or seed banks. Fortunately, however, through the leadership shown by the Center for Plant Conservation, Native Seeds/SEARCH, North American Fruit Explorers, and individual botanical gardens, efforts to cultivate them are now on the upswing (Office of Technology Assessment, 1986). The historic neglect of the most valuable of our threatened and endangered plants is being corrected. We hope that these potentially useful organisms—whether they reach the kitchen table or not—will be growing many generations from now.

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Renaissance at Walden

Mary P. Sherwood

Valiant efforts at revegetation are restoring some of the lost charm and serenity of this renowned literary and historic site

The ongoing rehabilitation of Walden Pond has been a story of delay and frustration, progress and setback, caused by a superabundance of people, a near-total lack of money, and frequent misapplication of what little money there was. It has been a story, also, of coping with a habitat too harsh for most plants to get established in on their own, as well as with severe restrictions on the plants that would be appropriate for rehabilitating an historic natural site like Walden. In years long past—when people did not visit Walden in the huge numbers they now do (up to 17,000 on a single warm summer day)—the woods surrounding Walden had been able to grow spontaneously after having been cut for lumber or fuel during the last century. Even the site of a large, turn-of-the-century amusement park at the western end of the pond grew up to woods after the park was abandoned. Now, however, people visit Walden in such overwhelming numbers, trampling vegetation and disturbing the soil on the banks of the pond, that neither pioneer species of plants nor tree seedlings can get established on their own, but must have protection. Under the present conditions at Walden, revegetation requires persistent care and protection of plants that otherwise would succumb to the harsh environmental conditions or else be trampled by the throngs of visitors. The present urgent need for rehabilitation at Walden can be traced back three decades.

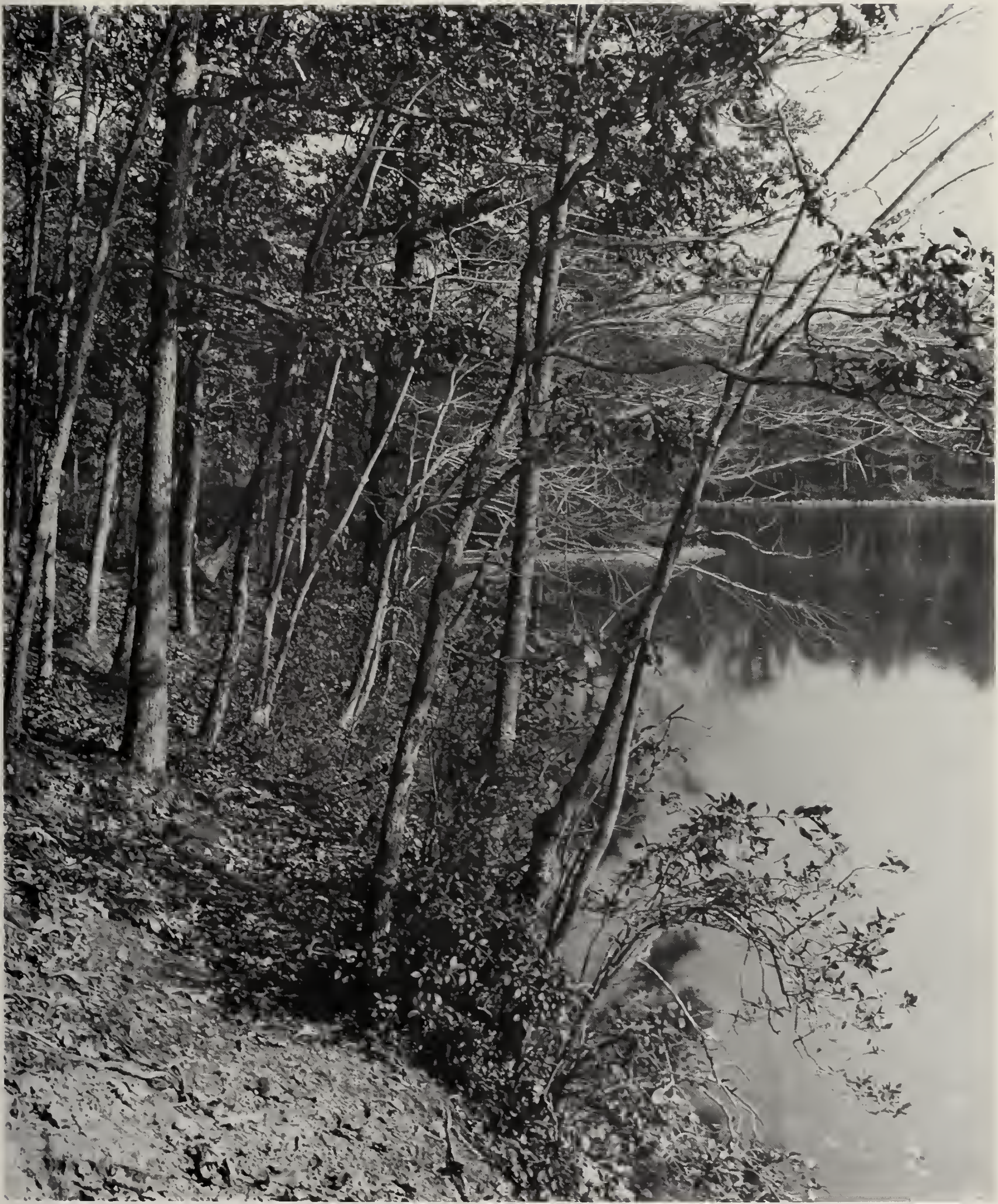
Visitors stroll along the northern shore of Walden. Photographed by Albert W. Bussewitz in October 1975. Courtesy of the photographer.

The Great Assault on Walden

In the summer of 1957, responding to a request by the local chapter of the American Red Cross, the commissioners of Middlesex County, Massachusetts, brought a bulldozer and power saws onto the Walden Pond Reservation to enlarge an existing small "beach," or swimming area. About one hundred trees were cut on the steep slope just above the beach, and the slope itself was gouged out with the bulldozer, which pushed some of the soil from the slope into the pond so as to enlarge the shallow-swimming area, and some of it to the southern, lower edge of the slope, in order to create a road for busses and ambulances. The Red Cross seems to have had something considerably more modest than this in mind when it communicated its request to the commissioners—namely, a truckload or two of sand to extend its swim-class beach.

Learning of the drastic alterations at Walden, the Thoreau Society, an international association of students and admirers of author Henry D. Thoreau, who had lived close to the shore of Walden in the 1840s, obtained an injunction to halt use of the saws and the bulldozer and then took the county commissioners to court. Three years later, on May 3, 1960, the state supreme court ruled that no more trees were to be cut, that no road was to be developed, that the soil removed from the slope had to be returned to its original location, and that trees must be planted to replace those that had been cut. The entire damaged area was to be returned to the "natural forest conditions of Emerson and Thoreau's day." (Descendants of Ralph Waldo Emerson had deeded Walden to the state of Massachusetts in 1922 with the stipulation that it be preserved as Emerson and Thoreau had known it. Middlesex County

View of the top of the denuded slope, looking westward. Nearly two hundred full-grown oaks and pines were cut down and tons of humus and topsoil pushed into the pond in a matter of two days. Photographed on August 11, 1957, by Roland Wells Robbins.



View toward the northeast along the western shore of Walden Pond, looking towards Thoreau's Cove, November 7, 1899. Photograph by Herbert Wendell Gleason. Courtesy of H. C. Conover and N. Mills.

assumed management of the new reservation.) The County claimed that it had no money to carry out the court-ordered repairs. For the next twenty-two years, the damaged slope remained barren and exposed. Gullies developed and grew deeper by the year. In the meantime, people began visiting the reservation in far greater numbers than they had previously, compounding the damage.

Replanting the Damaged Slope

In 1979, I asked the state of Massachusetts, which in 1975 had taken over management of the Reservation from the County, for permission to repair the great bare gash above the beach. The state granted permission and, in the early spring of 1980, I began replanting the damaged slope with the help of four young people.

The slope, including the so-called "ambulance road," faces due south and is therefore fully exposed to the sun on clear summer days. It also bears the brunt of the prevailing westerly wind, which swoops down the full length of the pond and funnels up the open slope. The lack of vegetative cover, such as trees and shrubs, which would shield the slope from the force of the wind, and which would provide shade, results in stressful conditions comparable to those of a desert. Planting in such an environment would require careful planning, a fussy technique, and persistence—even to the point of con-

View of the same section of the western shore of Walden Pond, showing a footpath as it appeared in the late 1940s. Photograph by Roland Wells Robbins. Courtesy of the photographer.

The swimming beach at Walden. Photographed on May 30, 1903, by Herbert Wendell Gleason.

The swimming beach as it looked in 1948. This photograph, taken on July 11, 1948, by Roland Wells Robbins, shows the beach from the south, while Gleason's view shows it from the west. The slope in the background was denuded of trees and bulldozed in 1957 to enlarge the beach.

View of the swimming beach at Walden, looking north toward the denuded slope. Photographed on August 11, 1957, by Roland Wells Robbins.

tinual replanting. When we started work on the slope, only a few weeds, such as a wild mustard, a few species of grass, and some silvery cinquefoil (*Potentilla argentea*), grew there. Some staghorn sumacs (*Rhus typhina*) grew in one corner of the slope and, at the other end, a white pine (*Pinus strobus*) or two. In both areas, a horticultural variety of juniper had been planted five years before and, near the white pines, a cultivar of arbor vitae (*Thuja occidentalis*).

The task would be complicated further because, under the terms of the court order, I could plant only trees or shrubs that had made up the "natural forest conditions of Emerson and Thoreau's day." This requirement limited the species I could use in replanting. I could, however, use annuals and weedy ground covers, whether native or alien, because they would die out once the trees formed a forest and cast too much shade for them.

Adding significantly to the stresses that the plants would have to endure were the hundreds of thousands of people who were visiting the Reservation each year. Children on bicycles, horseback riders, visitors taking shortcuts from and to the nearby state highway, and sunbathers on blankets all prevented even weeds from gaining a toehold on the slope.

The plants I used, therefore, would not impress the sophisticated horticulturist. I selected them for their ability to withstand harsh conditions and abuse, and for their historical appropriateness when possible. Nor were the techniques I used sophisticated. The first major "technique," or goal, was to try to hold the soil in place with whatever species could grow in it. Trees and grasses proved best for this.

Holding the Soil in Place

Between the top of the damaged slope and a higher, undamaged slope that extends to the

The footpath along the north shore of Walden Pond. It leads from the swimming area to the site of Thoreau's hut (1845–1847). Photographed in 1948 by Roland Wells Robbins.

Gladys B. Hosmer of the Thoreau Society and Alvin G. Whitney, a forester from New York State, surveying the same footpath in 1957. Photographed on August 10, 1957, by Roland Wells Robbins.

The same footpath in 1984, showing the continued erosion of the banks. A boardwalk has been constructed in an effort to accommodate the thousands of visitors who use the path every week. Photographed on April 19, 1984, by Roland Wells Robbins.

state highway (Route 126) there is a flat, shady wooded area. The forty- to fifty-year-old trees in this area (mostly red oaks, white pines, and a few hickories and white oaks) had not been cut in 1957. They provided shade and had helped create some woodland soil. Yet by 1980, this area had been so trampled by the ever-increasing crowds of visitors that the ground was completely bare of vegetation. There was not a single tree seedling in the woodland; no understory of young trees was coming along, and no ground-level plants existed at all.

In this shaded area, I dug small, crude beds that I gradually filled with plants of native, shade-demanding species gleaned from other parts of the 400-acre reservation—Canada mayflower (*Maianthemum canadense*), pipsissewa (*Chimaphila umbellata*), early low blueberry (*Vaccinium angustifolium*), partridgeberry (*Mitchella repens*), checkerberry (*Gaultheria procumbens*), and many white pine (*Pinus strobus*) and red oak (*Quercus rubra*) seedlings. I covered the beds lightly with leaves, placing sticks on the leaves to keep them from blowing away. I was delighted that, even before a fence could be put up, people walked around rather than through the small mounds of leaves and sticks, sparing the vulnerable new transplants. By the end of the third year, when I had moved some of these plants onto it, the flat area became green from one end to the other, and the young white pines and red oaks were thriving.

Timber cribbing installed farther along the footpath to arrest erosion of the northern bank of Walden. Photographed on March 20, 1981, by Roland Wells Robbins.

Replanting the bare, damaged slope immediately above the beach has proven to be entirely another matter. In 1980, under the supervision of Roland W. Robbins, the well known archaeologist, much of the original topsoil (which in 1957 had been moved to a turnaround on the "ambulance road") was put back on the slope with a bulldozer and backhoe. But the gullies had first been filled by the bulldozer with the gravel that originally had underlain the topsoil. Thus, more than two decades after the court ruling, the approximate original contours of the slope at Walden were back in place.

Once the contours had been more or less restored, my crew and I quickly planted perennial rye grass (*Lolium perenne*) to prevent the loose soil from eroding. We then covered the newly seeded slope with a layer of hay, over which we spread branches, to hold the hay in place. The next night there was a light shower, and in five days the green of the new grass began to show through the hay.

We then had to wait until the grass took hold before we could tuck in the sun-loving weeds that do best in such an environment. In front of the juniper cultivars and the *Thuja* we planted three- to four-foot-tall white pines. Though the junipers and the *Thuja* were horticultural varieties, I did not want to disturb them because their roots were deeply established, holding the soil in those spots; the pines eventually would shade them out, and the pines's roots would take over. Nor did we disturb a flowering crab at the east

Restoring the contours of the slope during the spring of 1980. Photograph by Roland Wells Robbins.

end of the slope or a clump of flowering cherries at the edge of the ambulance road, all of which had been planted as nursery stock in 1975. They, too, will eventually die out; for the present, their roots serve to hold the soil.

Harsh conditions and trampling were not the only problems with which I had to contend. Sometimes it proved impossible to obtain the healthy nursery stock I needed. At one point, for example, I ordered twenty-five five-foot-tall red oaks that I planned to set out in groups of five in the middle of the slope and along the ambulance road, in order to create patches of shade for the native woodland ground-cover plants I intended to transplant there. What arrived were eight oaks, ten feet tall, which had only a few tufts of leaves remaining at their tops. They had sat unwatered at a nursery for a full month, and, though we immediately set up a bucket brigade to water them daily from the pond, all but three died the first winter—a record-cold and very windy winter. It was a merciless environment for them.

The "Ambulance Road"

Having failed in our attempt to plant the oaks as originally planned, we had to settle for using the same ground species on the ambulance road that we had used on the damaged slope. Again, we planted grass and then transplanted the same pioneer weeds we had used on the slope—red clover (*Trifolium pratense*), common cinquefoil (*Potentilla simplex*), silvery cinquefoil (*P. argentea*),

*The restored slope with a layer of hay, which was spread to protect the just-sown perennial rye grass (*Lolium perenne*). The green of the grass began to show through the hay within a matter of days. Photographed in June 1980 by Roland Wells Robbins.*

creeping lady's sorrel (*Oxalis corniculata*), yarrow (*Achillea millefolium*), oxeye daisy (*Chrysanthemum leucanthemum*), and pussytoes (*Antennaria neglecta*). We even gathered tough clumps of grass from the Reservation's parking lot and spot-planted them over both the upper and lower slopes.

We then moved the transplanted oak and pine seedlings from the beds in the flat, wooded area out onto the slope, planting them among the grasses and the weeds. I realized that, though the slope was loose gravel, their roots would have difficulty reaching the deep water table, or even capillary water. The oaks, with their long taproots, would have a better chance than the shallow-rooted pines. We mulched all of the seedlings with oak leaves and pine needles, which we had stockpiled on the flat. To prevent the mulch from blowing away, we placed small stones on it. Later, when wood chips became available, we added some to the mulch.

Replanting the slope. Deborah G. Lee, a naturalist with Walden Pond State Reservation (left), and J. Walter Brain, president of the Friends of Walden, prepare holes for young pitch pines on the rehabilitated slope in May 1982. Photograph by Lois Clark and Roslyn McNish. Courtesy of the photographers.

The second season, a crew of Reservation workers chopped two dozen white pine trees out of the frozen ground at the far end of the Reservation. These were planted, their roots in balls of ice, in two staggered rows, up the sides of the ambulance road. Most have survived, though during their second growing season gypsy moth caterpillars almost denuded them. They since have recovered and will, in time, provide the shade we had hoped the nursery-grown red oaks would provide. During the first two years, we transplanted many oak and pine seedlings on the ambulance road and on the slope; during the second year we planted countless *Quercus rubra* acorns.

On the beach side of the lower portion of the ambulance road was a cluster of staghorn sumac. We carefully avoided stepping on sprouts from this cluster that had come up in the roadway. The gullied slopes from the ambulance road down to the beach proved very difficult to control because young people persisted in vaulting the fence and clambering up and down the slope. We did succeed in planting a few native junipers (*Juniperus communis*) on the slope, as well as the same weed species and clumps of grass we had put elsewhere. Some spots on these slopes required three plantings because of the damage people caused. One slope beyond the beach area was damaged again, all of the plants on it having slid to the bottom by the time the winter of 1984 set in, children having broken the fence down. Thus, repair of this area must be a continuous process for a while. On the slope across the ambulance road from the stand of sumac there is a colony of sweetfern (*Comptonia peregrina*), a plant that holds the soil in place very well. We hope it will spread, now that people are being kept out of the area, for at last they have accepted the temporary snow fence.

Along much of the upper, eastern, edge of the damaged slope above the beach, there is a stand of gray dogwood (*Cornus racemosa*) shrubs. When the backhoe was being used in 1980 to return the moved gravel to its original position, we had to move some of the shrubs because they were growing in the displaced gravel of the slope. We kept them in a temporary ditch, watering them well until we could gradually transplant them onto the ambulance road.

Across the bottom of the damaged slope, just above the beach, we planted a row of gray birches (*Betula populifolia*) and, behind it, staggered red oaks, our intention being to link the existing woods at either end of the damaged slopes. The birches, favoring open, hot sun, will grow faster than the oaks and will provide shade for the oaks, which when young do not do well in open locations. Being short-lived, the birches will have died out by the time the oaks are ready to stand on their own.

J. Walter Brain transplants a young pitch pine. Photograph by Lois Clark and Roslyn McNish.

Progress and Setback: The Prospect of Success

Over the last six years we have experienced many setbacks in our rehabilitation work at Walden. For example, a large wild grapevine, the riverbank grape (*Vitis riparia*), had grown for many years at the foot of the ambulance road, near the bottom of the damaged slope. While we were working on the slope we kept the grape's runners carefully tucked out of harm's way. When the work there was completed, we spread the runners out onto the road, weighting their root-forming nodes against the soil with stones. By the fall of 1983, the grape was spreading over a wide area. The following year, this encouraging situation changed for the worse.

The level of water in Walden Pond, which is a groundwater lake (it has no inlet or outlet), fluctuates in an approximately thirty-year cycle. In 1984, the water was so high that it covered, to a level of two feet or more, the beach, the row of birches, and the oak seedlings in back of the birches. In response to the high water, the administration opened a path down the ambulance road, rather than asking visitors to use another, existing path to reach the site of Thoreau's cabin. Within a week, everything we had planted on the lower portion of the ambulance road had been ground to dust. Not a single young oak or pine was left standing. The wild-grape runners were crushed dead—proof that people must be kept off wooded slopes in the Reservation. Nature is simply too fragile to endure such pummeling. Fortunately, now that the water has receded, permission has been given to close the path and to replant it in 1986. Vegetation now completely covers the once-gullied slope and the flat area above it.

Every spring, groups such as Friends of Walden, Walden Forever Wild, and, on Arbor Day, scouts and school children, plant a few more trees on the slope. It will take years for the trees to reach maturity, but in time the terrain that the County denuded of trees nearly thirty years ago will be covered with trees, restoring shade, coolness, and beauty to the beach area.

Note

Readers interested in further information about the situation at Walden Pond will find a useful overview and legal analysis in a recently completed study by David E. Rabinowitz, a student in the Harvard Law School. Entitled *The Abuse of a Public Trust: A Case History of Walden Pond*, the 67-page typescript report is available for $10.00 (prepaid) from: Walden Forever Wild, Post Office Box 275, Concord, Massachusetts 01742-0002.

Acknowledgments

Most of the illustrations that accompany this article were made available through the kindness and generosity of several individuals: Heather C. Conover and Nick Mills (the photographs of Herbert Wendell Gleason), Roland Wells Robbins, Lois Clark, Roslyn McNish, and Albert W. Bussewitz (views of Walden Pond and its environs).

Mary P. Sherwood founded the Thoreau Lyceum in Concord, Massachusetts, and Walden Forever Wild, an organization dedicated to rehabilitating and protecting the shore of Walden Pond. For the past several years she has coordinated the revegetation of eroded and denuded areas around the pond.

Walden's most critical problem is overuse, which is manifested in the physical deterioration of all areas adjacent to the pond edge. Most evident is the erosion of the sandy soil and vegetative cover flanking the main pond path. This erosion is due largely to the behavior patterns of Walden's many visitors—random trampling of the shrubs and ground covers which stabilize and protect the soil in which they grow, random creation of footpaths, which results in loss of vegetation, and establishment of destructive stormwater drainage channels.

Efforts to limit the number of visitors have had limited success, and use of the reservation remains at a high level—700,000 users counted in 1983 (this figure is based on cars parked in authorized parking areas and does not include illegally parked cars or walk-in users).

The very noticeable erosion problem is the cause of a less easily perceived problem—the siltation of the pond and, ultimately, its eutrophication. Despite the pond's high water quality and substantial depth, there is reason to be concerned over the increasing rate of material deposition within the pond.

Bank erosion at Walden Pond is not a new problem. For more than two decades there has been concern largely over the integrity of the pond path, and more recently over the loss of plants and soil. Various treatments have been applied, beginning with timber cribwalls, followed by rock embankments, and finally a small section of wood plank boardwalk. These treatments have solely addressed the issues related to path integrity—i.e., public safety—and to that end have served well. However, the most obvious deficiency of past efforts is the lack of concern for aesthetic quality. Their negative impact upon the visual character of the pond environment is striking even to the casual observer. The conglomeration of man-made elements, and the severe erosion problem combine to create a physical reality which is incongruous with the image of Walden the public has held since Thoreau's time.

—From *Walden Pond State Reservation Bank Restoration Project: Report on the Approach and Methodology,* by Stuart Weinreb. Boston: Massachusetts Department of Environmental Management, 1985.

Herbert Wendell Gleason, Photographer

Herbert Wendell Gleason was forty-four years old and living in Minneapolis when poor health forced him to withdraw from the Congregational ministry in 1899. The next thirty-eight years of his long life he devoted to photographing nature. Born in Malden, Massachusetts, on June 5, 1855, he had graduated from Williams College in 1877 and then had attended Union and Andover seminaries.

Gleason began to photograph Walden Pond and the Thoreau country in the fall of 1899, and is best known for that work. About one hundred twenty of his photographs were used to illustrate the twenty-volume "Walden" edition of Thoreau's *Writings*, which Houghton Mifflin and Company published in 1906. Gleason's own photographic record of Thoreau's travels, *Through the Year with Thoreau*, was published in 1917. By 1920, he had assembled well over one thousand negatives of Thoreau country alone.

But Gleason did not limit himself to photographing Thoreau's haunts, or even sites in New England. Drawn strongly to the wilderness, he travelled extensively and arduously, always carrying along with him his bulky camera equipment. A dedicated conservationist, he was appointed an Interior Department inspector by the first director of the National Park Service, Stephen Mather. Gleason's charge was to photograph and observe both the existing national parks and lands that had been proposed for national-park status. Over the years, he would make thirty separate trips to western North America, visiting Alaska, the Pacific Coast, the Grand Canyon, and the Rockies, from Canada to Colorado. Some of the photographs from these trips appeared in *National Geographic* and in John Muir's *Travels in Alaska*. Yet Gleason was always a New Englander at heart.

In his introduction to *Through the Year with Thoreau*, Gleason felt obliged to put his affection for New England into proper perspective. "Lest any should assume that the fondness for New England scenery here avowed is due to lack of acquaintance with other regions more famous for their grandeur," he wrote, "it may be stated that during this same period the writer made two trips to Alaska, six to California and the Pacific Coast, three to the Grand Canyon of Arizona, seven to the Canadian Rockies, two to Yellowstone Park, and three to the Rocky Mountains of Colorado."

His very active professional life included friendship with Luther Burbank, whom he photographed performing his plant-breeding work in California. The friendship with Burbank spurred Gleason's own botanical interests. Gleason knew John Muir well during the last seven years of Muir's life, "camping and tramping with him in his beloved 'Range of Light' [the Sierra Nevada], visiting him in his California home, entertaining him on his occasional visits to Boston, traveling with him by rail, receiving his confidence with regard to some of his most cherished plans, and having many opportunities to catch something of the lofty inspiration which controlled his life."

For several years in the 1920s and 1930s, he was the official photographer for the Arnold Arboretum; several dozen of his glass slides, some of them hand-colored, remain in the Arboretum's Photograph Archives. The largest assemblage of Gleason photographs, however (some six thousand in all), is owned by Heather Conover and Nicholas Mills of Cohasset, Massachusetts, to whom we are indebted for the Gleason photographs appearing in this issue of *Arnoldia*. In the past few years, the Conover–Mills collection has been used to illustrate the new edition of Thoreau's works currently being issued by Princeton University Press (*The Illustrated Walden, The Illustrated Maine Woods,* and *The Illustrated Week on the Concord and Merrimack Rivers,* to date). Gleason's photographs also have appeared in *Thoreau's Cape Cod* (1971) and *The Western Wilderness of North America* (1972), both published by Barre Publishers, and in *Thoreau Country* (1975), published by Sierra Club Books.

Photograph of Walden Pond taken by Herbert Wendell Gleason on April 28, 1906. The pond appears here essentially as it did when John Muir visited it in 1893. Used through the courtesy of Heather C. Conover and Nick Mills.

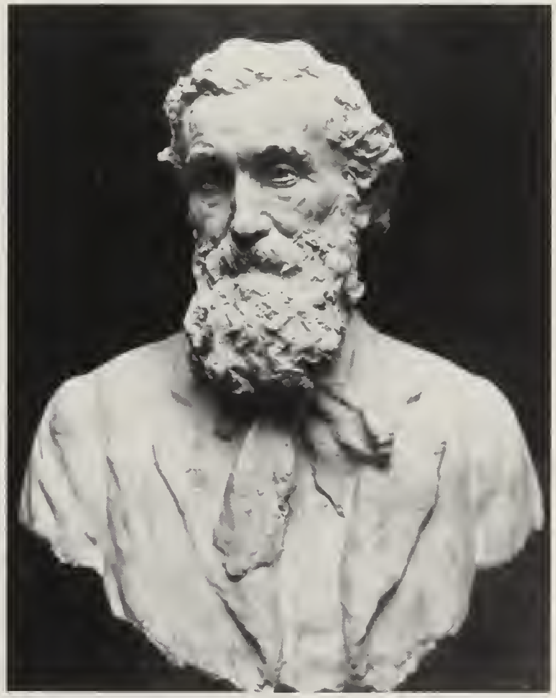
A Visit from John Muir

Toward the end of spring in 1893, the renowned conservationist and nature writer, John Muir (himself a horticulturist at the time), visited the Boston area, primarily to meet in person Charles Sprague Sargent, the first director of the Arnold Arboretum. In a long letter to his wife at their ranch in California, Muir described visits he had just made to both Walden Pond in Concord and "Holm Lea," Sargent's estate, in Brookline. Muir apparently did not visit the Arboretum during the trip but did pay a call on the ailing historian–horticulturist, Francis Parkman (author of *The Oregon Trail)*, who lived nearby, in Jamaica Plain. Excerpts from his letter follow:

> After leaving [Thoreau's and Emerson's graves at Sleepy Hollow Cemetery in Concord], we walked through the woods to Walden Pond. It is a beautiful lake about half a mile long, fairly embosomed like a bright dark eye in wooded hills of smooth moraine gravel and sand, and with a rich undergrowth of huckleberry, willow, and young oak bushes, etc., and grass and flowers in rich variety. No wonder Thoreau lived here two years. I could have enjoyed living here two hundred years or two thousand. . . .
>
> We went back to Boston that night on a late train, though they wanted to keep us [in Concord], and next day went to Professor Sargent's grand place, where we had a perfectly wonderful time for several days. This is the finest mansion and grounds I ever saw. The house is about two hundred feet long with immense verandas trimmed with huge flowers and vines, standing in the midst of fifty acres of lawns, groves, wild woods of pine, hemlock, maple, beech, hickory, etc., and all kinds of underbrush and wild flowers and cultivated flowers—acres of rhododendrons twelve feet high in full bloom, and a pond covered with lilies, etc., all the ground waving, hill and dale, and clad in the full summer dress of the region, trimmed with exquisite taste.
>
> —*The Life and Letters of John Muir*, Volume 2, edited by W. F. Badè. Boston and New York: Houghton Mifflin Company, 1924, pages 268–270.

In another letter, this one to his twelve-year-old elder daughter, he said of Walden that "Beautiful trees & flowers grow there & the water is clear, & all of the banks are shady & leafy."

Muir figures prominently in Stephanne B. Sutton's biography of Sargent, *Charles*



John Muir (1838–1914). Photograph from the Archives of the Arnold Arboretum.

Sprague Sargent and the Arnold Arboretum, published by Harvard University Press in 1970, to commemorate the Arboretum's then approaching centenary. For more than three decades, Muir and Sargent corresponded, collaborated, and travelled together on three continents in pursuit of their common interests and goals in horticulture, botany, and forest conservation.

Asa Gray had introduced them to each other in the late 1870s, although they did not meet in person until 1893. Many delightful letters from their long correspondence (some of the 165 Muir–Sargent letters known to be extant) survive in the Archives of the Arnold Arboretum in Jamaica Plain; other records in the Archives suggest that through Asa Gray Muir may have contributed seeds towards the Arboretum's Living Collections as early as 1872, its very first year of existence; during the summer of that year Gray and Muir had spent many days collecting plants together in the Sierra Nevada and elsewhere in California. Muir visited Boston (and "Holm Lea") again, in 1896 (to receive an honorary degree from Harvard), 1898, and 1903. In 1898, he visited both Horatio Hollis Hunnewell's arboretum in nearby Wellesley and the Arnold Arboretum. The visit of 1903 was the rendezvous for the start of an around-the-world trip Muir was to make with Sargent and Sargent's son, A. Robeson Sargent. The last issue of *Arnoldia* (Spring 1986) contains a brief account of one leg of that trip.

A view of the grounds and mansion at "Holm Lea." "This is the finest mansion and grounds I ever saw," Muir declared. Photograph from the Archives of the Arnold Arboretum.

BOOKS

Wild Gardening: Strategies and Procedures Using Native Plantings, by Richard L. Austin. New York: Simon & Schuster, 1986. $12.95 (paper); $19.85 (cloth).

KERRY S. WALTER

This is a beautiful book to look at, one filled with many spectacular images, most of which were taken by Derek Fell. In spite of its beauty, however, the book falls short of its potential to stimulate the reader to grow wild plants.

Wild Gardening begins with a very brief synopsis of gardening practices, starting with ancient Egypt and Greece, continuing through the Roman Empire, Medieval monastic gardens, Renaissance France, Eighteenth Century Persia, and into Twentieth Century municipal-park design. This whirlwind tour of some 3,500 years of gardening introduces the basic tenet of the book—that formal gardens were a natural outgrowth of humankind's domination of nature, but that a different, and very natural, ethic is evident today, an "alternative to formalism," a change the author ascribes in part to the energy crisis of the early 1970s.

Having set the stage, the author proceeds to discuss the various positive and negative aspects of wild gardening. On the positive side, the author suggests that such gardening requires less of the gardener's time, because less control is exerted over the manmade environment, and it requires less money to implement and maintain. According to the author, the drawbacks to gardening with wild plants are: problems associated with establishing the plants, difficulties in obtaining material, complaints by neighbors, possible citations from community officials for growing "noxious weeds," and governmental regulations under the Endangered Species Act. This last point should be expanded upon: not only is the Endangered Species Act something to be concerned with (ignorance of the law is no excuse for breaking it), but there are many state laws protecting native plants that may or may not be on the Federal Government's list. Unfortunately, Austin neglects to mention state laws or to give the reader any idea of how to become informed of them.

Following the introduction, the book is divided into four chapters and an appendix. Unfortunately, the first chapter, "The Wild-Garden Systems," is weakened by what seems to be an attempt to use only easily understood words and concepts, to the point of creating oversimplified and nonstandard terminology. Thus, Austin partially defines and then continues to use such phrases as the "individual system" and the "population system," which appear to refer to nothing other than autecology and synecology. This makes for awkward wording when he writes about an "individual system" dying because of prolonged cold temperatures, or about "population systems" dying out because of a drying of the environment due to prolonged high temperatures. The drying out is said to "expand" competition!

Happily, the other chapters are more substantial and accurate. In the chapter entitled "Wild-Garden Themes," Austin stresses the importance of planning a theme for any garden, whether it be a traditional formal garden or a wild garden. Wild gardens are classified into three groups: woodland gardens, meadow gardens, and water gardens, and discussions of the natural ingredients and the planting structure for each type follow. He then illustrates with a photograph and range map six forest zones of North America and eight grassland types. While a single photograph cannot do justice to any of these plant zones, the images are well chosen to convey the feeling one gets when visiting different parts of the country. In the unlikely event that a reader were trying to create a type of wild garden he had never seen in person, these photographs would provide him with a sense of the space and mood to strive for. This brings up a recurring complaint I have about the book—although the photographs are beautiful in the main, there is no indication of where they were taken, nor are many of the plants shown in them identified. It would be very useful to know exactly where to go to see some of these spectacular scenes. Incidentally, I find it hard to believe that some of the "garden" shots were not taken in the wild.

The chapter on "Organizing Your Garden" discusses the traditional elements of landscape design—plant color, form, and texture. Useful ideas and photographs are presented that stress the importance of using these elements carefully. A great deal is made of selecting and utilizing functional masses—the trees, shrubs, and herbs used in varying compositions depending upon the type of wild garden being designed.

"Wild-Garden Amenities" discusses how to design gardens to attract wildlife, including birds, insects, mammals, and reptiles. Austin presents brief notes on which plants will likely attract which animals; these seem quite accurate, although the suggestion that poplar, ash, and elm will attract butterflies is debatable. This chapter finishes with discussions of the use of rocks, stones, and tree stumps in the wild garden.

The Appendix is composed of several lists and should have been one of the highlights of the book. Unfortunately, the lists are often inaccurate or incomplete. The first list, "Where to Visit Wild Gardens," is an excellent idea, but two of the best known and finest wildflower gardens in the country—the Garden in the Woods in Framingham, Massachusetts, and the North Carolina Botanical Garden in Chapel Hill—are left out. The list of native plant societies contains fewer than half of the societies that exist. And, the list of suppliers of wild-garden materials misses some important suppliers, especially those specializing in propagated, as opposed to collected, material.

Wild Gardening concludes with a series of tables covering regional wildflower mixes and, finally, an "Individual Wild-Flower Species List." It is encouraging to note that commonly attempted but nearly always ill-fated plants such as the lady's-slipper orchids (*Cypripedium*) are lacking from these lists. But, other plants do show up on the list for unknown reasons—*Achillea filipendula* (from Asia Minor), *A. millefolium* (a Eurasian weed), *Cheiranthus cheiri* (from southern Europe), *Chrysanthemum leucanthemum* (a Eurasian weed), *Dimorphotheca aurantiaca* (from South Africa), *Gypsophila elegans* (from the Ukraine to Iran), *Lobularia maritima* (from southern Europe), *Papaver rhoeas* (naturalized from Eurasia), *Thunbergia alata* (from tropical Africa), etc. The book seems to suffer from an identity crisis—does it deal with native plants or with wildflower gardening? The subtitle, *Strategies and Procedures Using Native Plantings*, indicates the former, but the plants in the lists suggest the latter.

This small book is beautiful to look at—it contains many exceptional photographs which are printed well, and its design is elegant. In spite of its visual appeal, however, I found it lacking in substance.

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Fall 1986

arnoldia

The Magazine of the Arnold Arboretum

Vol. 46 No. 4 Fall 1986

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

Subscriptions are $12.00 per calendar year domestic, $15.00 per calendar year foreign, payable in advance. Single copies are $3.50. *All remittances must be in U.S. dollars, by check drawn on a U.S. bank* or *by international money order.* Send subscription orders, remittances, change-of-address notices, and all other subscription-related communications to: *Arnoldia,* The Arnold Arboretum, Jamaica Plain, MA 02130-2795.

Postmaster: Send address changes to:
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Arnoldia is designed and printed by the Office of the University Publisher, Harvard University.

Front cover: An inflorescence of *Heptacodium jasminoides* Airy Shaw, a rare Chinese shrub being introduced to horticulture in North America this fall by the Arnold Arboretum. This original painting by former staff member Amy Eisenberg shows, not blossoms (which have white corollas), but purplish calyces. The Chinese calligraphy, which says "Zhejiang seven-son flower," was graciously supplied by the artist Wang Wen-Fang of Beijing. Copyright © 1986 by Amy Eisenberg. (See pages 2 and 14.) *Opposite*: Professor Richard Evans Schultes (center) conferring with a Kamsa Indian medicine man (left) in the Valley of Sibundoy, Colombia, as another Indian looks on. For a discussion of the need to preserve plant lore of the Amazon basin, see page 52. Photograph by Richard Evans Schultes. *Inside back cover*: A porter hefts plant specimens and supplies for the 1980 Sino–American Botanical Expedition. Photograph by David E. Boufford. (See page 15.) *Back cover*: *Cypripedium tibeticum* King *ex* Rolfe, part of an extensive colony discovered in the Cang mountain range, Malutang, Yunnan province, China, by the 1984 Sino–American Botanical Expedition. Photograph by David E. Boufford. (See page 15.)

Page

浙江七子花

Seven-Son Flower from Zhejiang: Introducing the Versatile Ornamental Shrub *Heptacodium jasminoides* Airy Shaw

Gary L. Koller

This fall, the Arnold Arboretum will begin distributing seedlings and rooted cuttings of a splendid new shrub from China

In 1916, Alfred Rehder of the Arnold Arboretum described a new genus of shrub in the pages of *Plantae Wilsonianae*, the hefty, three-volume "enumeration of the dried plants collected by Mr. E. H. Wilson during his expeditions to western China in behalf of the Arnold Arboretum." Dubbed *Heptacodium* "in allusion to the seven-flowered heads of the inflorescence" (from the Greek ἑπτά, seven, and κώδεια, a poppyhead), the genus was assigned to the Caprifoliaceae, the family to which *Lonicera* (the honeysuckles) and *Abelia* belong. Translated, the plant's Chinese name means "seven-son flower from Zhejiang."

Wilson collected the plant at Hsing-shan in western Hupeh (Hubei) province, China (Collection Number 2232). He made two collections of it, one in July and the other in October 1907, from cliffs at nine hundred meters (about three thousand feet) above sea level, where it was rare. In examining the herbarium specimens, Rehder found "that only a single ripe fruit was available for examination," which probably explains why no living plants resulted from that expedition. Rehder named the plant *Heptacodium miconioides* because, he wrote, "In its habit and general appearance this plant suggests a member of the family of *Melastom[at]aceae* and on account of the comparatively small flowers in terminal panicles it resembles particularly *Miconia*. Only close examination," he continued, "showed that this interesting plant belongs to the *Caprifoliaceae*." It is interesting to note that Wilson collected *Magnolia biondii* near the same site, but at an elevation of six hundred meters (above two thousand feet). *Magnolia biondii* recently was introduced to North America through the efforts of the Arnold Arboretum.

The next reference to the genus *Heptacodium* did not occur until thirty-three years later, in 1952, when Henry Kenneth Airy Shaw, a taxonomist at the Royal Botanic Gardens, Kew, described "A Second Species of the Genus Heptacodium Rehd. (Caprifoliaceae)" in the *Kew Bulletin*. Airy Shaw states that

> for many years there have lain in the Kew Herbarium two sheets of an undetermined Chinese shrub with opposite trinerved leaves and a terminal thyrse of superficially jasmine-like flowers. . . .Having previously taken some interest in the Caprifoliaceae (Honeysuckle Family), the writer recalled a rare shrub collected in Hupeh and described by Rehder. . . .[R]eference to the isotype preserved at Kew showed that this was clearly the correct generic disposition of the mysterious specimen. . . .The discovery is of some

Opposite: *A leaf of* Heptacodium jasminoides *Airy Shaw showing the trinerved venation. This and the other photographs that accompany this article were taken by the author in the Arnold Arboretum during the fall of 1985. Professor Zou Shou-qing kindly supplied the calligraphy, which says "Zhejiang seven-son flower."*

> interest, since the original species was noted by Wilson as being very rare, and as far as I am aware has not been collected since.

Airy Shaw described the new species, naming it *Heptacodium jasminoides.* Since he had only dried herbarium specimens, no living material of the new species could be distributed.

The 1980 Sino–American Botanical Expedition

Heptacodium again disappeared from the view of plant scientists outside China. The first opportunity Western botanists had to observe it firsthand did not come until recently, when the 1980 Sino–American Botanical Expedition provided seeds and the opportunity to introduce living plants to North America. The American contingent of the Expedition consisted of Stephen A. Spongberg of the Arnold Arboretum; Theodore R. Dudley of the United States National Arboretum; Bruce Bartholomew of the University of California Botanical Garden at Berkeley; David E. Boufford, then at the Carnegie Museum in Pittsburgh (now with the Arnold Arboretum); and James Luteyn of the New York Botanical Garden. They collaborated with a team of Chinese scientists from various institutions in exploring the native wild flora. Their travels through China took them to Hangzhou Botanical Garden in Hangzhou, Zhejiang province, China (30° 15′ north latitude, 120° 16′ east longitude, at 26.42 meters [about 83 feet] above sea level). Spongberg and Dudley report that while on a tour of the Garden on November 1, 1980, they were shown a plant of *Heptacodium jasminoides.* Multiple-stemmed and arching, it was growing in full sun. The staff of the Garden kindly accommodated the Americans's request for seeds. Dr. Dudley, who felt great excitement at seeing a living plant of *Heptacodium*, a genus he had read about while doing research on the Caprifoliaceae, recalls having avidly and voraciously plucked the fruits.

The seeds came from a plant originally dug up in the Zhejiang Province Preserve, approximately five hundred miles south of Hangzhou. This is the type locality for *Heptacodium jasminoides*, and Dudley feels that the original seedlings are as authentic as botanists can hope to get at the present time. The seeds proved to be fresh and reliable, producing plants at both the Arnold Arboretum (AA 1549-80) and at the National Arboretum (NA 49226). The National Arboretum's records state that the seed parent was a tall, arching, multistemmed shrub about five meters (sixteen and a half feet) tall. Dudley reports that seedlings were quickly distributed to the Cary Arboretum of the New York Botanical Garden in Millbrook, New York. I was unable to find that any plants had been introduced to the University of California Botanical Garden at Berkeley. Thus, it appears that only the three East Coast gardens were responsible for the original introduction materials.

On February 26, 1981, the Arnold Arboretum obtained a second lot of seeds (AA 403-81) through the 1980 *Index Seminum* (Item 519), circulated by the Hangzhou Botanical Garden to botanical institutions throughout the world. It is quite likely that a number of other gardens received seeds of *Heptacodium jasminoides* through this distribution.

As of January 1986, the Arnold Arboretum had six plants from the 1980 Expedition. They are growing out of doors in the nursery and range from two to three meters (about six to ten feet) in height. One plant from this seed lot appears to be a compact form, for, while it is the same age as the other plants, it is only seventy-five centimeters (about thirty inches) tall. It is, however, crowded into the middle of a row of tightly spaced seedlings and is therefore subject to intense competition. Perhaps, if given more space, its growth will accelerate to the typical rate.

A spray of Heptacodium jasminoides. *The "opposite trinerved leaves" and "superficially jasmine-like flowers" are easily seen in this photograph.*

Barry R. Yinger, the Curator of Asian Plants at the National Arboretum, reports that the National Arboretum has eleven plants from the original collection, which recently were planted outdoors, in China Valley. In addition, they have one plant (NA 54102) that they acquired from Dr. James C. Raulston, Department of Horticultural Sciences, North Carolina State University, Raleigh. Dr. Raulston obtained his original cuttings when he was on a field trip to the Arnold Arboretum in 1983. (This demonstrates just how fast plants can change hands, passing from one garden to another, once they arrive in North America!) At this point it seems that all plants in North America can be traced back to these two seed lots, which appear to have a common origin in a single parent plant at the Hangzhou Botanical Garden. Since the genetic diversity is therefore so limited, it is important that we seek additional germplasm directly from wild sources in China.

Our first order of business was to get the seeds to germinate. As with most seeds for which we have no recorded experience, we divided the seed lots into a number of treatment groups. Peter Del Tredici of the Arnold Arboretum's plant-propagation staff reports that the best germination resulted from exposing the seeds to five months of warm stratification at 65 degrees Fahrenheit in a moist medium consisting of equal parts of sand and peat moss, followed by three months of cold stratification at 36 degrees Fahrenheit. Five seeds in Lot 1549-80 and six in Lot 403-81 germinated after this treatment. Unfortunately, our records do not indicate how many seeds were sown in either lot; we therefore cannot give germination percentages. Four additional seedlings resulted from alternative treatments.

Hardiness

Once we had obtained seedlings, we turned our attention to the question of cold hardiness. Would the seedlings of *Heptacodium jasminoides* at the Arnold Arboretum survive outdoors during the winter? We found that they grew rapidly and were large enough to be transplanted outdoors in regular rows within one or two seasons. They have survived three, perhaps four, winters out of doors. During their first winter out of doors, the plants resided in the shadehouse with winter shelter of white pine boughs. The original seedlings were then moved to a location in the nursery immediately adjacent to the weather station, where daily temperature records are kept. According to Robert G. Nicholson of the plant-propagation staff, they were exposed to a minimum winter temperature of minus 10 degrees Fahrenheit during January 1984. No special winter protection was given them. They are growing in an open location in an exposure of full sun, in acid soil with excellent air and soil drainage. We have not observed any winter injury nor any type of dieback due to climatic or soil conditions at our site. The Arnold Arboretum has already distributed plants to sites with much lower minimum winter temperatures so as to establish quickly the cold tolerance of this species.

Growth

Growth has been rapid and vigorous. After five growing seasons, our oldest plants stand from just under two to three meters (six to ten feet) tall. Plants growing at the same location in the nursery for at least three years have produced seasonal growth that averaged ninety centimeters (thirty-six inches). At the base of the new (1985) growth, the thickest stems had a girth of one and one-quarter to one and nine-tenths centimeters (one-half to three-quarters inch). The plants have produced multiple stems originating from ground level, and the growth thus far is erect and upright, with little side-growth development. Small branches are square or four-angled. The thickest stem on any of the plants is four and one-half centimeters (one and three-quarters inches) in diameter at approximately two and one-half centimeters (one inch) above the soil level. The stems produce thin bark that peels off in small, paperlike strips or sheets. During the winter, these plants stand out from their neighbors because of their light tan to brown bark. It is eye-catching and a relief from the darker browns and brown-black bark patterns typical of most plants in winter. Both the winter color and the shredding bark are reminiscent of *Kolkwitzia*, while the stem color is similar to that of *Diervilla*.

While growth has been rapid, no mature plants of *Heptacodium jasminoides* yet exist in North America. Therefore, it remains to be seen what the ultimate height, spread, and form might be. According to the Chinese literature, the plant grows as a small tree, reaching seven meters (twenty-three feet) in height. They state that it grows best in the shade of trees. During April 1985, I had the

A close-up view of the inflorescence.

opportunity to visit the Hangzhou Botanical Garden and to observe firsthand a cutting rooted from the original specimen collected at the type locality. The plant grew as part of a mixed-woodland situation where, because of overcrowding, it stretched for light. As a result, it was thin and gaunt, stood approximately six meters (twenty feet) tall, and did look like a small tree. I questioned my Chinese guide about the plant and was told that it was rare in China and at one point was thought to exist no longer. In my travels, which admittedly were limited, I saw no other specimen of *Heptacodium*.

As a young plant, *Heptacodium* seems to develop multiple branches from near soil level. With some training, it should grow quite well as a single-stemmed standard. Indeed, it might make the perfect-sized small tree for cramped urban and modern landscape spaces.

Foliage

The foliage of *Heptacodium jasminoides* is one of the plant's finest assets. The leaves, which measure eight to ten centimeters (three to four inches) long and about five to five and two-thirds centimeters (two to two and one-quarter inches) wide, are opposite. Their bases are rounded or heart-shaped and their tips pointed. Their margins are entire but somewhat wavy. Visually, the leaves are remarkable because of their deeply impressed, trinerved veins, which run parallel to the margins. They bear a superficial resemblance to the leaves of species in the tropical family, Melastomataceae.

As with most plants, leaves on young, lush major stems are most vigorous, while those on older and secondary branches are much smaller. During the spring season of 1986, I kept a close watch for the appearance of the new-season foliage and found it to be among the earliest to appear, commencing its growth during approximately the third week in April. The leaves emerge a light to medium green and become a handsome dark green as they mature. During autumn, after the leaves of most neighboring plants have fallen away, the leaves of *Heptacodium* still cling fast, remaining until middle to late November.

On nursery plants exposed to full sun, the leaves fell away without any change in color, however, except perhaps for the slightest tinge of yellow. However, rooted cuttings that grew nearby in quart-sized plastic containers and provided with light shade did turn a splendid shade of muted purple. What caused this color? Was it moisture stress,

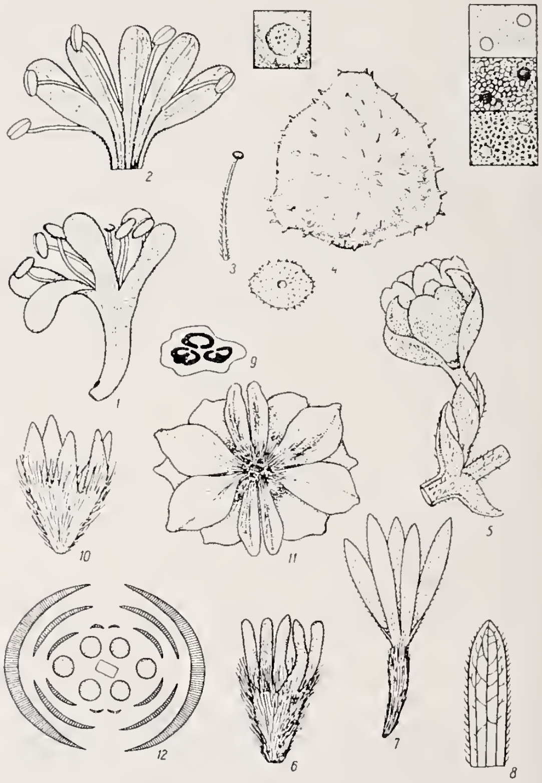
Illustration of an inflorescence, a single flower, and a fruit of Heptacodium jasminoides *as rendered in Volume 4 of* Iconographia Cormophytorum Sinicorum *(see the "Bibliography and Iconography").*

shade, cramped root space, or slightly greater warmth provided by nearby brick walls? It is evident that the plant possesses the potential for autumn color, and I am sure that, under the right environmental conditions the color might be a significant ornamental asset. Will the long retention of leaves ultimately be a hazard to the plant? The leaves might trap and hold early-season ice and snows, allowing a buildup of weight, causing structural damage to the plant's trunk and stems.

Flowers and Fruits

The most distinctive ornamental assets of *Heptacodium jasminoides* derive from its flowers and fruits. The flower buds form in June and increase in size ever so slowly, bursting forth in mid-August. Single flowers are quite small but are borne in a tiered, six-flowered whorl that is terminated by a flower, hence the name *Heptacodium*, in allusion to the seven-flowered thyrselike inflorescences. The flowers are pale, creamy white and in structure resemble those of *Lonicera*. They open slowly, in sequence from the bottoms to the tops of the inflorescences. In Massachusetts, the flowering period is quite long, lasting from mid-August until early October, when it is put to rest by the onset of chilling temperatures and frost. It appears that the flowering period is triggered by photoperiod; Dr. James C. Raulston of North Carolina State University suggests that *Heptacodium* might be used as a flowering houseplant that could be retained and planted outdoors. When grown for the flowering pot-plant market, it could be kept small with growth-controlling chemicals.

Flowers are abundant on the plant, and they are borne on an annual basis. If the flowers were presented in May, they would hardly be worthy of a second look because they simply cannot compete with lilacs, azaleas, or spiraeas. Coming late in the season as they do, however, they become significant late-season flowering specimens. In the vicinity of Boston, Massachusetts, flowering is heaviest from mid-August to late September. Occasional flowers appear until mid-October. How much longer would flowering last where the autumn is longer and milder?



Anatomical details of the flowers and floral parts of both Heptacodium jasminoides *Airy Shaw (1–8) and* Heptacodium miconioides *Rehder (9–12) as shown in* Novosti Sistematiki Vysshikh Rasteniĭ, *Volume 2 (1985) (see the "Bibliography and Iconography").*

Heptacodium jasminoides*: 1, corolla; 2, a corolla laid open; 3, style and stigma; 4, a pollen grain; 5, bracts and bractlets; 6, calyx; 7, fruit; 8, calyx lobe in the fruit.*

Heptacodium miconioides*: 9, diagram of the ovary in cross section; 10, calyx; 11, bracts and bractlets as seen from above; 12, floral diagram.*

Perhaps it would last twice as long in California or Georgia.

The premier ornamental feature of *Heptacodium jasminoides* is its fruits, which are borne in clusters. What makes the fruits so valuable from an ornamental point of view is the fact that the calyces do not fall off when flowering is over, but persist and (more importantly) continue to grow. Individual fruits develop slowly from the flowers; light green at first, they ripen to the most glamorous rose to purple. A large cluster of fruits, each fruit with its "accrescent persistent calyx," is more spectacular than the blossoms at the peak of flowering, especially when the cluster is held high and glows with backlighting from the sun. The rich purple color remains attractive for several weeks as the fruits continue to ripen. At full maturity, the fruits turn tan and slowly fall away.

Heptacodium jasminoides in North Carolina

In a letter of February 1, 1986, Dr. Raulston answered questions I had posed about his continued interest in *Heptacodium*. He has become enthusiastic about this plant, he replied, and has decided that it would be worth trying to increase its numbers and to get it into the nursery trade somehow. He described his experiences with *Heptacodium* in some detail.

During the autumn of 1985, at the University of British Columbia Botanical Garden in Vancouver, he had seen for the first time a plant, about six feet (just under two meters) tall, in full flower. The attractive flowers were very fragrant. This past winter, an all-time low temperature of minus nine degrees Fahrenheit occurred at the North Carolina State University Arboretum. No injury was noted among the plants, so it was generally felt that the plants would be hardy indefinitely in this location. Plants at that locale also bloomed in late September to early October. The reddish calyces, which remained colorful long after the flowers were gone, were also impressive there. "One of the plusses for commercial production," he writes, "is the easy propagation." He continues:

> I find that softwood and semi-hardwood cuttings can be rooted easily and quickly under mist at any time of year that the plant has the appropriate wood available. Single node cuttings allow rapid build-up of material. I would gather that it is quite photoperiodic—in the greenhouse under long day conditions I can keep it growing through the winter to allow continual cutting production. The flowers are likely produced under short day conditions—which makes me think that it could possibly have potential for a pot plant crop—multiple cuttings per pot, pinched, growth retardant-treated, flowered at any time of year—then could be planted out to the landscape for further growth.

Dr. Raulston has about thirty cuttings rooted in his bench now. They are in active growth, receiving exposure to light from 10:00 p.m. until 2:00 a.m. He informs me that he was trying to build up a supply of plants to give away in August, at the annual distribution to nurseries in North Carolina.

In another letter, Dr. Raulston discloses that Mrs. Chin Chin Lee, a graduate student, intends to work on *Heptacodium* for her doctoral dissertation research project. This is an exciting development because it probably will be the first research conducted in the West on fresh material of the genus *Heptacodium*.

Heptacodium jasminoides in Canada

Upon learning that the University of British Columbia Botanical Garden in Vancouver is raising *Heptacodium*, I contacted that garden's staff for details. Charles Tubesing, plant propagator, informed me that the Garden had received three *Heptacodium* seedlings (Accession Number 23220-083-83) on February 9, 1983. The seedlings trace back to the National Arboretum's Accession Number 49226, the original seed introduction to North America. Peter Wharton, curator of the Garden's Asiatic plants, said that the three seedlings were planted out into the permanent collections two years ago; because their exact cultural requirements were unknown, they were placed in different areas. Each plant gets an exposure of full sun and grows in a sandy, stony soil derived from glacial till. One plant is in direct root competition with a nearby Douglas fir (*Pseudotsuga menziesii*). The soil's pH is in the region of 5.0 to 6.0. Their response indicates that *Heptacodium* can endure considerable drought. All three plants survived; in fact, they have grown to a height of four to five feet (one and one-fifth to one and one-half meters) and first flowered in 1985. Wharton said they were flowering by early July. He noted, however, that there had been an abnormally hot spring and that he would expect flowering to begin a bit later with usual spring temperatures. Unfortunately, he did not have the opportunity to note when flowering had ceased. Wharton commented that the plants flowered profusely and produced a delightful scent. The bold foliage he thought would make the ideal background subject for a shrub border.

Propagation of *Heptacodium jasminoides* at the Arnold Arboretum: Germination Experiments

In early December 1985, we harvested seeds from the Arnold Arboretum's own plants of *Heptacodium jasminoides*. We are now attempting to learn more about the seed biology of the species. We had feared that the growing season in Boston would be too short for the seeds to mature, but Peter Del Tredici reports that as of mid-June 1986 seedlings had developed from the seeds we collected here. To achieve germination, we used the following procedure: Seeds collected from Accessions 1549-80 and 403-81 on December 17, 1985, were cleaned, divided into lots of two hundred, assigned Accession Number 1284-85, and sown in a warm greenhouse. One lot was sown in the greenhouse without any prior exposure to cold, one lot was exposed to one month of cold before being sown, and a third lot was exposed to cold for three months before being sown in the greenhouse. As of June 12, 1986, the results were those shown below in the tabulation.

As the tabulation shows, one month of cold stratification sped up germination but reduced the amount of germination from 14 percent to 7 percent. The tabulation also shows that three months of chilling resulted in no germination at all, which suggests that cold stratification actually inhibits the germination of *Heptacodium*, a conclusion supported by the fact that seeds stored for five months in warm stratification germinated at a rate of 7 percent, while seeds given the same treatment, followed by a month of cold stratification, failed to germinate at all. This conclusion should be conisdered strictly provisional, however, because the germination of seeds imported directly from Hangzhou was not inhibited by a warm treatment followed by cold stratification. Since germina-

Treatment	Number of Seeds That Germinated	Time To Germinate, months
Sown in warm greenhouse	28	5
Exposed to one month of cold before being sown	14	4
Exposed to three months of cold before being sown	0	–

tion tests are still in progress, these results might have to be interpreted differently at a later date.

During the first week of April 1986, seven of the original seedlings were transplanted from the nursery at the Dana Greenhouse to a prominent and permanent location at Jamaica Plain, near the Centre Street gate. They had stood eight to twelve feet (about two and one-half to three and two-thirds meters) tall. Before they were transplanted, they were severely pruned and reduced to a height of four feet (about one and one-quarter meters) so as to ensure their survival after transplanting. Four plants were placed adjacent to the gate in a sunny location, and three were placed across the gravel driveway in semishade, but within fifty feet (fifteen meters) of the first group. This seedling population should provide cross pollination, if in fact cross pollination is necessary, and will, we hope, result in abundant seed crops and a permanent seed colony for New England.

As of June 2, 1986, all seven of the transplants had survived and had already produced lush new-season growth; some shoots had already reached lengths of twenty inches (fifty centimeters). At the same time, we lifted the compact plant and moved it to a new location in the Dana Greenhouse nursery, where it will be subjected to less competition from neighboring plants. Continuing careful observation will reveal whether this individual really is compact.

A large cluster of Heptacodium *fruits, each with its "accrescent persistent calyx." These clusters of rich purple fruits are the chief ornamental feature of* Heptacodium jasminoides. *The color lasts for several weeks as the fruits continue to ripen.*

A close-up view of a fruit cluster. The calyces are especially obvious in this photograph.

Propagation by Softwood Cuttings

The Arnold Arboretum has already produced several hundred plants from softwood cuttings. The cuttings were taken from both seedling lots during the summer of 1985. On July 8, one hundred twenty cuttings were taken from all eleven parent plants. The cuttings, which were four to six inches (ten to fifteen centimeters) long, were given a five-second dip in a solution of ten thousand parts per million indolebutyric acid (IBA) in a mixture of fifty percent ethyl alcohol and fifty percent deionized water. The cuttings were then stuck in a mix of equal parts of sand and perlite and placed under intermittent mist (a two and one-half-second blast every two and one-half minutes). By October 1, ninety-seven of the one hundred twenty cuttings (eighty-one percent) had developed excellent root systems.

One hundred more cuttings were taken on July 26 and given the same treatment as above. Of them, seventy-nine (seventy-nine percent) had developed roots by October 1. These rooted cuttings have been distributed to institutions and specialty collectors in Alabama, California, Delaware, Georgia, Illinois, Maryland, Massachusetts, Minnesota, Ohio, New York, North Carolina, South Carolina, Pennsylvania, Virginia, and Wisconsin. Robert G. Nicholson tells me that seeds have been supplied to nurseries in Canada, the Netherlands, and England, as well as to the Royal Botanic Garden, Edinburgh, and the Royal Botanic Gardens, Kew. During 1985, five seedlings that had originated at the United States National Arboretum were growing at the Darthuizer nursery in Leersum, Holland.

Allen C. Haskell of New Bedford, Massachusetts, recently reported that as of April 1, 1986, he began taking cuttings from his specimen weekly in an attempt to determine the best time to make new-season softwood cuttings from an outdoor plant. In a period of two and one-half months, he succeeded in producing over two hundred rooted cuttings. Haskell found that the timing made little difference in terms of the quantity and quality of rooted cuttings. Cuttings were taken from exceptionally soft wood, treated with Hormex #16, placed in a sweat-box, and left undisturbed until they had rooted. During this short time period, the rootings have been so successful that in some instances the roots penetrated the peat pots in which the

The thin bark of Heptacodium, *peeling off in paperlike strips or sheets.*

cuttings were planted. Haskell commented especially about the lush quality of the early new-season growth, which he considered surprisingly vigorous despite the poor root system of this specimen, which he had acquired in late September 1985.

Heptacodium jasminoides: Secure in Its Newfound Home

A rare Chinese plant has been brought to North America; within the short span of six years it has received preliminary testing, has been stock increased, has been distributed widely across North America (and to Europe), and has become the subject of a research project. I suspect that in a few more years *Heptacodium jasminoides* will be more abundant in North America than it is in its homeland, if it isn't so already. Once again the gardens and botanical research institutions of North America have proven themselves to be good custodians of species that are rare or threatened in their native lands.

To date, *Heptacodium jasminoides* remains untested in residential and commercial landscapes. If it is considered a flowering shrub, I fear that many people will view it as too large for small contemporary landscape species. Trained to a single stem or to a few main trunks, it will form a small, late-summer-flowering tree growing to approximately twenty feet (six meters). Its smallness, lateness of flowering, and fragrant blossoms guarantee it a niche at a time when few other small trees bloom. It makes the perfect candidate for planting at summer resorts, where it can contribute to the festiveness of a summertime retreat or sanctuary. The open base, which might be considered leggy, can be utilized as a space in which to mass shorter shade-tolerant shrubs, herbaceous perennials, and spring bulbs. Its tolerance of droughty soil might enable it to adapt to urban soils too poor for the growth of other species. Should *Heptacodium* turn out to be as tolerant of salinity as *Lonicera*, *Diervilla*, and *Leycesteria*, it will be the perfect subject for seacoast locations and along high-speed roadways where cars whip up mist laden with deicing salts in winter. The fact that *Heptacodium* propagates easily, grows rapidly, transplants with ease, and reestablishes vigorous growth within one growing season makes it a landscaping plant that will be valued highly by the nursery industry.

Distribution of *Heptacodium jasminoides* by the Arnold Arboretum

This fall, the Arnold Arboretum will distribute rooted cuttings and seedlings of *Heptacodium jasminoides*. To speed its entry into private gardens, we will be pleased to supply Friends of the Arnold Arboretum and other readers of *Arnoldia* who live in the conterminous ("Lower Forty-eight") states of the United States with two plants for a cost of thirty dollars, prepaid, packaging and shipping included. Readers who wish to obtain plants of *Heptacodium* should direct their orders, along with full payment, to:

Heptacodium Distribution
The Arnold Arboretum
Jamaica Plain, MA 02130-2795.

Acknowledgments

In addition to the individuals mentioned in this article, I acknowledge with thanks the assistance of Peter Del Tredici (for allowing me to cite the results of his germination experiments), David E. Boufford, Robert McCartney, Zhang Zhih-ming, John H. Alexander III, and the staff of the Hangzhou Botanical Garden, who made possible the introduction of *Heptacodium jasminoides*.

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A Word about the Cover Artist and Her Work

Arnoldia is delighted to have for the cover of this issue a fine new painting of *Heptacodium jasminoides* by the young botanist and botanical illustrator Amy Eisenberg, who has spent the past several years illustrating and familiarizing herself firsthand with plants in their natural habitats. A wilderness ranger and naturalist at Sequoia National Park for several years before coming to the Arnold Arboretum in 1985, she currently is working at Mount Yu National Park in central Taiwan as advisor to the Republic of China's Ministry of the Interior. Ms. Eisenberg holds degrees in botany from Utah State and Humboldt State universities, and has done additional graduate study at Harvard University. Her illustrations of plants have appeared in such periodicals as the *American Journal of Botany*, *BioScience*, the *Journal of the Arnold Arboretum*, *Madroño*, and *Mycologia*. Three of her drawings were published in the Summer 1986 issue of *Arnoldia*.

Heptacodium Notecard Available

Through the artist's generosity, the Arnold Arboretum is pleased to offer for sale a notecard featuring a full-color reproduction of Amy Eisenberg's painting of *Heptacodium jasminoides* (see the cover of this issue of *Arnoldia*). Measuring 5 by 7 inches, the cards (plus envelopes) are available for purchase at the Arnold Arboretum Shop in the Hunnewell Visitor Center for $1.00 each, or $8.50 per dozen. They are also available, prepaid, by mail. To order cards by mail, send a check for the full amount (which includes postage and handling), made out to "The Arnold Arboretum," to:

Arnold Arboretum Shop
Hunnewell Visitor Center
The Arnold Arboretum
Jamaica Plain, MA 02130-2795

The 1984 Sino–American Botanical Expedition to Yunnan, China

David E. Boufford
Bruce Bartholomew

A recent expedition to China yielded sixteen hundred flowering plants and ferns from a botanically rich part of that vast country

The 1984 Sino–American Expedition to Yunnan province, the People's Republic of China, was only the second time that American and Chinese botanists were able to undertake extensive fieldwork together in China since Liberation in 1949. Botanical exchanges between the United States and China had begun in 1978, when a delegation of American botanists, including past Director of the Arnold Arboretum, Dr. Richard A. Howard, visited China to initiate discussions on how best to carry out cooperative projects between botanists of the two countries (Thorhaug, 1978). The following year, 1979, saw a reciprocal visit to the United States by a delegation of Chinese botanists. The delegation visited botanical gardens, arboreta, and other research facilities throughout the country and, in a series of meetings with their American counterparts at the University of California in Berkeley at the end of their tour, decided that a joint field expedition in China would be an ideal means of continuing botanical exchange.

The First Joint Chinese and American Expedition: *Metasequoia* in the Wild

The first joint expedition took place between 15 August and 15 November 1980 and involved botanists from the Arnold Arboretum; the University of California, Berkeley; the Carnegie Museum of Natural History, Pittsburgh; the U.S. National Arboretum; and the New York Botanical Garden (Bartholomew *et al.*, 1983*a*). This group, which included both authors of this article, was accompanied in the field by Chinese botanists from the Institute of Botany, Beijing; the Jiangsu Institute of Botany, Nanjing; the Wuhan Institute of Botany; and the Kunming Institute of Botany. One of the two regions visited by that expedition was especially significant because it included the valley in Lichuan Xian (county) where the dawn redwood, *Metasequoia glyptostroboides* Hu & Cheng, grows (Bartholomew *et al.*, 1983*b*). The *Metasequoia* valley had been the site of the last American collecting expedition in China before the country was closed to the West more than thirty-one years previously.

Seeing the largest assemblage of wild plants of the dawn redwood (about six thousand individuals in this valley) was truly exciting, but our group was disappointed to find that the ecological conditions in the area had changed drastically since the previous expeditions had visited there. The thickets reported by Chu and Cooper (1950), in which seedlings and young plants of *Metasequoia* were found, had been completely cleared from the base of each *Metasequoia* tree. Most of the other trees on the surrounding hillsides, seen in pictures taken by Gressitt in 1948 (Gressitt, 1953), had been cut for fuel or construction purposes. The existing trees are now surrounded by rice paddies and fields of corn instead of natural vegetation, and the human population in the isolated valley has increased dramatically! Even though the remaining trees have been given full protection, once they die they are unlikely to be replaced naturally under present conditions; the wild populations of *Metasequoia* will slowly pass out of existence, even though the widespread cultivation of the dawn redwood will ensure the survival of the species.

One interesting observation our group made during the visit to the *Metasequoia* region was that only the tree from which the type specimens of *Metasequoia glyptostroboides* were collected has a broad, somewhat buttressed base. All of the other trees in the *Metasequoia* valley, about one hundred kilometers from the "type tree" at Modaoqi (Modaochi), have smooth, straight trunks from ground level to the lowest branches. The oldest trees in cultivation in the United States are now large enough to show their mature growth habit, and all of them exhibit a swollen, slightly buttressed base. It seems very likely that the large number of seeds gathered in the late 1940s and widely distributed by E. D. Merrill, then Director of the Arnold Arboretum, were from the type tree and not from a tree in the main valley. Anyone fortunate enough to have trees derived from those first-distributed seeds should be aware of their probably direct descent from one of botany's most famous and historic plants.

Despite the severe habitat destruction, members of the Expedition were able to find several plants in the dawn redwood valley that had not been reported previously by either Gressitt (1953) or Hu (1980). In a summary of our impressions and suggestions for conservation in the *Metasequoia* valley, the American and Chinese botanists were unanimous in recommending that several hillsides supporting remnants of the original forest be set aside and allowed to regenerate naturally. With time, something approaching the original vegetation, which supposedly existed before the settling of the valley about three hundred years ago, might return.

Approximately four days were spent in the *Metasequoia* region, but getting there and back by boat, minibus, and jeep took about two weeks, and most of the fieldwork during the 1980 expedition was conducted in the Shennongjia Forest District, a mountainous region in northwestern Hubei province. This area had been visited previously by Western botanists, notably by Augustine Henry and E. H. Wilson, but the interior of the area was so rugged and difficult to reach that they spent little time there. In the early 1970s the Chinese government declared the region a "Forest District," a designation roughly equivalent to *xian* (county), and began constructing roads for the harvesting of timber. Roads now connect nearly all parts of the district, which allowed our group to reach remote and once isolated areas.

In total, we spent six weeks in the Shennongjia Forest District. Our base camp in the village of Jiuhuping, at about fifteen hundred meters, was in an area with a climate very similar to New England's, except that central China receives far more rain throughout the year. The stream along the road in front of our base camp would rise dramatically after several days of torrential rains, then, because of severe deforestation on many slopes, would fall abruptly as the rains were followed by several clear, sunny days. But even without going outside we could guess at the level of the river from the brightness of the electric lights. Nearly all villages in mountainous regions of China are now supplied with elec-

Opposite: Arisaema franchetianum *Engler (Araceae), a relative of the jack-in-the-pulpit of North America. Père David collected the type specimen of this species in "Tibet orientalis" (i.e., western Sichuan). The plant shown here was growing at an elevation of 2,800 meters (9,200 feet) in Yangbi Xian (county), Yunnan province. This and all other photographs accompanying this article were taken by David E. Boufford, as was that on page 37.*

tricity through the widespread use of small hydroelectric plants. Each village has a small generating station fed with water channeled from the main bed of the river somewhere upstream to a point high above the plant. The water then plunges through a nearly vertical pipe (or pipes) to run the generator. When the river was high our lights would burn brightly, but as the level of the water in the streambed dropped, the lights would dim, and after several rainless days the electrical supply became somewhat uncertain.

Noteworthy Plants of Central China

The trees around the village belonged to such familiar genera as *Acer* L. (maple), *Fagus* L. (beech), *Quercus* L. (oak), *Betula* L. (birch), *Sorbus* L. (mountain ash), *Salix* L. (willow), *Populus* L. (aspen), and *Tilia* L. (basswood). Associated with them, however, were a number of plants including *Cercidiphyllum* Sieb. & Zucc. (katsura), *Euptelea* Sieb. & Zucc., and *Pterocarya* Kunth (wing-nut), endemic to eastern Asia, and *Tetracentron* Oliver, *Decaisnea* Hooker & Thomson, *Davidia* Baillon, *Cyclocarya* Iljinskaja (one of the wing-nuts, but with the wing completely circling the fruit), *Sinowilsonia* Hemsley, *Sinofranchetia* (Diels) Hemsley, and a number of others, mostly or completely restricted to China.

Many of these genera now known only from China are important in hypotheses

Beijing's main thoroughfare.

regarding evolution and past geographic distributions of plants, particularly of plants in the north-temperate regions. One particular plant, *Saruma* Oliver (its name being an anagram of *Asarum* L.), a member of the Aristolochiaceae, resembles our wild ginger in leaf shape and overall appearance, but it has an erect, leafy stem with a flower in each leaf axil. The flowers are unusual in that they bear both sepals and petals. In wild ginger, the stems are creeping and the flowers have only sepals (the petaloid structures sometimes produced in *Asarum canadense* L. are actually modified stamens). *Saruma* suggests the kind of plants one would guess to be the ancestor of *Asarum*. It is very unlikely, however, that *Asarum* arose directly from *Saruma*, but the similarities and differences in the two genera clearly provide tantalizing clues as to what the ancestor of *Asarum* might have looked like.

Other noteworthy plants in central China include a number of herbaceous species that have their closest relatives in the Appalachian region of the eastern United States. One of these, *Diphylleia sinensis* H. L. Li, has a scattered distribution in central China. Its closest relative, *Diphylleia cymosa* Michaux (umbrella leaf), is restricted in the United States to the narrow area along the North Carolina–Tennessee state line and a few localities in adjacent Georgia, South Carolina, and Virginia. The third species in the genus, *Diphylleia grayi* F. Schmidt, named for Harvard botanist Asa Gray, is restricted to Japan and the Soviet island of Sakhalin. It is interesting that, even though they are more widely separated geographically from each other than they are from *Diphylleia grayi*, the Chinese and American plants are more similar to each other than either is to the Japanese plant.

One particularly interesting aspect of the 1980 expedition was being able to see many of the commonly cultivated plants of the eastern United States growing in their natural environment. Plants that had seemed to be restricted to university campuses, botanical gardens, and arboreta were much more splendid when seen growing from a crevice in a sheer rock cliff, or intermixed with other trees to form a particular kind of vegetation. At times, when seeing such plants as *Viburnum rhytidophyllum* Hemsely, *Buddleja davidii* Franchet (butterfly-bush), *Pachysandra terminalis* Sieb. & Zucc. (pachysandra), or some of the rhododendrons, it was hard to understand why they had not become more widespread in parts of North America, where the climate seemed so much like that of central China.

In total, the Chinese and American bota-

Professor S. C. Sun, the Leader of the 1980 Sino–American Botanical Expedition.

nists collected over twenty thousand sheets of herbarium specimens and about five hundred collections of living plants and seeds during the 1980 expedition. The opportunity to collect these specimens and to see the plants growing naturally made a strong impression on all of us. When examining herbarium specimens from China, we now can recall the kinds of situations under which the plants may have grown in the field, and can consider the various species that might have grown with it. The observations that are only available through fieldwork are most important in providing a clearer understanding of many aspects of biology, plant geography, taxonomy, and evolution that would otherwise either be speculative, or remain completely unknown.

Père Delavay and the Flora of Yunnan

The 1984 expedition to southwestern China was in a completely different vegetational and floristic region. While the provinces of central China have a flora with strong affinities to those of Japan and parts of North America, the flora in Yunnan is more like that of the Himalayan region and of northern Thailand and Burma. The area where we conducted the greatest portion of our fieldwork in 1984 was in the Dali (Tali) region of Yunnan province. The first botanical collections in this area were made by French missionaries in the late 1800s, and since then the area has been noted for the richness of its flora. Père Jean Marie Delavay, in particular, made most of the early collections in the Diencang Shan (Cang Shan [Tsang Shan] for short) mountain range west of the walled city of Dali.

Père Delavay first went to China in 1867 where, in addition to his missionary work, he was an avid botanical collector. On returning to France in 1881, Delavay met the French botanist Adrien Franchet, with whom he made an agreement to send all future collections to him at the Muséum d'Histoire Naturelle in Paris. On returning to China in 1882, Delavay was stationed at a mission near the northeast corner of Erhai Lake, not far from Dali. Over the next ten years Delavay sent Franchet an enormous number of specimens, many of which were new to science. Plants such as *Rhododendron arboreum* W. W. Smith subsp. *delavayi* (Franchet) Chamberlain, *Vaccinium delavayi* Franchet, *Paeonia delavayi* Franchet, *Clethra delavayi* Franchet, *Viola delavayi* Franchet, *Thalictrum delavayi* Franchet, to mention only a

A flower of Nomocharis pardanthina *Franchet photographed at Yinglofeng, Yunnan province, at an elevation of 3,200 (10,500 feet) in the Cang Shan mountain range. Blossoms of this member of the Liliaceae are rosy purple, freckled with crimson. Allied to* Fritillaria *and* Lilium, *this commonly cultivated perennial herb is native to western Yunnan, Tibet, and the Himalaya, where the inhabitants eat its bulbs like onions. Plants are about three feet tall. The species was first collected by Père Delavay, in 1883, in the mountains near Dali.*

few, commemorate this prodigious early collector.

The flora around Dali is now quite well known, since the region has been visited by many Western and Chinese botanists over the past hundred years. It is interesting to note that some of the taxa named by Franchet have subsequently been shown to be synonymous with Himalayan plants described earlier by British botanists working in the western extension of the Sino–Himalayan floristic region. The Dali area was, however, the farthest west in Yunnan province that foreigners were allowed to visit in 1984, and it was for this mountain range that permission was granted for the second Sino–American Botanical Expedition.

To Kunming by Way of Hong Kong

The 1984 trip began in Hong Kong, where the four American participants met before entering China. Bruce Bartholomew of the California Academy of Sciences, who had been in Hong Kong for several days after returning from several weeks of fieldwork in Bhutan, met the three of us (Dr. Dan H. Nicolson, Department of Botany, Smithsonian Institution; Dr. Paul L. Redfearn, Southwest Missouri State University and Missouri Botanical Garden; and Dr. David E. Boufford, Arnold Arboretum) at the airport and took us to our hotel. At about six o'clock the next morning we all met in the hotel lobby for a brief before-breakfast excursion to the misty summit of Victoria Peak, which overlooks the city. The forests on this steep-sided mountain are now preserved, and those of us who had never been to Hong Kong before were quite surprised at the extent and richness of the forest in this tiny, overpopulated British colony. We returned to the city for a Cantonese *dimsum* breakfast at about nine o'clock, then checked out of the hotel and went to the airport to wait for the flight to Kunming.

The flight took us across the extensive delta of the Pearl River and over some of the most impressive karst formations in the world, in Guangxi (Kwangsi) province. Once over Yunnan we could see the red earth so characteristic of central Yunnan.

Kunming is in a large basin surrounded by hills, most of which had long since been denuded of their forests and eroded to bedrock. The city is at an elevation of about two thousand meters (a little over six thousand feet), and, at about twenty-five degrees north latitude, is located at roughly the same latitude as the southern tip of Florida, near Miami. After the intense heat and humidity of Hong Kong, the climate of Kunming, which is more like May in New England all year 'round, was perfect.

At the airport in Kunming we were met by several old and new friends. Professor Zhang Ao-luo, who had visited the Arnold Arboretum in 1982 as Vice-Director of the Kunming Institute of Botany, was now the Director of the Kunming Branch of the Chinese Academy of Sciences, and had played a leading role in arranging for the 1984 expedition. Also at the airport were Professor Ying Tsun-shen, who had spent one year as a Mercer Fellow at the Arboretum in 1981–1982 and who had also been a member of the 1980 expedition to Hubei; Professor Li Hsi-wen, who had visited the Arboretum for about four days in 1981; and Ms. Wang Siyu, who was a visitor the Arboretum from November 1984 to August 1985. All of these people have been instrumental in furthering cooperation between botanists in the United States and China.

On the evening of our arrival we were hosted at a magnificent banquet by Professor Wang Xianpu, the Vice-Director of the Institute of Botany, Beijing, and Professor Zhou Jun, the Director of the Kunming Institute of Botany. Among some of the more exotic dishes were fried larval bees, freshwater shrimp and crabs from Kunming Lake, and whole, deep-fried frogs, which are now raised in China but which had come originally from Cuba. The banquet provided an opportunity for everyone to express his best wishes and to toast further cooperation between Chinese and American scientists.

The next two days were spent sorting out the ton and a half of supplies that had been shipped from the United States, loading everything on a large truck and making general plans for how we would proceed in the field. This short period gave us an opportunity to meet some of the Chinese botanists with whom we would work for the next several weeks and to renew friendships with those who had been with us before. There was also time to inspect the new herbarium building at the Kunming Institute of Botany and to become familiar with the Institute's botanical garden.

On to Xiaguan over the Burma Road

On the morning of June twelfth we were ready to go. The vehicles met us at the Kunming Hotel, where we were staying, and the caravan of two trucks and a minibus, loaded with collecting equipment and six weeks's supply of soft drinks, beer, preserved eggs, rice, Yunnan sausages, and other staples, headed off toward the Western Hills at the far edge of the city. There we reached the terminus of the Burma Road, the highway we were to follow, for the next ten hours and four hundred kilometers, to the city of Xiaguan, which was to be the site of our base camp for the next seven weeks. The day was bright and clear with only a few large, puffy, white clouds in the sky. Little did we know that this was to be the only completely

The countryside near Xiaguan, Yunnan.

sunny day out of thirty! The Americans were fascinated by the passing landscapes and spent most of their time looking out of the windows of the minibus. As we drove to the west we traversed progressively higher hills and low mountain ranges separating broad basins. Even after many hours along the Burma Road we were still impressed—and disturbed—by the complete absence of forests or even small plots of trees, but we knew that once we neared our destination, far from the city of Kunming, we would begin seeing more and more extensive forests and other types of natural vegetation. After all, we had read of the rich botanical treasures that had come from the region of Dali and had seen the specimens in herbaria. Nevertheless, it was more than a little upsetting to see one mountain range after another, completely stripped of trees, pass by in the distance. It was also upsetting to see that as we proceeded farther and farther from Kunming, the villages were not becoming smaller and smaller! We were later told by one official that the Dali Autonomous Region was home to about one and three-quarter million persons. Finding towns in China with names completely unknown in the West, but with populations exceeding one million, or even two million, is not uncommon.

A few hours after leaving Kunming, as we neared the city of Lufeng, we dropped down into a large basin with landforms reminiscent of the Painted Desert in Arizona and very unlike anything we had seen in eastern Asia. The basin was totally devoid of trees (except for the ever-present single row of introduced *Eucalyptus* trees planted along the road), and the dry, layered rock outcrops were completely barren and in sharp contrast to the irrigated depressions filled with rice that separated them..We were told that this region was noted for the "dragon bones" (dinosaur fossils) that had been found there. We later stopped in this desolate region on our return to Kunming six weeks later and found only three species of noncultivated vascular plants: one grass, a species of *Arundinella* Raddi (Gramineae); one herb, a *Euphorbia* L. (Euphorbiaceae); and one shrub, *Dodonaea viscosa* (L.) Jacquin (Sapindaceae, or sometimes Dodonaeaceae).

Around noon we stopped for lunch in the city of Chuxiong, about halfway between Kunming and Dali. According to present custom in hotels throughout China, the Americans and Chinese were seated in separate dining rooms. The only times we could eat together were when we were hosting banquets for our colleagues, when they were giving a banquet for us, or when we were in the field under less formal conditions.

After lunch we continued on our journey, but since it was still relatively early and we had only about five more hours of travelling to do, we decided to make a few brief stops along the way to stretch our legs and to look at the plants. The first stop was along a narrow ravine where all of the trees had been cut, and all that remained were some straggly shrubs of *Gaultheria forrestii* Diels, *Camellia saluenensis* Stapf *ex* Bean, *Viburnum foetidum* Wallich var. *ceanothoides* (C. H. Wright) Hand.–Maz., a few other shrubs, and some overgrazed herbaceous plants. Despite the disturbance we were glad to get an idea of the kinds of plants we would be seeing later. The next and last stop was at the top of a high pass in the last mountain range we had to cross before reaching the wide plain to the east of Dali and the Cang Shan mountain range. Again there were no trees, and this time there were even fewer shrubs. The few herbaceous plants other than grasses grew only next to the road, and the mountain slopes were completely grass covered. We later learned the reason for the absence of trees and shrubs. Since the valley floors are used strictly for agriculture, the people must drive their animals to these higher elevations to graze, and to provide more grazing land the slopes are periodically burned to remove the woody growth. In some places the extensive burning has so altered the growing conditions and depleted the soil that only bracken (*Pteridium aquilinum* [L.] Kuhn var. *wightianum* [Aghard] Tryon) is able to grow. The view to the east was spectacular as the sun, now starting to drop in the west, highlighted the jagged peaks and narrow ravines of the mountains ringing the heavily populated basin below. About two hours after this stop we got our first glimpse of Erhai Lake and the cloud-covered Cang Shan mountain range, where we would finally be able to begin our fieldwork.

Our driers and presses in the Erhai Lake Hotel, Xiaguan. This was to be our base camp for seven weeks.

Setting Up Our Main Base in the Erhai Lake Hotel

A necessary ingredient for anyone conducting fieldwork in China, as has been said many times, is a good measure of patience. Our first day was spent organizing facilities for drying specimens in a large room at the Erhai Lake Hotel, our main base of operations. We asked to have built two large wooden boxes with open bottoms and tops in which we would put kerosene heaters to dry our plant specimens. The work was contracted out to a local carpenter who took full advantage of artistic license and the relaxing regulations on free enterprise by charging us the equivalent of two hundred American dollars for two rather crude boxes, built mostly of scrap boards, that did not quite conform to our specifications. Nevertheless, we were able to arrange strips of wood over the tops of the boxes in such a way that the plant presses could be arranged side by side and end to end over the heat sources. The construction of the boxes took the better part of a day, and we then spent the remainder of the afternoon visiting Erhai Park, at the south end of Erhai Lake.

From the hills above the park we got our first glimpse of the walled city of Dali and its famous pagodas, far off in the distance, on the west side of the lake. The following day was spent at a meeting with officials from the Dali Autonomous Region and Yangbi Xian, and with several people from the scientific bureaus of Dali and Yangbi. Everyone was cordial and most generous in offering assistance, and we knew we could count on these people in the event of problems.

In the Field at Last

Finally, on the third day after our arrival in Xiaguan, we set out for the field. Our first trip was to be a five-day excursion into the mountain directly east of Yangbi. Yangbi is situated on the western side of the Cang Shan; although Dali and Xiaguan, on the opposite side of the mountain range, are now open to foreigners, Yangbi can be visited only with special permission. For this first trip we would be able to drive to our temporary base camp at twenty-eight hundred meters and then hike upward from there, but first we set out for the town of Yangbi, where we were to spend the night. For the first twenty to thirty kilometers out of Xiaguan the Burma Road descends as it follows the river draining Erhai Lake, the water of which eventually flows into the Mekong River just slightly to the northwest. This river cuts through the southern extension of the Cang Shan and has formed a spectacular gorge that is now marred by several hydroelectric stations and the complete pollution of the river by the effluent of a paper mill situated near the southern end of Erhai Lake.

A Bai woman selling eels in Xiaguan.

The collections made on that first day out were from fifteen hundred meters, the lowest elevation we were to reach on the entire trip, and some of the plants collected were never seen again during our stay in China. We stopped twice to collect before reaching Yangbi, where we had lunch and pressed the collections we had made that morning.

During the pressing, one of our Chinese colleagues nearly severed a finger with his clippers while trimming a woody specimen to fit in the press. The rich flow of blood was stopped with an abundant wrapping of Johnson & Johnson Band-Aids, and, surprisingly, after a few days the wound had healed quite nicely. The only other medical problem on the trip occurred when another of our Chinese colleagues, He Si, remained in bed one morning complaining of intense pains in his stomach. This problem proved to be rather serious. Mr. He was taken back to the city of Xiaguan, where it was found that he was bleeding internally. He was then hospitalized for several days. After leaving the hospital he was restricted to a diet of mostly rice soup and mild vegetables for the next several weeks, and even this rather serious problem eventually passed.

Once the morning's collections had been processed we decided to walk down to the river at the edge of the city of Yangbi and to try climbing the slopes on the far side of the river, to see what vegetation remained. Our walk through the town revealed a construction boom taking place; lots of new buildings were going up, and many old buildings were getting facelifts. It was interesting to see that the old, ornately carved wooden fronts of the buildings were meticulously being replaced with with exactly carved replicas. The afternoon's collecting was not particularly noteworthy since much of the natural vegetation had been removed years before we arrived, but we did manage to collect our first specimens of the coniferous genus *Keteleeria* Carrière and a small, creeping plant in the morning glory family (Convolvulaceae), *Dichondra repens* Forster, that has a close relative, *Dichondra caroliniensis* Michaux, in the southeastern United States. With the afternoon's collections safely between sheets of newspaper and bundled up to go back to the base in Xiaguan for drying, we took time to discuss the day's work, what had gone wrong, how procedures could be made more efficient, and what we would have to do to maximize our time in the field. Once discussions were out of the way we prepared for the following day's trip to high elevations and then turned in for the night.

Collecting in the Cang Shan

Our trip to high elevations was one of the easiest of the Expedition. A road had been built to about the twenty-eight-hundred-meter mark for the construction of a hydroelectric station, and we were able to drive the entire way. The valley in which Yangbi is situated is completely under cultivation. As we drove up the west side of the Cang Shan the wet terraces of paddy rice gave way to drier slopes with corn and small orchards of various, irregularly planted fruit trees, but very little native vegetation. On the mountainsides above Yangbi are planted many trees of English walnuts (*Juglans regia* L.), for which Yangbi is famous. It was not until we had nearly reached the hydroelectric facility that we began to see extensive areas of disturbed, but essentially native, vegetation.

The storage buildings used in the construction of the power station served as our base for the next three days, and a small complex of three additional buildings provided housing for the workers and a place to prepare our meals, which we ate outside when it was not raining too hard. From this camp we were able to go off in several directions, but all mostly upward, and it was near this first camp that we found some of the best-preserved forests of the entire trip. The fact that the forests occur in the watershed of the

Trollius yunnanensis *(Franchet) Ulbrich (Ranunculacaae), a globe flower originally collected by William Purdom and introduced into cultivation in England by James Veitch & Sons around 1910. A common herb of the alpine meadows of northwestern Yunnan and the adjoining parts of Sichuan from 3,000 to over 4,200 meters (9,800 to over 13,800 feet), it does well in loamy, wet soil. The golden-yellow flowers are nearly flat and measure some 3 inches across. As this photograph, which was taken at 3,000 meters (about 9,800 feet) in the Cang range, shows, flowers tend to bloom in threes.*

hydroelectric plant will probably result in their continued protection.

Directly behind the camp at an elevation of about thirty-one hundred meters was a magnificent forest of *Rhododendron sinogrande* Balfour *f.* & W. W. Smith. These rhododendrons, reaching heights of about thirty meters and having trunks some fifty centimeters in diameter, bore thick, leathery leaves that were often sixty to seventy centimeters long and thirty centimeters wide. The trees looked more like magnolias than rhododendrons, and—in the very wet, cloud-forest habitat on a plateau high above a spectacular, misty waterfall, with everything covered by mosses, liverworts, and epiphytic ferns—they looked particularly lush. We were too late to see this rhododendron in flower, but it is known to have large, white campanulate (bell-shaped) flowers, each with a bright purple spot in the center. Although much too tender to grow in the Boston area, this species does well in the cool coastal areas of northern California.

Because of the moisture, this was one of the few places where the local people had been unable to burn the forests, even though immediately adjacent areas showed signs of recent fires. One of the disadvantages brought on by the abundant moisture was the prevalence of terrestrial leeches, which were by far the worst in this area. These leeches are abundant throughout the Old World Tropics and Subtropics and are one of the occupational hazards of fieldwork in this part of the world. They are usually found on the undersurfaces of leaves and readily attach themselves to passing animals that brush against them. The leeches release a powerful anticoagulant into a bite, causing blood to flow copiously. Even after the leeches have been removed or have drunk their fill of blood, the wound continues to bleed, sometimes for several hours. Keeping pant legs tucked into the tops of boots and wearing special, tightly woven linen socks that reach up and tie around the leg just below the knee help to keep most leeches out, but a few always manage to find an opening somewhere.

After three days of thoroughly collecting this site, we returned to our main base in Xiaguan to see how the specimens we had sent back each day had turned out. We were rather disappointed to find that the kerosene

Osbeckia crinita *Bentham* ex *C. B. Clarke (Melastomataceae), a small shrub found from the northwestern Himalaya to China. It is rare in Hubei province but can be common in open grassy places elsewhere in its range. Attaining 2 to 7 feet in height,* Osbeckia crinita *has opposite leaves and reddish, four-angled branchlets. Cultivated in England as early as 1820, it is easily grown in the greenhouse, where it forms a shrub about 2 feet in height. Plants flower in autumn, producing blossoms with four lilac–rose petals and yellow stamens. This plant was found at Chingbiqi, Yunnan, at 2,300 meters (7,600 feet) in elevation.*

space heaters that we shipped from the United States were not operating as expected. The most serious problem was that we could not keep the flame properly adjusted, but what appeared to be much worse was the thick, black smoke that poured out of the tops of the heaters. This soot-filled smoke clogged the perforations in the corrugates and hindered the flow of warm, drying air. After reading the directions that came with the heaters and finding that they produced smoke at elevations greater than two thousand feet (we were at three times that elevation) and then pondering the problem for most of a day, we decided to try the small kerosene stoves that the Chinese used for cooking. The disadvantage of using these was that there was no protective cover over the open flame they produced, but they did give dependable, smokeless heat. With visions of accidentally burning down the building that housed our driers, we decided to give the kerosene cook stoves a try. After some experimenting the flame was adjusted for adequate drying, and through the diligence of several technicians we avoided causing a major conflagration.

A Series of Efficiently Organized Marches

After the relative ease of travelling by minibus to nearly three thousand meters, the rest of the expedition was to prove more strenuous; we would have to hike to our temporary base camps, work there for several days, and then hike back to the nearest road before

The marble market in Dali, Yunnan. The Chinese word for marble, dali shi *(the stone of Dali), comes from the name of this city on the eastern slope of the Cang mountain range.*

driving on to the next site. These efficiently organized marches included about twenty pack animals to haul our tents, sleeping bags, food, a dry change of clothing, cooking utensils and other supplies needed to support a group of ten botanists, a cook, the procurer of supplies, several officers from the local scientific bureau, two or three guides, and several assistants. Each trek of about twenty kilometers started from an elevation of about fifteen hundred meters and coursed upward over well-worn, but primitive trails to around twenty-seven hundred to twenty-nine hundred meters and usually took eight to ten hours of continuous hiking, with a short break for lunch. Except for some of our Chinese colleagues and the local people who supplied the pack animals and were accustomed to such hikes, most of us were exhausted by the time we reached the sites where we would make camp. A short rest often revived us enough for us to be able to pitch the tents and dig ditches around them to drain off the inevitable torrents of water that would fall. A hot meal consisting of several dishes (rice, several kinds of vegetables and meats, bean curd, and other standard Chinese staples) provided the energy we would need for the following day's collecting. When it was not raining, the short twilight between dinner and bedtime frequently afforded spectacular views of the surrounding mountains and valleys and the approaching and departing storm fronts.

During the day at several of these camps we shared what little level ground there was

The Catholic Church at Dali.

with small groups of four to eight young (five to twelve years old, rarely older) herders, who would drive their mixed assemblages of pigs, sheep, cattle, goats, and horses to these high-elevation pastures each day to graze. At about six o'clock in the afternoon, each young herder would cry out at periodic intervals in his own distinctive, melodic voice for his charges to return. Without fail the cries would produce a rush of animals from every direction, heading toward the source of the sound. To maintain these important grazing lands, the local people periodically burn the vegetation to remove all woody growth. Each year the fires burn more deeply into existing forests, leaving less and less of the original diversity and resulting in more and more extensive bracken-filled pastures. (The cut bracken did come in handy, though, for use as a thick, springy ground cover under the tents.)

From several of these high-elevation camps we were able to explore upward into the alpine zone at around four thousand meters, and in other directions into rich, wet ravines filled with ferns, mosses, and other moisture-loving plants. Every day produced some botanical surprises: an extensive colony of the deep-purple-flowered lady's-slipper, *Cypripedium tibeticum* King *ex* Rolfe, at about thirty-five hundred meters; a bog at around twenty-four hundred meters with *Burmannia disticha* L. and *Epilobium blinii* H. Léveillé, an exceedingly rare willow-herb collected only once in the previous thirty-five years and known only from a few other collections; several spectacular and bizarre species of *Arisaema* Martius; the magnificent lily, *Cardiocrinum giganteum* (Wallich) Makino; an unusually common sundew, *Drosera peltata* W. W. Smith var. *lunata* (Buch.–Ham.) C. B. Clarke, on slopes under *Rhododendron arboreum* subsp. *delavayi*; many plants of *Habenaria davidii* Franchet in an overgrazed pasture; *Osbeckia crinita* Bentham *ex* C. B. Clarke; and many unusual species of *Impatiens* L., *Rhododendon* L., and *Vaccinium* L., including the Cang Shan endemic, *Vaccinium delavayi*, a small evergreen shrub about ten to twenty centimeters tall. Unfortunately, it was too early in the season to see most of the seventy or so species of *Gentiana* L. known from this mountain range.

We pressed many of these plants in the field as we collected them, but because of bad weather or insufficient time, we placed some in large plastic bags and took them back to the campsites for pressing. After dinner we sorted, numbered, and bundled the

A shepherd in Malutang, Yunnan, at an elevation of 2,800 meters (9,200 feet).

collections for shipment the next day by mule and then by truck back to Xiaguan for drying. To assist the regular staff member from the Institute of Botany in Kunming, who stayed in Xiaguan to care for the specimens, a technician from Xiaguan was hired to help with the processing of specimens being sent back. She proved to be remarkably capable and, despite the language barrier, was extremely quick to grasp techniques and to pitch in with whatever had to be done. On Sundays she delighted everyone by bringing her daughter to stay with her during the half day that she worked.

Collecting on the Eastern and Northern Slopes

With the western, and wetter, slope of the Cang Shan thoroughly collected along most of its length, our party shifted operations to the eastern slope. The eastern side of the range has been inhabited for several thousand years, no doubt because of the abundance of fish, freshwater shrimp, and golf-ball-sized snails in Erhai Lake and the numerous, fertile alluvial fans and the broad plain its base. The effects of this long history of human habitation are clearly seen in the nearly total

A scene at 2,800 meters in Malutang, Yunnan.

absence of forests on the eastern slope of the Cang Shan and the total destruction of forests on more-accessible sites. The only forests remaining in the Cang Shan are small expanses of *Abies delavayi* Franchet forests that occur above thirty-two hundred meters. Some recent plantings of *Pinus armandii* Franchet and *Pinus yunnanensis* Franchet have been made at lower elevations, but many of these smaller trees are frequently cut by the local people for whatever needs arise, and the plantations appear to be relatively unproductive.

As important and famous as the walnuts are for Yangbi on the western side of the Cang Shan, they do not compete with the considerable fame and importance held for the marble quarried on the eastern slopes. So famous is the marble from this region that the word for marble is *dali shi* in Chinese and *dali seki* in Japanese: *dali* for the famous walled city at the foot of the mountain and *shi*, or *seki*, the word for stone. The quarrying of marble and the crafting of the stone into various ornamental and functional items is a considerable industry in the area, and many buildings and other large structures are totally or partially made of marble.

In many places the heavy rainfall in the Cang Shan has eroded the marble of the mountain into deep gorges. The top of the mountain is almost continuously in the clouds, except for periods in the winter and for briefer times at other seasons of the year, and the clouds generally bring a good supply of water from farther west that falls as rain or snow at the higher elevations. The rain, often torrential, has eroded away large boulders and carried them to the foot of the mountain, where they are now buried beneath tons of alluvial till on the plain adjacent to the lake. These huge boulders, some of marble and others of granite, are large enough to be of commercial value for building stones and are actively excavated from the outwash plains and chiseled into building blocks. This industry is so extensive at some sites that the ground appears as cratered as any place on the moon.

Our final long collecting journey in the Cang Shan was at the northern end of the range. After having hiked in to several previous areas, we inquired about the possibility of renting additional pack animals for riding. We were told that this would be possible, and relatively inexpensive—about two and a half American dollars per day—and we were all looking forward to an effortless, all-day journey on horseback. When our "horses" arrived we discovered, first, that they too were mules, and second, that the "saddles" were the usual pack saddles with only a blanket thrown over them. Nevertheless, we climbed aboard and were delighted at this new, effortless means of mountain climbing. It took only a few hours, however, to discover how uncomfortable a wooden pack frame can be, and for several days afterwards we were instantly reminded of our "horseback" ride each time we tried to sit.

This last site in the Cang Shan proved to be one of the most interesting, for it contained the greatest number of truly temperate elements that we saw on the entire trip. Whereas all of the other sites were vegetated with Himalayan, Thai, or Burmese elements, this area, primarily on north-facing slopes, supported such more typically central Chinese plants as *Malus* Miller, *Sorbus* L., *Viburnum* L., *Clintonia* Rafinesque, and *Enkianthus* Loureiro in an abundance that we had not seen before in this part of China. We could only guess that this flora represented an extension from the Lijiang Snow Range, which was just a short distance to our north.

The Return to Kunming

After several days of packing up supplies, readying specimens for transport, cleaning up the room we had used as a base camp, and meeting with various officials to discuss the results of our trip, we began our journey back to Kunming. This time we decided to make it a two-day trip, with occasional stops for collecting on the way. The stops allowed us to add a few additional plants to our collections and to discover one small patch of relatively mature vegetation along the road that made for brief, but interesting, study. On our return to Kunming, as planned, we made several day trips out of the city to collect in various habitats. When our collecting options were finally exhausted, we divided the specimens into a Chinese set and an American set. As agreed beforehand, the first set of all collections was to remain in China and the second set was to go to the United States. The American participants further agreed that the first set of the American portion of the specimens should be deposited in the Arnold Arboretum Herbarium to supplement what is already one of the most extensive collections of Asian plants in the world. Once the specimens were divided, the American set was boxed for shipment, and the Chinese set was arranged in systematic order for identification. We had decided that identifying the collections in Kunming made the most sense; botanists at that institution have been actively working on a multivolume *Flora of Yunnan* and would have the expertise to help with any problems that might arise, and the herbarium would contain representatives of most, if not all, of the plants we had collected. After three weeks of herbarium work everything was identified to

Our memorable mule caravan trek from Dali (1,900 meters, or 6,200 feet, in elevation) to Huadianba (elevation 3,000 meters, or 9,800 feet).

the best of our abilities, but a large number of sheets remained for examination by specialists at other institutions working on particular families for the multivolume *Flora of China*. These identifications were made after we left China and were forwarded to us by mail.

The Expedition's Results

In the United States, all of the data associated with the specimens were entered into a computer at the California Academy of Sciences in San Francisco. The data were brought up to date periodically as new identifications arrived from China and as spellings and author citations were checked. The computer was then used to generate labels for all of the collections, probably the first time a computer has been used for this purpose for plants collected in China. The data are still available in the computer and can be manipulated in various ways to generate reports on the expedition and for various kinds of studies on the flora of China.

In total, the expedition produced 1,653 collections of flowering plants and ferns, which, with duplicates, resulted in 19,015 herbarium specimens. The main sets of these specimens will be stored in the herbaria of the participating institutions, the Institute of Botany in Beijing, the Kunming Institute of Botany, the Arnold Arboretum, and the California Academy of Sciences, and duplicates will be sent to other major botanical research institutions throughout the world where studies of the Chinese flora are taking place. In addition to the vascular plants, we collected more than two thousand numbers of mosses. The first set of these will remain in China, but the second-most-complete set will be deposited in the herbarium of the Missouri Botanical Garden; duplicate specimens of the mosses will also be distributed to other botanical institutions throughout the world.

The Future: Botanical Research and the Need for Conservation

Although we were not permitted to collect living plants or seeds on the 1984 expedition, we fully expect that this situation will change in the near future. Between the time of the first Sino–American botanical expedition, which took place in 1980, when essentially no protection was given to natural areas or plants anywhere in China, and the second expedition in 1984, the Chinese government and the Chinese people have become greatly concerned about the environment and the protection of rare and endangered plants and animals. Many areas have now been set aside as preserves, and many others are regulated in various ways, sometimes without much study or consideration. Once these areas have been scientifically evaluated it is almost certain that new regulations will be formulated that will allow for scientific research and the judicious removal of living plants and seeds for study and for exchange with botanical institutions outside of China. Until a balance can be reached, which should happen within the next few years, we can only be patient and understanding of these restrictions. Chinese botanists are most sympathetic to this problem, which also directly affects them and their research efforts, and are doing all that they can to foster botanical research and cooperation between Chinese and American botanists. Their efforts have been extraordinary in many cases, and it has only been through their persistence and dedication that the joint expeditions and botanical exchanges have been, and will continue to be, so remarkably successful.

Acknowledgments

We are grateful to the National Geographic Society for providing funding for both the 1980 and 1984 Sino–American Botanical Expeditions and to the Chinese

Tripterigium forrestii *Loesener, a member of the Celastraceae, which George Forrest first collected in 1906, on the eastern flank of the Dali range, during one of his early trips to Yunnan. He introduced it into cultivation. The species, which is a shrub 2 to 4 feet in height, is common in scrub and thickets at elevations of 1,500 to 3,000 meters (5,000 to 10,000 feet). Photographed at Yinglofeng, Yunnan province, in the Cang mountain range, at an elevaton of 2,400 meters (about 7,000 feet).*

Academy of Sciences and the Institutes of Botany in China for their support and financial assistance in China. Numerous individuals in the United States and China have contributed much time and effort towards the success of the United States–China botanical interchanges, but those who deserve special recognition for their continuing efforts are Peter H. Raven, Director of the Missouri Botanical Garden; William Tai of the University of Manitoba; Professors T. T. Yu, P. S. Tang, Y. C. Chien, X. P. Wang, T. S. Ying, and S. Y. Wang of the Institute of Botany, Beijing; Professor A. L. Zhang, Director of the Yunnan Branch of the Academy of Sciences of China; and Professors J. Zhou and X. W. Li of the Kunming Institute of Botany. We also thank our many colleagues and assistants who made sure that our time in the field was productively and profitably spent and that our living accommodations were comfortable and pleasant.

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Along with the steady rise of science and increasing development of industrial and agricultural production, mankind more and more assumes it is his right to conquer the earth and change its form or nature. In the process, intentionally or unintentionally, he has opposed the laws of the natural world, destroyed the dynamic equilibrium of many ecosystems, and often brought catastrophe upon himself and other creatures. Forest denudation, grassland degeneration, the constant spread of deserts, and the pollution of the atmosphere and water systems are now common phenomena in many areas of the world.

From the ecological viewpoint, the establishment of protected areas in different natural zones or biogeographical regions will be of great advantage to society. To maintain typical natural ecosystems for advanced study and to provide a scientific base for rational utilization and restoration of nature are of overwhelming importance.

China, as with many countries in the world, has high regard for this important cause. More and more people are giving attention to expanding and strengthening this work.

Two reports on current work in conservation follow. The first is an overview excerpted from an article ("Nature Conservation in China: The Present Situation") by Professor Wang Xianpu, of the Institute of Botany, Academia Sinica, Beijing, that was originally published in Parks, *Volume 5, Number 1, pages 1 to 10 (April/May 1980). (The above three paragraphs come from that article.) The second report ("*Burretiodendron hsienmu *Chun & How: Its Ecology and Its Protection"), by Professor Wang and two of his associates, focusses on efforts to preserve a valuable but endangered species of tree native to China and Vietnam. It has not been published before.*

Nature Conservation in China: Two Reports

Protected Natural Areas in China

Wang Xianpu

The protected natural areas being established in China reflect the diverse needs of that vast and populous country

China is a populous country. Most parts of eastern China have been cultivated for millennia, and the remaining primary vegetation is not extensive. It will be very difficult to achieve real protection of natural areas if we do not consider this situation and accommodate the needs of industrial and agricultural production necessary for people's livelihood. In China, the establishment of a farm or forest plantation can proceed according to a distinct regulation, but not that of a protected natural area. Either pure conservation is emphasized, or the area is actually "under production" (albeit in name only). As a result, both conservation and production suffer, and their original goals are not attained.

Given conditions in China, the establishment of protected, natural areas should serve four primary functions: conservation, scientific research, production, and tourism. The areas should be bases for scientific research, production, and tourism, and such nature conservation as is undertaken should relate closely to the needs of production. Such protected natural areas thus will have full vitality and will include not only virgin regions, but also parts of developed regions. Different regions have different ways of being managed, but they may be subdivided into three related parts.

☐ *Core Area:* The original vegetation of the natural landscape within a protected natural area is called the "core area." It should include the typical representative location of the natural landscape zone or natural biogeographic province. It must be strictly protected to avoid inadvertent destruction. The main use is to carry on ecosystem studies of the relationship between the biological and environmental factors and among different ecosystems, and to study the role and significance of their existence in relation to industrial and agricultural production and people's livelihood, etc. Thus, it can provide basic information for environmental conservation and monitoring.

☐ *Buffer Area:* A buffer area must be set up around the core area to prevent the destructive influences of human activity. The buffer area may be a semideveloped place composed of successional vegetation. Within this area we can undertake different experiments in the rational utilization and reformation of the vegetation according to practical needs. The work can include vegetation succession, multistory management of the community, and the breeding and feeding of animals.

☐ *Experimental Area:* The protected natural area should also include a part that is exploited called "the experimental area." Based upon the environmental features of the locality and people's needs, we can exploit local biological resources, cultivate special native products, and establish artificial ecosystems. Thus, the area will play a typical and expansive role in vegetational renewal and in the establishment of artificial ecosystems of the same natural landscape zone. Necessary service facilities should be set up in suitable places for the needs of research and tourism. Since nature conservation is a popular cause, people should be encouraged to carry out the work together. Managers of protected natural areas still must have links with related institutions of science, education, and production; invite their experts to serve as advisors and to work together when possible. The natural protected area must provide necessary and possible support, such as seeds, seedlings, and technical materials, for productive institutions, to make suitable contibution to industrial and agricultural production. Thus the protected natural area not only protects the original natural ecosystem, becoming a pool of the natural resources and a place of prevailing scientific knowledge and tourism, but also provides for rational utilization and reformation of the lands, and creates certain material wealth for society. Therefore, such an organization will certainly and easily get the support of the government and a welcome from the people. The workers themselves will be interested in their work and the cause of nature conservation will be advanced.

Although we have done some work in nature conservation, as compared with other advanced countries our effort falls behind. Up to 1979 we had established only about fifty natural protected areas, occupying only 0.16 percent of the total area of our country. The distribution of natural protected areas also is not adequate. Most of them are concentrated in the forest regions of the eastern half of the country. In the areas of steppe, the desert of the western half, marshland and coastline, etc., adequate reserves have not yet been established.

The management of existing protected natural areas needs to be improved. The contradiction between conservation and the needs of woodcutting, collecting medicinal herbs, and hunting has not yet been entirely solved. Destruction still occurs. Provisions for scientific research and investigation and tourism are, comparatively, in the primary stage. At present we are carrying on overall planning to strengthen the organization, and are ready to establish some protected natural areas in the western part, and to increase the numbers of the protected natural areas in the eastern part of the country. The area of the increase will certainly not be too large, but the distribution must be treated as equally as possible.

The Main Types of Protected Natural Areas in China

The establishment of protected natural areas in one of the important ways natural resources can be preserved and safeguarded. These places are living natural museums and gene pools of biotic resources. They provide an excellent base for observing and studying the laws of nature, protecting and breeding rare or endangered plants and animals, introducing and acclimatizing valuable species, carrying out research on ecosystems, education, tourism, and so on. Different countries give different names to these places, such as national parks, national forests, protected areas, reserves, preserves, national biotic areas, managed resource areas, multiple-use management areas, and the like. Although these names have different specific meanings, depending on uses and limitations, their basic meaning is more or less similar. We consider that, as a whole, it is suitable to call these places "protected natural areas." We recognize however, that they differ from each other and the protected element usually is not the same. We may divide the present protected natural areas of China (Table 1) into the following several types and introduce them briefly:

□ *Areas for the Protection of the Whole Natural Landscape:* In general, this protected natural area is large enough to include different ecosystems of the whole natural landscape in a given location, and it must have enough area to provide living environments for the protected animals.

☐ *Areas for the Protection of Special Types of Ecosystems:* The total size of these protected areas is not large enough, certainly, but they do protect mainly certain types of ecosystems and some species of rare animals and plants. They may be used for scientific research and collecting seeds or conserving water and soil. Most of the protected natural areas in the eastern part of China, especially in the tropical and subtropical mountains, belong to this type. In the future many more of this kind of protected natural area should be established according to actual needs.

☐ *Areas for the Protection of Rare Species of Animals and Plants:* The establishment of this kind of protected natural area is determined according to actual condition and needs. For example, the remaining 3,000 trees of *Metasequoia glyptostroboides* in Lichuan, Hubei province, are distributed over an area of about 600 square kilometers. The protected area is based on the distribution of the feature protected. There are many bird islands, snake islands, and related lakes and other water systems in different regions.

☐ *Areas for Tourism and Recreation:* There are many regions of attractive scenery in China. Most of them are connected with famous historical monuments and temples, and still there are small patches of natural forest and, rarely, some old trees. Natural scenery is attractive to tourists. Some areas have great value for scientific research. In general, organizations have been established to take the responsibility for management of these interesting places. But it is useful to put them into the category of protected natural area to strengthen their multiple use and management.

Vegetation Regions

The vegetation regions of China may be divided into three main groups, (a) the forest regions in the east, (b) the steppe and desert regions in the northwest and northeast, and (c) the regions of high mountains and plateaus in the west and southwest.

Of the eastern forest regions, from north to south, there are (1) coniferous forest, (2) the mixed coniferous and deciduous broadleaf forest, (3) the deciduous broadleaf forest, (4) the mixed deciduous and evegreen broadleaf forest, (5) the evergreen broadleaf forest, (6) the tropical monsoon forest and rainforest, and (7) the tropical vegetation coral islands.

In the northern dry region, we distinguish, from east to west, the following regions: (8) the forest steppe, (9) the steppe, and (10) the desert steppe and desert.

Of the highland region, we distinguish: (11) the mountains of northwestern China, namely, the Chilienshan, the Tianshan, and the Aertaishan, (12) the mountains and plateaus of eastern Tibet, and (13) the Tibetan Plateau. There are particular types of forest, shrub, meadow, steppe, and desert in these regions.

Description of the Regions

The thirteen vegetation regions of China are described in the following paragraphs.

☐ *The coniferous forest* occupies the extreme north of China. It embraces chiefly the Daxinganlin, a long and narrow chain of gneiss and granite mountains forming the uplifted margin of the Mongolian plateau. The average elevation of the region is between 500 and 1,000 meters.

Considerable area of forest is still preserved. Daxinganlin Nature Reserve was established in 1960 at the upper reaches of the Hanma and Nuomin rivers. With an area of some 480,000 hectares, it is the biggest protected natural area in China. At present the region is under exploitation, however, so the work of nature conservation must be strengthened.

☐ *The mixed coniferous and deciduous broadleaf forests* are situated in the northeast corner of northeastern China. They include the Changbaishan massif and a large portion of the Xiaoxingalin. This is the main forest region of China. Owing to the cutting of timber for a long time, the area of forest is being more and more reduced. The rational cutting and regeneration of the natural forest and silviculture of the artificial forest are the chief tasks of forestry management there. The matter of vegetation conservation cannot be delayed.

☐ *The deciduous broadleaf forest* is principally the broad area stretching from the southern portion of the Manchurian plain to the northern shore of the Huai River and the northern slopes of Qinling. The region was exploited early. The plain is almost entirely under cultivation. In Qinling the Taibaishan forest region is well protected. The Taibaishan Nature Reserve was established in 1965. It occupies 54,158 hectares and includes all vertical vegetation types. In addition, there are many famous scenic mountains in the region, containing many celebrated places and historical ruins. They all must be brought under control as protected natural areas.

☐ *The mixed deciduous and evergreen broadleaf forest,* the transitional region between the deciduous and the evergreen broadleaf forests, belongs more to the subtropical category from the viewpoint of vegetation analysis, so we call it northern subtropics. It includes the southern portion of Shanxi lying between Qinling and the Dahashan, large parts of Hubei province, and the Lower Yangtze Plain. The western part of the region is rugged, varying mostly from 800 to 2,000 meters in elevation, while the eastern part is an alluvial plain with hills rising from 100 to 200 meters.

The plain has been almost entirely cultivated. The climax community on the yellow brown soil of the mountians is mixed deciduous and evergreen broadleaf forest. At higher elevations one finds subalpine coniferous forest dominated by endemic *Picea,* and *Abies,* alpine bush, and alpine meadow. The vegetation of the limestone hills is deciduous broadleaf forest dominated by *Ulmus, Celtis, Zelkova,* etc. Owing to increased cutting of timber, the forested area is limited. The hills and mountains are chiefly occupied by pine woodland, secondary bush, and grassland. It is very necessary to strengthen vegetation conservation. Several years ago protected natural areas were established on the southern slope of Qingling in Foping, Shanxi province, and Shennongjia, Hubei province. The latter reserve is about 2,000 hectares in area and is occupied by subalpine coniferous forest, in which the golden monkey and the Chinese dove tree (*Davidia involucrata*) are comparatively rare.

☐ *The evergreen broadleaf forest,* which has a climate typical of the moist subtropics of eastern Asia, occupies a vast expanse in China. It may be divided into two subregions—the eastern and western. The former subregion is mainly influenced by the Pacific monsoon, and its climate is moist and warm, the dry and wet seasons not being distinct from each other. The latter is affected by the Indian monsoon; its dry and wet seasons are very marked.

There are twenty-seven protected areas in this region, most of established in the mid- to late 1970s. Fifteen of the areas were set up to protect the evergreen broadleaf forest itself. Because of the need to establish a large gene pool, and the need for forests for the conservation of water supplies, it is very necessary to establish many more natural protected areas. These wil be of great advantage to biological research applied to meeting the needs of industry and agriculture.

☐ *The tropical monsoon forest and rain forest* lie in the northern margin of the Tropics (the "Northern Tropics"). They include the southern part of Kuangdong, Kuangxi, Yunnan, and the extreme southern corner of Tibet and the islands of Hainan and southern Taiwan. The task of nature protection is large and very urgent in this region. Five areas have been set up for the protection of tropical forests; besides these, there are several smaller areas for special protection of rare animals on Hainan. It is also necessary to protect mangroves, which have been much damaged recently.

☐ *The coral islands of the South China Sea* experience frequent typhoons and strong winds. The typical vegetation consists of tropical shrubs growing on coral islands, such as *Pisonia grandis*, *Guettarda speciosa*, and *Scaevola sericea*.

☐ *The forest steppe* is a transitional zone between the forest to the east and the steppe to the west. It may be divided into two subregions, the northeastern and the northwestern. Their common features are large patches of woodland alternating with grassland. The northwestern subregion has been exploited for thousands of years. The destruction of forest, problems of waterlogging and soil erosion are all extremely severe. Sand and silt in the lower reaches of the Yellow River originate in the loess plateau of the northwestern subregion. To regulate the Yellow River, it will be necessary to strengthen efforts to protect the loess plateau by planting grasses and forests to prevent waterlogging and soil erosion.

There is only one protected natural protected area in the region, in the wetland of Zhalong, near Qigihari city, Heilongjiang province, to protect the red-crowned crane and other water birds. Ziwuling and Haunglongshan are suited for the establishment of protected natural areas.

☐ *The steppe* occupies largely the Inner Mongolian plateau west of the Daxinganlin and north of the loess highlands. The climax community is *Stipa* (a grass) steppe. Because of inadequate management, the grassland is being very severely denuded. It is urgently necessary to strengthen vegetation protection by rational utilization and restoration of the grassland. No protected natural areas have been established in this region, but six or seven years ago an experiment station for the study of steepe ecosystems was founded in Inner Mongolia and plans made to establish a protected natural area.

☐ *The desert steppe and desert* include the western part of Mongolia, the northern part of Gansu, the Talimu and Zhungeer basins of Xinjiang, and Chaidamu basin of Qinghai. This region is mostly surrounded by high mountains that keep out the moist winds from the distant oceans. Glacial meltwater from the mountains irrigates many oases, where cotton, grapes, melons, and some vegetables grow very well. Because the soils are dry and saline, it is difficult to exploit virgin land. Recently, certain shrublands and woodlands have been severely damaged. There is an urgent need to strengthen the management of the species that have been damaged.

☐ *The mountains of northwestern China* consist of three sections, (1) the Tianshan, (2) the Qilianshan, and (3) the Aertaishan. (The suffix *-shan* means "mountain range" in Chinese.) The foothills of Tianshan are desert; higher up, the desert is gradually replaced by desert steppe, above which is the mountain steppe dominated by grasses (*Stipa*, *Festuca*, *Koeleria*, etc.). Qilianshan, situated at the northern limit of the East Tibetan Plateau, marks the boundary between Gansu and Qinghai provinces. *Picea crassifolia* occurs in pure stands on the northern slope of Qilianshan. Clear cutting of large areas of the *Picea* results in the formation of bushland or aspen woodland. From lowland up to the mountains in Aertaishan, desert steppe, mountain steppe, subalpine coniferous forest appear in succession. Occasionally, elfin wood and alpine tundra also occur. Protected areas are very urgently needed because these mountain forests are very slow to recover if they are destroyed.

☐ *The mountains and plateau of East Tibet* encompass the eastern part of Tibet, northwestern Sichuan, and northwestern Yunnan. The region is heavily wooded, ranking second only to northeastern China in this regard. The contrast between cutting of timber and protection of the forest is more and more marked. The establishment of protected natural areas cannot be delayed.

☐ *The Tibetan plateau* is a lofty plateau rimmed by even loftier mountains—the Kunlun to the north, the great Himalaya range to the south. The average elevation of the whole region may be taken as from 4,700 to 5,300 meters. Under cold and dry climate, winters are extremely severe; even in summer the temperature scarcely rises above the freezing point. From southeast to northwest, there is a clear zonal distribution of vegetation, namely, high cold meadow dominated by *Kobresia*, and cold steppe dominated by *Stipa purpurea*, high cold desert composed of *Ceratoides compacta* and *Ajania fruticulosa*. In these communities different cushion plants grow which are seldom seen in the northern steppe and desert of lower elevation. There is a great need to establish natural protected areas in this region.

Table 1. Protected Natural Areas in China as of 1980

Name of Protected Area	Location (Province)	Area, hectares	Year Established	Main Protected Element(s)
Fenglin Forest Reserve	Heilongjiang	18,400	1963	Red pine and deciduous broadleaf mixed forest
Qiqihari Zhalong Crane Sanctuary	Heilongjiang	42,000	1976	Red crowned crane and wetland ecosystem
Hanma–Hujin Daxinganlin Nature Reserve	Heilongjiang	480,000	1960	Coniferous forest dominated by *Larix*
Changbaishan Nature Reserve	Jinlin	215,110	1960	Different ecosystems and northeast tiger, sika deer, *Panax schinseng*, *Boschniakia rossica*, etc.
Luda Snake Island Sanctuary	Liaoning		1963	Snakes
Qinghaihu Waterfowl Island Sanctuary	Qinghai	7,850	1975	Waterfowl
Baishuaijiang Nature Reserve	Gansu	95,292	1963 (1978)	Subalpine coniferous forest ecosystem and giant panda, golden monkey, etc.
Taibaishan Nature Reserve	Shanxi	54,158	1965	Different ecosystems
Foping Yueba Nature Reserve	Shanxi	35,400	1978	Subalpine coniferous forest ecosystem and giant panda
Wenchuan Wolong Nature Reserve	Sichuan	200,000	1975	Subalpine coniferous forest ecosystem and giant panda
Nanping Baihe Nature Reserve	Sichuan	20,000	1963	Subalpine coniferous forest ecosystem and giant panda
Nanping Jiuzhaigou Nature Reserve	Sichuan		1978	Subalpine coniferous forest ecosystem and giant panda
Pingwu Wanglang Nature Reserve	Sichuan	27,700	1965	Subalpine coniferous forest ecosystem and giant panda
Hainan Nanwanling Wildlife Sanctuary	Guangdong	930	1965	Macaque
Heyuan Xingang Wildlife Sanctuary	Guangdong	2,500	1976	Rare animals

Name of Protected Area	Location (Province)	Area, hectares	Year Established	Main Protected Element(s)
Luyuan Wuzhishan Chingjendong Nature Reserve	Guangdong	5,000	1976	Evergreen broadleaf forest and rare animals
Ledong Jianfengling Tropical Forest Reserve	Guangdong	1,635	1960	Mountain rainforest
Zhaoging Dinghushan Nature Reserve	Guangdong	1,140	1956	Evergreen broadleaf forest
Nanjing Hexi Dadoushan Forest Reserve	Fujian	15	1963	Evergreen broadleaf forest
Sanming Shenkou Forest Reserve	Fujian	800	1960	Evergreen broadleaf forest
Jianou Wanmulin Forest Reserve	Fujian	110	1976	Evergreen broadleaf forest
Wuyishan Forest Reserve	Fujian	56,666	1978	Evergreen broadleaf forest
Linan Xitianmushan Forest Reserve	Zhejiang	2,000	1962	Evergreen broadleaf forest
Taishan Wuyanlin Forest Reserve	Zhejiang	2,000	1975	Evergreen broadleaf forest
Longquan Fengyangshan Forest Reserve	Zhejiang	2,000	1975	Evergreen broadleaf forest
Kaibua Gutianshan Nature Reserve	Zhejiang	2,000	1975	Evergreen broadleaf forest
Wuhu Alligator Sanctuary	Anhuei		1977	Chinese Alligator
Qianshan Wuyishan Forest Reserve	Jiangxi	1,400	1977	Evergreen broadleaf forest
Longnan Joulianshan-Forest Reserve	Jiangxi	700	1976	Evergreen broadleaf forest
Yuoriqai Tiebu Wildlife Sanctuary	Sichuan	30,000	1964	Sika deer, etc.
Tianguan Labahe Nature Reserve	Sichuan	12,000	1974	Takin, etc.
Qingchuan Tangjiahe Nature Reserve	Sichuan	40,000	1978	Subalpine coniferous forest ecosystem and giant panda
Liangshn Dafengding Nature Reserve	Sichuan	40,000	1978	Subalpine coniferous forest ecosystem and giant panda
Baoxing Dachugou Nature Reserve	Sichuan	40,000	1975	Subalpine coniferous forest ecosystem and giant panda
Beichuan Nature Reserve	Sichuan	10,000	1979	Subalpine coniferous forest ecosystem and giant panda

Name of Protected Area	Location (Province)	Area, hectares	Year Established	Main Protected Element(s)
Tongyen Fanjingshan Nature Reserve	Guizhou	36,700	1978	Different ecosystems and golden monkey, etc.
Mengluen Nature Reserve	Yunnan	6,061	1958	Monsoon forests, rain forests and elephant, gaur, green peafowl, hornbill, etc.
Mengyang Nature Reserve	Yunnan	32,800	1958	Monsoon forests, rain forests and elephant, gaur, green peafowl, hornbill, etc.
Mengla Nature Reserve	Yunnan	6,733	1958	Monsoon forests, rain forests and elephant, gaur, green peafowl, hornbill, etc.
Longsheng Huaping Forest Reserve	Guangxi	13,918	1961	Evergreen broadleaf forests
Guilin Miaorishan Forest Reserve	Guangxi	1,559	1976	Deciduous and evergreen broadleaf forest
Lungzhou Longgang Forest Reserve	Guangxi	10,000	1979	Limestone evergreen monsoon forest
Dongfang Datian Wildlife Sanctuary	Guangdong	2,540	1976	Hainan thamin
Beisha Bangxi Wildlife Sanctuary	Guangdong	333	1976	Hainan thamin
Yifeng Guanshan	Jiangxi	800	1976	Evergreen broadleaf forest
Shennongjia Nature Reserve	Hubei	2,000	1978	Different ecosystems and golden monkey, Chinese dove tree

The flowers, leaves, and fruits of Burretiodendron hsienmu *Chun & How. From* Acta Phytotaxonomica Sinica *(1956). Courtesy of the Arnold Arboretum Library, Cambridge, Massachusetts.*

Burretiodendron hsienmu Chun & How: Its Ecology and Its Protection

Wang Xianpu
Jin Xiaobai
Sun Chengyong

The *xianmu* of southwestern China is a valuable timber-producing tree that now receives much-needed protection through newly established nature reserves and *xianmu* plantations

The tree *Burretiodendron hsienmu* Chun & How ("*xianmu*" in Chinese) is a member of the Tiliaceae. Endemic to the Sino–Vietnamese Border Floristic Province of the Indo–Malaysian Floristic Region, it is an important economic species. In China, it occurs in southwestern Guangxi Zhuang Autonomous Region, extending westward to southwestern Yunnan Province, between 22°05′ and 24°16′ N latitude, and 105°00′ and 108°06′ E longtidude, in the southern Subtropical and northern Tropical zones (Li and Wang, 1964; Li and Wang, 1965) (see the map on page 49). Xianmu grows well on hills of pure limestone, often on steep slopes, on bare rock or in shallow soil. By contrast, it does not occur in hilly areas where the substrate is derived from acidic rocks such as sandstone or shale, even where the slope is gentle and the soil deep. In the northern Tropical Zone, giant trees of this species often dominate the upper layer of seasonal rainforests at the feet of limestone mountians, below 700 meters in elevation (see the back cover of the Summer 1986 issue of *Arnoldia*), where they usually are mixed with such tropical tree species as *Garcinia paucinervis, Drypetes perreticutata, Drypetes confertiflora, Muricoccum sinense,* and *Walsura robusta*. In the southern Subtropical Zone or above 700 to 900 meters, *xianmu* still grows fairly well, mixed with such subtropical tree species as *Cinnamomum calcarea, Cryptocarya maclurei, Castanopsis hainanensis,* and *Cyclobalanopsis glauca*. Farther north, it no longer forms large forests but is scattered in certain localized areas with suitable habitat. The northernmost reported occurrence of *xianmu* is in latitude 24°16′ N (Hu *et al*., 1980; Li *et al*., 1956).

The Vulnerability of *Xianmu*

The timber of *xianmu* is hard and heavy, with good mechanical characteristics, and is suitable—and much prized—for making tools, vehicles, ships, and furniture and for use in construction. Wild trees are suitable for making wheels. Because of excessive felling of trees, the area of seasonal rainforest is decreasing; environmental conditions in many areas of rainforest are deteriorating, making it difficult for *xianmu* to regenerate. In some places there are scattered adult trees of *xianmu* but very few young trees and seedlings beneath; in other places, young trees and seedlings are present but lack the protection of adult trees in the canopy. Thus, it is doubtful whether they will be able to grow to maturity.

It is safe to say that *xianmu* is in a very vulnerable situation. Appropriate measures are urgently needed to protect the species and to promote its regeneration. Otherwise, it will soon become endangered and face extinction (Wang, 1980). Accordingly, four nature reserves have been established for its protection at the centers of its range in southwestern Guanxi. Meanwhile, a tree plantation has been established to produce *xianmu* timber for satisfying demand from various sectors of the economy (Liang *et al.*,1981; Wang, 1984; Wang, 1985*a*; Wang, 1985*b*).

Ecology and Life History

Because of *xianmu*'s economic and ecological importance, knowledge of its ecological relationships and life history is important. Accordingly, details about those aspects of the species's biology are presented in the following paragraphs.

Ecological Relationships

Burretiodendron hsienmu occurs where the annual mean temperature is 19.1 C to 22.0 C, the temperature of the coldest month (January) is 10.9 C to 13.9 C, and the temperature of the warmest month (July) is 25.1 C to 28.4 C. The absolute minimum temperature encountered during the year is minus 0.8 C to minus 1.9 C, the annual accumulated temperature being 6,269.2 C to 7,812 C. The annual precipitation is as high as 1,100 mm to 1,500 mm but is not evenly distributed; instead, 80 percent of it is concentrated in the period from April to September, more than 100 mm falling during each of those months, while during the dry season (November through March), less than 50 mm fall. Precipitation is scarcest in winter, accounting for only 5 percent to 7 percent of the annual precipitation. However, since the dry season is also the coldest period of the year, the relative humidity of the air is not less than 70 percent, ameliorating the effects of drought. This fact explains how giant *xianmu* trees with breast-high diameters of from 1 meter to 3 meters can grow on bare limestone rock in shallow soil with their thick roots partly exposed and extending beyond the extent of their crowns. On mountaintops, where conditions are extremely dry, fewer *xianmu* trees occur, and they are invariably small. *Xianmu* trees planted in sites with poor drainage and a shallow water table grow fast at first, but their roots grow upward and gradually rot, and the trees eventually die.

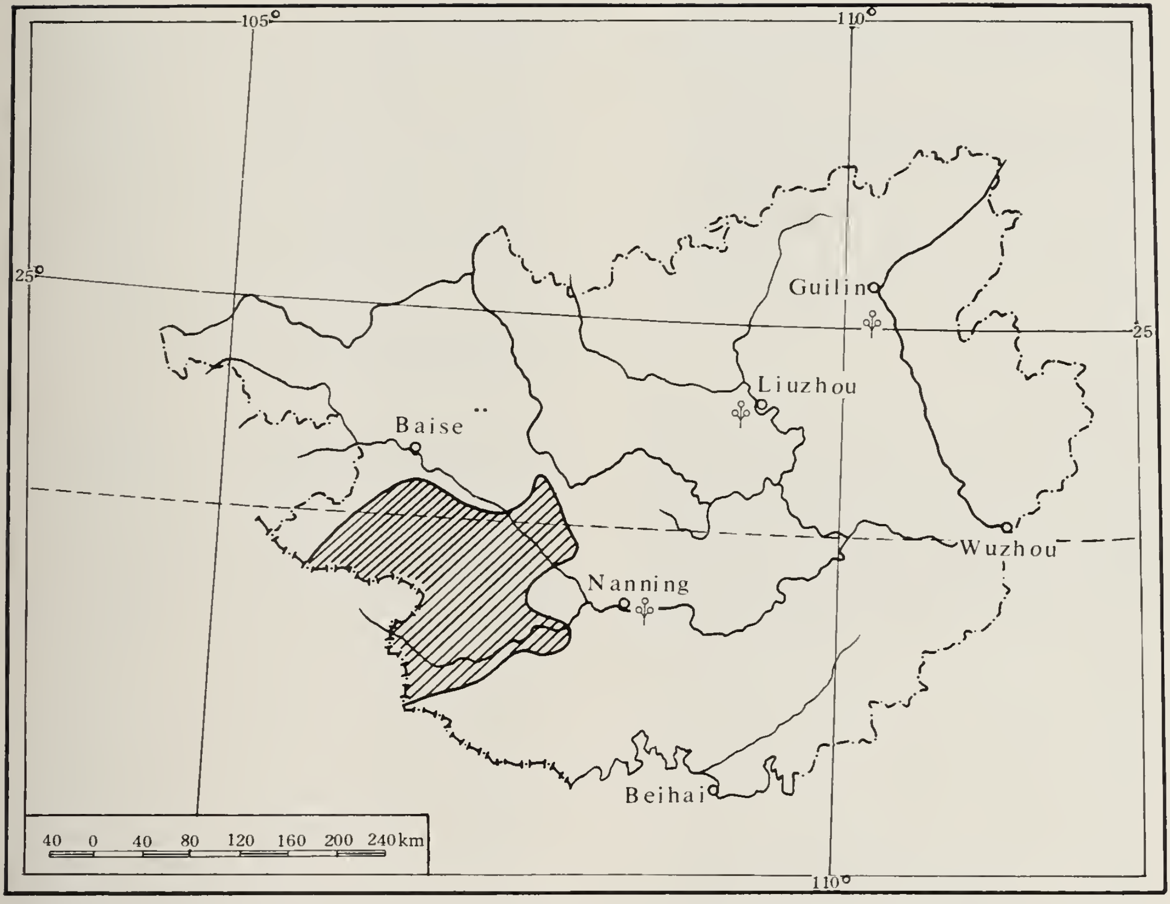
Xianmu is a calciphilous plant, containing little sulfur and manganese but abundant calcium and nitrogen (1.96 percent) in its leaves, which can be used to increase the fertility of soil. If the trees are to be planted in acid soil, the soil must be enriched with manure and supplied with lime beforehand. Otherwise, the trees will not grow normally.

Xianmu trees have pyramidal crowns with branches extending regularly in layers. The leaves are so arranged as to form a mosaic and therefore can make maximum use of sunlight. The leaves that fall each year accumulate on the ground, forming a thick layer up to 15 cm thick. The soil consists of 5 percent to 10 percent organic matter, while the layer of decomposing leaves and twigs may contain as much as 23.02 percent organic matter.

The buds and the young leaves of *xianmu* are protected by a gummy substance. The blades of adult leaves are thick and rigid, with developed xeromorphic structure, and are adapted to the relatively dry habitat, with its great fluctuation in available water over the course of a year. The seeds are not distributed by wind or animals to distant places. Natural seeding is mostly restricted to the ground under the crowns of parent trees and to immediately surrounding areas. Seedlings and young trees less than six years of age tolerate shade, but trees more than ten years of age do not grow well in shade. Thus, we can see that in forests, twenty- to twenty-five-year-old *xianmu* trees will not have reached the flowering stage, but solitary fifteen-year-old trees are already mature.

Flowering and Fruiting

The flowers of *xianmu* are open in March and April. Its fruits (capsules) begin to ripen in early June, then split open, and the seeds are shed in late June and early July. Seeds that fall to the ground either germinate rapidly or rot quickly, so seeds must be collected promptly, while still on the tree. Each year of fruit setting is followed by two or three off years,



Map of Guangxi province, China, showing the occurrence of Burretiodendron hsienmu. *The hatching indicates its current natural range, the two dots an outlying wild population, and the tree-like symbols localities where the species has been introduced into cultivation.*

when many trees bear few if any fruits. Within ten days after the collection of fruits, as many as 95 percent of the seeds may be viable; after twenty to thirty days' storage, only 60 percent to 80 percent are viable. Most seeds are nonviable after two months of storage. If seeds must be stored, they should be air-dried in the shade before being stored in sand. Seeds so treated have a germination rate that is 60 percent greater than that of seeds stored without sand. If seeds are exposed to bright sunlight for one hour, their rate of germination drops 20 percent; if exposed for longer periods of time, to the point that the seeds become very dry, the rate drops more than 60 percent. One thousand fresh seeds weigh about 210 g; 4,600 to 5,000 seeds weigh 1 kg.

Germination and Early Growth of Seedlings

The seeds start to germinate four days after they have been sown and are fully germinated in eight days. It is advisable to construct shading shelters in the seed beds to shield the young seedlings from bright sunshine, although shade is not necessary if irrigation can be provided to keep the soil moist. The seedlings grow slowly during during the first year, reaching only 10 cm in height by the next spring. Their roots, however, grow much faster. A seedling plant 6.0 cm to 6.5 cm in height, for example, may have a main root that is three to four times longer than the aboveground shoot is high, and that has fifty to seventy lateral roots 5 to 10 cm in length. This explains *xianmu*'s ability to grow in the dry conditions of stone crevices. Trees one and one-half years old usually have attained a height of 70 cm and a basal diameter of 1 cm; they are ready for transplanting in afforestation sites.

Growth Rate

Young wild *xianmu* trees grow very slowly during their first five years, increasing in height only about 30 cm each year. During their second five years, their growth accelerates rapidly to two to four times what it was during their first five years. The rate of increase in height reaches a peak between their tenth and fifteenth years, when their height increases more than 1 meter per year. After the peak period, until the thirtieth or fortieth year, no great reduction in growth rate occurs. The peak period for increase in the diameter of the *xianmu*'s bole is usually between the twentieth and twenty-fifth years, when the increase in diameter at breast height may exceed 1 cm per annum. After that period, the increase remains relatively high until the trees are thirty-two to forty-five years old. In favorable microclimates, the volume of timber in a thirty-year-old tree is 0.4747 cubic meter, the increase continuing well beyond the fortieth year. From these figures we conclude that *xianmu* has a medium growth rate.

When ten years old, *xianmu* trees usually are 5 to 7 cm in diameter at breast height and 5 to 6 meters tall. At this point the forest becomes too dense and a thinning operation may be carried out to remove trees that do not have straight trunks or that obstruct the growth of other trees. By the thirtieth year, and every tenth year thereafter, selective felling is carried out to provide structural timber (Yang, 1958).

When forty to fifty years old, wild *xianmu* trees are 30 cm or more in diameter at breast height and suitable for making wheels. For shipbuilding, fifty- to sixty-year-old trees should be used. Even at that age, however, the volume of timber is still increasing; thus, to obtain the greatest volume of timber per unit area and to produce large-diameter timber, clear-cutting should be done when trees are seventy to eighty years old. In artificial forests, or plantations, the trees grow faster and can be felled ten years sooner.

A Note on Nomenclature and Orthography

The name *Burretiodendron hsienmu* was first published in 1956, by the well known plant taxonomists Professors Chun Woon-young and How Foon-chew (Chun and How, 1956). Many years later, Professors Chang Hong Ta and Mian Ru Huai established a new genus, *Excentrodendron* Chang & Mian, to accommodate *Burretiodendron hsienmu*, which they regarded as distinct enough to require a separate genus (Chang and Mian, 1978). The resulting binomial, *Excentrodendron hsienmu* (Chun & How) Chang & Mian, has not been widely adopted so far, however.

The specific epithet, *hsienmu*, is the tree's Chinese common name as it is Romanized according to the Wade–Giles system. According to the now widely accepted *pinyin* system of Romanization, however, the Chinese name should be spelled *xianmu*. We chose to use the *pinyin* rendering in this paper. Nonetheless, since the form *hsienmu* was used by Chun and How when they described the species, the specific epithet remains *hsienmu*.

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Correction

The name Siebold was mistakenly used for Kaempfer in the article "The Chinese Species of *Camellia* in Cultivation," by Bruce Bartholomew (*Arnoldia*, Volume 46, Number 1, Winter 1986, page 5). *Arnoldia* apologizes to its readers for the error.

Conservation of Plant Lore in the Amazon Basin

Richard Evans Schultes

Salvaging irreplaceable knowledge about the properties of plants, gained over the millennia by fast-disappearing Amazonian cultures, has become an urgent goal of modern-day ethnobotany

With all you potent herbs do I now intercede; and to your majesty make my appeal: ye were engendered by Mother Earth and given for a gift to all. On you she has conferred the healing which makes whole, on you high excellence, so that to all mankind you may be time and again an aid most serviceable.

—An ancient Roman prayer to all herbs

The vertiginous growth in the world's population has put a serious strain on natural resources. The dwindling supply of nonrenewable resources has long been a concern of plant scientists and conservation-minded citizens, and now the severity of the situation has begun to attract the attention of the public and, fortunately, even of some governmental institutions.

Man has only recently begun to take stock of the chemical and genetic potentialities offered by the Plant Kingdom. No botanist can with certainty tell how many species of plants there are in the world. Most estimates in textbooks cite about 280,000, but those of us who work in tropical floras—especially in poorly explored regions—believe that the figure may surpass 500,000. We are currently faced with the incredible task of studying the many thousands of species, most of them still untested and unexamined, many of them not even as yet botanically identified.

The Science of Conservation

There are several aspects of the interdisciplinary science known generally as *conservation*. Three are, however, most urgently in need of wide and constructive attention: one, the protection of plant species in danger of extinction; two, the salvaging of the knowledge about plants and their properties held by fast-disappearing cultures; and three, the domestication of new crop plants or, in broader terms, the conservation of germ plasm of economically promising species.

Tremendous strides have recently been made in many parts of the world towards protecting endangered species, though much remains to be done, particularly in the Tropics. Fragile ecosystems like that of the Amazon basin are especially susceptible to the extinction of species, primarily because of the large pecentage of highly localized endemics which, with the present rapid and uncontrolled destruction of huge areas, may easily be exterminated even before they are discovered and classified by botanists. This aspect of conservation may be the most important, for if the plants themselves disappear, what is there left for us to conserve?

Ethnobotanical Conservation

The second aspect of conservation, which we have come to term *ethnobotanical conservation*, is not yet so widely recognized. But from the point of view of humanity's increasing dependence on the Plant Kingdom, it deserves to be given priority, especially in the search for new health-related products. Only recently has this aspect of conservation been given serious attention. The World Wildlife Fund, for example, has organized an Ethnobotany Specialist Group centered in the Botanical Musuem at Harvard University, the purpose of which is to collect and conserve as much knowledge about the properties and uses of plants as possible from indigenous peoples. Ethnobotanical leaders from around the world are united in a program destined to help salvage this precious information. Many experts in sundry scientific fields believe that this effort represents a milestone in conservation activities.

Conservation of Germ Plasm

The third aspect—and a most significant one—has been going on subconsciously for millennia, ever since the discovery of agriculture ten thousand years ago in the Old World, approximately seven thousand years ago in the New World, namely, the conservation of germ plasm. But it has now come into its own from a scientific point of view: germ-plasm collection must be considered an integral arm of the conservation of natural products.

It is surprising how many of our major economic plants were discovered, domesticated, changed, and improved by primitive societies long before advanced civilizations inherited them and began slowly to apply modern, sophisticated techniques to bend them further to man's use. Of the twelve or thirteen major food plants of the world—rice, wheat, maize, the common bean, soy bean, peanut, white potato, sweet potato, tapioca, sugar cane, sugar beet, banana, and coconut—only one, the sugar beet, did not come to us from primitive societies; it was developed in a deliberàte breeding and selection project instituted in France one hundred seventy years ago.

Primitive man everywhere has lived close to Nature. An important—yes, an essential—part of his living has been a deep and discerning acquaintance with the plants around him. This acquaintance led inevitably to experimentation. From the experimentation, there gradually accrued a knowledge of properties, useful and harmful, of many plants. This knowledge, tested by time, has grown into an integral part of the various aboriginal cultures and has been passed on from generation to generation. Some of it is still with us today. It may not be here long, however.

The Threat from Civilization's Relentless Advance

Civilization is relentlessly advancing in many if not most regions still sacred to primitive societies. It has long been on the advance, but its pace is now accelerated as the result of extended commercial interests, increased missionary activities, widened tourism, and world wars. The feverish road-building in the Amazon basin serves as an example of how fast penetration is proceeding.

With an estimated eighty thousand species of plants, or approximately 17 percent of the world's flora, the Amazon basin must be classified as one of the world's least-tapped emproia of vegetal wealth. Its rain forests have given civilization numerous major economic plants: the pineapple, tapioca, cacao, achiote, coca, timbó, curare, and other useful species. And they have likewise given us the rubber tree, which in only one hundred years has drastically altered life of rich and poor around the world.

Yet the Amazon forest still holds many wild plants that could be of great benefit to mankind. There are many plants which, if we are to judge from their use in local, aboriginal societies, merit consideration for domestication: as sources of food, oils, gums, resins, dyes, and waxes.

The bases of utility of these types of economic plants are, of course, immediately obvious to any observer, but what of those species whose utility depends upon chemical compounds that are invisible to the observer? The number of species that hold promise as potential sources of still-unrecognized constituents of biological activity cannot even be forecast.

We have an academic and a practical obligation to salvage some of the medicobotanical lore before it shall have been forever entombed with the cultures that gave it birth. From the practical point of view few activities can be more cogent than the search for new medicines from the Plant Kingdom. And on this practical obligation is directly founded all efforts in ethnobotanical conservation.

During the last forty-five years, I have concentrated my own ethnobotanical studies on tropical American plants, especially those of Mexico, the northern Andes, and the northwestern part of the Amazon basin. During this period I spent fourteen years of uninterrupted residence among the Indians of the Colombian Amazon and adjacent Brazil. This region is still one of the least acculturated parts of the hylea and, although it represents only a very small sector of the Amazon basin (which, incidentally, is an area larger than the United States), our investigations indicate that there are probably few places in the world where native peoples use a greater percentage of their flora for biodynamic or biological activity—that is as medicines, poisons, or narcotics.

A Nearly Limitless Chemical Factory

Everything points to the wealth of the Amazon's green mantle as a nearly limitless chemical factory almost untouched by scientific study and yearning for conservation, until the properties of its species, discovered and utilized by those humans who have lived with it for millennia, can be subjected to the impartial scrutiny of the laboratory.

It has truly been said that the primitive medicine man may hold, in his knowledge of plants, the key to great new advances in modern medicine. As a Brazilian chemist has recently written: "Since the Indians in the Amazon are often the only ones who know both the properties of the forest species and how they can best be utilized, their knowledge must be considered an essential component of all efforts to conserve and develop the Amazon."

Mainly as a result of the superstitious excesses of medieval European herbal medicine, pharmaceutical science during the last part of the Nineteenth and early Twentieth centuries turned definitely antagonistic to plant medicines. Synthetic chemistry would solve any and all problems, it was believed. Beginning in the early 1930s, there began a series of extraordinary discoveries of new drugs—the so-called "wonder drugs"—that have revolutionized modern medical practices: curare (muscle relaxants from South American arrow poisons); penicillin and a host of other antibiotics (all from lower plants); cortisone (from the Mexican yam); resperine (from the Indian snake root); vincoleucoblastine (an anticancer agent, from the periwinkle); the alkaloids from *Veratrum* (hypotensive agents); podophyllotoxin (a cytotoxic and antifungal resin from the May apple); strophanthine (a cardiotonic from an African arrow-poison plant); and others, all discovered and first isolated from plants—and usually from plants that play significant roles in primitive medicine. As a result of these marvellous discoveries, the pharmaceutical sciences have gradually turned back to the Plant Kingdom as an almost virgin field for new biologically active principles.

Ethnopharmacological Research

A few examples from my own ethnopharmacological research may suffice to indicate the perspicacity of the Indians of the northwestern Amazon basin and the basic reasons why conservation of ethnobotanical information is so fraught with promise. From the norhwestern part of the Amazon, we have field notes on more than two thousand species valued by aboriginal populations for their biodynamic activity. Almost all need investigation, for many species (and even genera and whole families) have never been examined by phytochemists, even superficially.

Recently, I counted the number of new alkaloids isolated from Amazonian species and reported in the literature during the last ten years. My very superficial and most certainly far from complete count gave a total of 278 alkaloids—and we must remember that alkaloids are only one of the many categories of biologically active secondary organic constituents in plants.

My field notes, for example, indicate that thirty-two species are used for purposes suggesting possible cardiac activity; seventy-eight are involved in the preparation of arrow poisons; twenty-seven seem to be insecticidal; forty-two are used as fish poisons; three are employed by the Indians as oral contraceptives; fifty-two are taken to expel intestinal parasites; six are said to be stimulants; eleven are valued as hallucinogens or narcotics—and so the list goes on.

Patinoa ichthyotoxica *R. E. Schult. & Cuatr., a bombacaceous tree the fruit pulp of which is used as a fish poison by the Tikuna Indians of the Colombian Amazonas. Shown here are the tree's flowers and leaves (left) and its fruit (right). Drawings by Irene Brady.*

The Promise of Ethnobotany

Two examples illustrate the botanical perspicacity of the Indians of the northwestern Amazon basin and my reasons for suggesting that conservation of ethnobotanical information is filled with promise. There is an Amazonian hallucinogenic drink variously called *ayahuasca, caapi,* or *yajé*, prepared from the bark of species of liana (*Banisteriopsis caapi*), which contain beta-carboline alkaloids that cause visions in blues, grays, and purples. It is employed in magico-religious ceremonies and as in medicine. To increase the intensity and duration of the intoxication, the natives sometimes add the leaves of another liana of the same family (*Diplopteris cabrerana*) or the leaves of a bush belonging to the coffee family (*Psychotria viridis*). It has been found that these leaves contain other types of psychoactive alkaloids known as tryptamines. Tryptamines are inactive when taken orally, unless they are protected by a chemical constituent known to inhibit monoamineoxidases. The beta-carbolines in the bark of the liana are monoamineoxidase inhibitors. How did our unlettered Indians ever find these two appropriate additives among the eight thousand species in their forests?

A similar extraordinary phenomenon concerns the hallucinogenic snuff prepared from a resinous exudate from the bark of certain Amazon trees of the nutmeg family (*Virola* spp.). This powder, recent investigation has discovered, contains very high concentrations of tryptamines, which, of course, can be active in the form of snuff. But several tribes—Witotos and Boras—do not use the narcotic as a snuff but take it ceremonially in the form of pills. How could these tryptamines be active when taken orally without the addition of a monoamineoxidase inhibitor? More precise chemical examination disclosed the presence in the exudate of trace amounts of beta-carbolines serving as a built-in monoamineoxidase inhibitor that activates the abundant tyrptamines.

Domestication As Conservation: Curare

Finally, we might well consider two examples of domestication as a form of conservation; one a possible new departure in domestication, the other one of the world's most important crop plants.

It was a study of the preparation of curare, or arrow poison, that first took me to the northwestern Amazon, in 1941.

The Indians of this region have the most complex formulas and use the greatest number of plants in preparing their curare. Each tribe and each medicine man has its own recipe. Each recipe calls for a different number of ingredients—from one to fifteen or more. An alkaloid—tubocurarine—isolated from certain forest lianas of the mood seed Family (especially *Chondrodendron tomentosum*)

Banisteriopsis caapi *(Spruce* ex *Grisb.) Morton, a liana whose bark is the basis of a sacred hallucinogenic drink used over a wide area of the Western and Southern Amazon by many tribes in their magico-religious and medicinal ceremonies. This and the two other photographs accompanying this article were taken by the author.*

has become extremely important in modern medicine as a muscle relaxant and for other uses. The synthetic alkaloid apparently does not have the same properties as that isolated from the bark of the lianas. A serious shortage of curare from the forests seems to be imminent.

Pharmaceutical companies still must purchase for the extraction of tubocurarine the syrup prepared by Indians in Amazonian Ecuador and Peru. The liana is extremely slow-growing. Indians must fell it for its bark. Each year, they must go farther afield, and the liana is becoming scarce. Furthermore, rich deposits of oil are being developed in the region, and Indian labor for bark-collecting is harder to find each year. It would seem to be feasible to seek germ plasm of high-yielding lianas for cultivation under greenhouse conditions. The young sprouting shoots might repeatedly be harvested for extraction of the alkaloid and left to grow again, thus assuring a more or less continuous supply.

*A heavy-crowned young Pará rubber tree (*Hevea brasiliensis *[Willd. ex A. Juss.] Müll. Arg., center) on the banks of the Río Loreto Yacu, Amazonas, Colombia.*

The Pará Rubber Tree: Slavery, Then Emancipation

There is one very recently domesticated plant with which I have worked intimately in the Amazon from 1942 to the present: the Pará rubber tree (*Hevea brasiliensis*), domesticated only one hundred years ago. No other plant has so drastically altered life around the world in so short a time. Before its domestication, most of the world's natural rubber came from wild trees in the Amazon basin, produced by Indians living in deplorably subhuman conditions in the malarial forests, far from their homes, under economic conditions approaching slavery or worse, with inadequate diets and no health services against tropical diseases, often sadistically tortured or killed as punishment for not bringing in sufficient latex—a nefarious industry that decimated or extermi-

The flowers and leaves of the Pará rubber tree, which yields almost all of the natural rubber used in the world. Photographed in Amazonian Colombia.

nated whole tribes of a wonderful race.

I am reminded of the feelings of the German anthropologist Koch-Grünberg, an early and earnest conservationist, who spent a long period in the northwestern part of the Amazon basin and who returned to the field there after an absence of five years, during which time the Natives had been impressed into rubber tapping. His words in German are forceful; they lose much of their power in my translation of them into English:

> Hardly five years have passed since I lived in the Caiarý-Uaupés. Whoever goes there now will no longer find the idyllic region that I knew. The pestilential stench of a pseudo-civilization is sweeping over these brown people, who have no rights. Like an all-destructive swarm of grasshoppers, the inhuman hordes of rubber collectors press on and on . . . and force my friends farther and farther into the deathly rubber forests. Raw brutality, mistreatment, murder are the order of the day. . . . Their dwelling sites become deserted, their houses are reduced to ashes, and their gardens, deprived of caring hands, are taken over again by the jungle. Thus a vigorous race, a people with a magnificent spirit and friendly character, are annihilated, and human material capable of development is destroyed as the result of the brutality of these modern barbarians of culture.

In 1876, the British succeeded in domesticating the rubber tree. Two thousand seeds of seventy thousand collected germinated in greenhouses in Kew Gardens. Although the seeds were quite openly exported with the help of Brazilian officials, Brazil prohibited further exportation of rubber seeds. All the millions of acres of today's Asiatic plantations are populated with descendants of these few original trees.

The seeds were collected from one small locality and represent only one strain—and not the best—of the rubber tree. Yet what vast improvements have been brought about from the wild trees in only a century! The yield of rubber from the first plantations was 450 pounds per acre per year; some modern clones are yielding more than 3,500 pounds per acre per year.

Plant Conservation and Human Salvation

Domestication of the rubber tree yielded two results, both of which are relevant to the practical aspects of conservation. It furnished a steady, ample, and inexpensive supply of rubber without which our modern world, especially its transportation systems, could not have come into being. It also saved from virtual annihilation whole tribes of Indians, for once the well run Asiatic plantations began to fulfill the world's need for rubber, the extraction of rubber from wild trees in the jungle, for all practical purposes, died out. Thus, the commercial cultivation of a wild tree saved a whole people, an unexpected result of that branch of conservation known as *domestication*.

The Plant Kingdom remains an almost virgin field for the discovery of biologically active compounds waiting in silent hiding. Can we afford any longer to ignore the hunting ground that has provided, through folklore and serendipity, leads that the pharmaceutical industry has turned into products having annual sales in excess of three billion dollars in the American prescription market alone?

We cannot imagine the uses that the future may have for the thousands of genera that the world's flora holds out to us. For the good of our descendants, for the progress of civilization, and perhaps even for the survival of humankind it behooves us—nay, it obliges us—to protect this nonrenewable gift of Nature and to conserve the knowledge of aboriginal people on how to use it, for the benefit of the entire race.

Note

This article is a modified version of the talk presented on May 21, 1984, to the World Wildlife Fund's International Board of Trustees in Washington, D.C.

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Designing Plants with Rare Genes

John W. Einset

By means of gene-transfer technology important crop plants may someday be enhanced through the shrewd transfer of genes from rare and threatened species

Science is a communal enterprise; it makes significant progress only when findings from diverse avenues of investigation are shared and consolidated. Nowhere is this more apparent than in modern biotechnology, the utilization of living systems (plant, animal, and microbial) for practical purposes. In fact, it can be said that the recent success of plant biotechnology has been built on a foundation of earlier progress in such varied areas of botany as anatomy, biochemistry, ecology, genetics, morphology, physiology, and systematics. In the future, plant conservation, with its emphasis on the preservation of rare and endangered species, will undoubtedly also have a significant impact.

The most spectacular recent innovations in biotechnology involve improved technology for genetically modifying plants and producing individuals with new characteristics. Based on so-called "gene-transfer methods," these novel techniques for plant genetic engineering are currently being accomplished by two different procedures. The first procedure exploits a pathogenic bacterium known as *Agrobacterium tumefaciens*, which normally causes the crown-gall disease, characteristic tumorous overgrowths on infected plants, to transfer desired genes (DNA) into plant cells. By an as-yet undefined mechanism, *Agrobacterium* can mobilize, or transfer, virtually any DNA sequence via its Ti plasmid (a tumor-inducing ring of DNA) into cells in which the sequence becomes stably attached to the plant's own DNA, perpetuated, and expressed as new genetic material. The second gene-transfer method, known as electroporation, utilizes a mixture of plant protoplasts (cells that have had their cell walls removed by enzymatic digestion) plus purified DNA incubated in the presence of a strong electric field. This treatment apparently opens channels in the membranes of protoplasts, enabling DNA to enter cells and to be inherited. Even though electroporation is a less efficient means of transferring genes than is crown gall, its advantage is that it avoids the complex biochemical manipulations required to produce inactivated Ti plasmids that are capable of transferring DNA but are inactive as producers of tumorous crown galls. In addition, electroporation is a more versatile technique than is crown gall, which apparently can be used only on dicotyledonous plants and a few conifers.

Up to this time, the success of plant genetic engineering has consisted primarily of careful demonstrations of the gene-transfer principle with model experimental plants.

A salt-tolerant biotype of Lycopersicon cheesmanii *Riley (left foreground), a species of tomato endemic to the Galapagos Islands of Ecuador. Of some fifty-five biotypes collected from the shoreline to the highest elevations of the island, only this one was salt tolerant. Photograph by Charles M. Rick. Courtesy of the photographer.*

Less emphasis, therefore, has been placed on the kinds of genes that are being manipulated or, for that matter, on the plants that are being transformed. Tobacco plants, for instance, have been produced that are resistant to the medicinal antibiotic kanamycin, but this characteristic has no obvious agricultural value. Nonetheless, experiments such as these are significant in setting the stage for important advances in the future. Because of the progress that has already been made, it now appears theoretically possible that practically any characteristic of a plant could be transferred to any other plant, provided the characteristic can be defined at the gene level. Once the gene (or genes) involved is identified, it can be isolated and purified from the donor plant. Then, it can be incorporated by means of gene-transfer technology into the genetic makeup of a recipient cell. Finally, tissue-culture methods involving phytohormones can be used to regenerate plants with the new characteristic, starting from single, genetically modified cells.

What kinds of characteristics will be exploited by plant biotechnology? Obviously, the possibilities are numerous, some in the near future and others in the long term. One promising approach involves the development of herbicide-resistant plants. The Monsanto Company in the United States, for example, is attempting to produce soybean cultivars resistant to glyphosate (trade name, Roundup), an agriculturally important, nonselective herbicide. Significant, practical gains could be realized from this research project in the next ten years. Other bioengineering objectives, on the other hand, are farther in the future. Disease-resistant or cold-hardy plants probably won't be produced for another twenty-five years, and effective transfer of nitrogen-fixing abilities are at least fifty years away, even according to the most optimistic observers.

At this very moment, several rare and endangered plants undoubtedly harbor genetic characteristics that would be of tremendous potential significance to biotechnology. Many of them probably have not even been discovered yet; some, in fact, may become extinct before their value is appreciated. Fortunately, at least a few valuable endangered plants are the subject of intense conservation efforts.

Potential Economic Uses for Rare Plants

The following paragraphs describe a few of the potentially valuable characteristics or chemical compounds that endangered species might someday contribute to human welfare through genetic-engineering techniques.

Pharmaceuticals. It has been estimated that, on the average, for every one hundred twenty-five plants closely examined for valuable chemicals, one eventually will become an important source of prescription drugs. Since about two thousand plants are expected to become extinct in the United States alone by A.D. 2000, one pharmaceutically significant species will be lost every year for the next fifteen years. Conservation measures, of course, could dramatically change this serious possibility.

Oilseed Crops. Long-chain fatty acids from plants are used as lubricants in steel production and to make plastics for gear wheels and electrical insulation. Although these fatty acids currently are obtained from imported rapeseed (*Brassica* species) oil, researchers with the United States Department of Agriculture are actively pursuing work with other potential sources. One of these, *Limnanthes alba* (meadowfoam), is a rare and endangered species native to northern California. Research with this plant currently focusses on the development of suitable parent strains for seed production and on possible economic uses of the seed oil.

Salt Tolerance. Lycopersicon cheesmanii is a rare species of tomato found only on the

Potentilla robbinsiana *Oakes, the dwarf cinquefoil, an endangered species endemic to the White Mountains of New Hampshire. Known only from the Monroe Flats on Mount Washington,* Potentilla robbinsiana *is adapted to one of the harshest environments of North America. Photograph by Bruce A. Sorrie.*

shores of the Galapagos Islands in the Pacific Ocean. A variety of this endemic species thrives in a coastal habitat barely five yards from salty ocean water. At the University of California–Davis, researchers have been working for nearly ten years on *Lycopersicon cheesmanii* to evaluate its salt-tolerance characteristics at the biochemical level and to incorporate the genes involved into commercial tomato varieties. If this work is successful, not only will it improve the vigor of tomato plants in agriculture, it should extend the range of soils and irrigation practices that can be used to grow tomatoes, thus increasing growers's flexibility in producing one of the most important crops in the United States.

Cold Hardiness. The dwarf cinquefoil, *Potentilla robbinsiana*, has been listed as a Federally endangered species for only the past five years. As a native inhabitant of the alpine regions of Mount Washington in New Hampshire, this endangered rare member of the rose family (Rosaceae) displays an extraordinary degree of cold tolerance, surviving, as it does, in one of the harshest environments of North America. Because of this, *Potentilla robbinsiana* could be of tremendous value as a source of genes for improving the cold hardiness of commercially valuable species of Rosaceae, such as strawberries, raspberries, and apples.

These examples illustrate only a few of the plant characteristics that might be exploited in biotechnology. Science has only just begun to appreciate the treasures that exist on a global scale in the world's flora. If one keeps this important fact in mind and recognizes that technological advances depend on setting long-term goals as well as on using integrated approaches, it is easy to see how crucial plant conservation is to the future. As more is learned, the value of plants—even rare and endangered species—becomes more and more evident.

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In the latter 1830s, just as the preposterous legend of Paul Bunyan was being given birth in the lore of Canada's (some say Maine's) lumberjacks, John Muir was born at the edge of the North Sea, in far-off Dunbar, Scotland; some dozen years later, when Muir was emigrating to the United States with his family (their original destination had been Canada), the Bunyan legend was being borne by word of mouth to the same virgin forests of the Old Northwest in which the Muirs had resolved to homestead. There, on the crest of the ever-westering frontier, the legend found a home among the loggers who, then in their heyday, were cutting off the great timberlands of Michigan, Wisconsin, and Minnesota. Come 1860 and restless, young John Muir would escape the grinding drudgery of his father's farm for brief matriculation in the University of Wisconsin. Foiled in this endeavor because the Civil War quickly depleted the University's supply of students, Muir set out for the wild forests of Canada on one of those long, epic walks that someday would ensconce him, cultural hero now, in the growing pantheon of his adopted country—a fit flesh-and-blood counterpoise to the phantasmagoric Paul Bunyan.

In 1861, a year after Muir left the farm for good, there was born in his hometown of Portage, Wisconsin, Frederick Jackson Turner, historian-to-be of the American frontier. By that date, the frontier had surged far to the west, leaving Portage in its wake. In another three decades a report on the Census of 1890 would declare that the American frontier was no more, that it had disappeared altogether, evoking from Turner—who was by then a professor of American history at the University of Wisconsin—the novel proposition that, "now [in 1893], four centuries from the discovery of America, at the end of a hundred years of life under the Constitution, the frontier has gone, and with its going has closed the first period of American history." "What the Mediterranean Sea was to the Greeks, breaking the bond of custom, offering new experiences, calling out new institutions and activities"—Turner declared—"that, and more, the ever retreating frontier has been to the United States directly, and to the nations of Europe more remotely"—whereupon, off in San Francisco, John Muir and a circle of influential associates founded the Sierra Club as a means of salvaging what islands of wilderness had not been swept away by the westward rush of northern European man. Thenceforth Muir would be a powerful force in America, a force not even the Bunyan legend could neutralize when it later was appropriated and embellished by publicists for commercial timber interests.

At about this time (1891), the first volume of Charles Sprague Sargent's classic *Silva of North America* was published by Houghton Mifflin; eleven years later, the fourteenth, and last, volume would be published. Shortly after the first volume appeared, Muir and Sargent began to correspond. They developed a close professional association that would endure until Muir's death, in 1914. Volume 11 of the *Silva*, published in 1897, Sargent dedicated to Muir, "lover and interpreter of Nature who has best told the story of the Sierra forests."

"Few men whom I have known loved trees as deeply and intelligently as John Muir," Sargent wrote in a memorial to the lately deceased Muir which was published in the *Sierra Club Bulletin* in 1916. "The love of trees was born in him, I am sure, and had abundant nourishment during his wanderings over the Sierra," Sargent continued,

> where for months at a time he lived among the largest and some of the most beautiful trees of the world. No one has studied the Sierra trees as living beings more deeply and continuously than Muir, and no one in writing about them has brought them so close to other lovers of nature.
>
> Muir and I travelled through many forests, and saw together all the trees of western North America, from Alaska to Arizona. We wandered together through the great forests which cover the southern Appalachian Mountains, and through the tropical forests of southern Russia and the Caucasus and those of eastern Siberia [see excerpts from Muir's scrawled record of this journey, in the Spring 1986 issue of *Arnoldia*], but in all these wanderings Muir's heart never strayed very far from the California Sierra. He loved the Sierra trees best, and in other lands his thoughts always returned to the great sequoia, the sugar pine, among all trees best loved by him; the incense cedar, the yellow pine, the Douglas spruce, and the other trees which make the forests of California the most wonderful coniferous forests of the world. With these he was always comparing all minor growths, and when he could not return to the Sierra his greatest happiness was in talking of them and in discussing the Sierra trees.

As conservation leader, Muir was advisor to the Federal Government's Forestry Commission, organized in 1896 to survey the nation's forest reserves. Although not an official member, he was a close friend of the Commission's chairman—Charles Sprague Sargent—and he joined the Commission on an inspection tour of forests in the Northwest. Muir left the tour for a brief trip to Alaska with Henry Fairfield Osborn but rejoined the Commission in Oregon and continued with them into California and Arizona. Over the next two years he travelled with Sargent and William M. Canby in a wide-ranging study of forest resources in Canada and Alaska, in the South Atlantic states, in the Midwest, and in New England. Muir felt that Sargent was the only member of the Commission who "knew and loved trees as I loved them."

John Muir and the Arnold Arboretum

For a period of forty years John Muir interacted with Boston, Harvard, and the Arnold Arboretum. Asa Gray visited Muir in Yosemite during the summer of 1872, for example, and spent much time with him collecting plants there and elsewhere in California, and later corresponded with him. It was probably on Gray's word that Muir was listed in the Torrey Botanical Club's directory of North American botanists in 1873. Muir sent seeds to Gray in Cambridge, some of which may have been among the very first accessions of the nascent Arnold Arboretum (via the Harvard Botanic Garden and the Bussey Institution), though by no means all of the species represented could have survived in Boston. Louis Agassiz was well aware of Muir's work on the glaciology of Yosemite and would have visited Muir there, en route home from Tierra del Fuego, had he not been unwell. (Muir, for his part, was too busy to travel to San Francisco to call on the ailing Agassiz.) Through Asa Gray, perhaps, Muir made contact with Charles Sprague Sargent, though Muir would not meet Sargent in person until 1893. In 1896, Harvard bestowed an honorary degree on Muir (his first), possibly through the instigation of Sargent. Sargent, as has been said, dedicated the eleventh volume of his *Silva of North America* to Muir, in 1897. Muir reciprocated in 1903 with a glowing review in the *Atlantic Monthly* of the just-completed *Silva*. Muir visited Sargent in Boston at least four times and travelled widely with him on three continents. In June 1898 he collected specimens for Sargent on Mt. Shasta and Mt. Scott. Many of Muir's writings originally were published in Boston—from an article on *Calypso bulbosa* in a Boston newspaper as early as 1865 (his first) and short items in the *Proceedings of the Boston Society of Natural History*, to

The Writings of John Muir *("Manuscript Edition"), photographed by Herbert Wendell Gleason. Photograph from the Archives of the Arnold Arboretum.*

entire books and (posthumously) his complete works, which were published by Houghton Mifflin. If for these reasons alone, readers of *Arnoldia* who live in the Boston area ought to become acquainted with Muir and his writings.

The origins and history of the Arnold Arboretum, Charles Sprague Sargent's masterpiece, cannot be understood fully without taking into account the wider, concurrent developments that were occurring in the American forestry and conservation movements (of which John Muir was a primal force). The Arboretum's chroniclers have paid close attention to developments in the botany and horticulture of Sargent and Muir's day but have largely overlooked those in forestry and conservation, especially the broader social context out of which they grew. Perhaps this is so because Sargent was highborn and seems, therefore, to have operated outside or above pressure politics. Yet his successful campaign to make the Arboretum a part of the Boston park system was evidence that, on the local level at least, Sargent was a most savvy and effective lobbyist. Or perhaps this is so partly because John Muir's papers have been virtually locked up, unavailable to scholars until very recently, their invaluable account of events largely denied to the world since his death, or else very widely scattered.

It is equally impossible to understand the history of forestry and conservation without taking account of Sargent's strategic influence on those movements, for Sargent was in the vanguard of the long campaign to set up the national forests and similar reserves. At one point, in fact, he singlehandedly redeemed the national forests in the face of fierce opposition from powerful special interests. When, in 1897, the newly inaugurated President, William McKinley, seemed about to capitulate to "the protests of western politicians" against the twenty-one million acres of national forest reserves outgoing President Grover Cleveland had just established, Sargent, in his own words, "went to see him alone and had a private conversation with him. He told me that he was going to break up the reservations and I had a very plain talk with him and explained to him that the President of the United States could not afford to put himself in the position of helping western timber thieves. We had a rather stormy interview, but he finally gave up his project." This, to the President of the United States! Sargent closes his revelation with a confession and an injunction: "I have never mentioned this to anybody before and the account of this interview is intended for you alone and not to be given out or in any way published." He was writing in 1908, many years after the fact, to Robert Underwood Johnson, editor of the New York-based *Century Magazine* and the person most responsible for John Muir's advent as a writer of national standing. (Sargent made the same claim in another letter, now at Yale University, written in 1921.) Here we see, perhaps, Sargent applying at the national level, on behalf of the fledgling national forests, tactics he had used locally to nurture the fledgling Arnold Arboretum.

In his letter to Johnson, Sargent revealed that his interest in forests and their preservation was due "almost entirely" to his having read George Perkins Marsh's *Man and Nature* in the mid-1870s. (The copy of *Man and Nature* that Sargent read is almost certainly the one now in the library of the Arnold Arboretum. Dated "*Dec. 1875*," it is inscribed: "Presented to my Arboreal friend C. S. Sargent Esq. by *Francis Skinner*.") At the time, Sargent was still Director of the Botanic Garden in Cambridge, and the Arnold Arboretum could scarcely be said to have existed yet. Early in 1879, Sargent began corresponding with Marsh himself, who was Ambassador to Italy, having been appointed to that post by Abraham Lincoln in 1861. "I have long been a student of Man and Nature," Sargent wrote, "and have derived great pleasure and profit from your pages." From January 1879 until July 1882, the month Marsh died, they corresponded frequently. It is, perhaps, a matter of no small significance that John Muir's first published essay on forest conservation, "God's First Temples: How Shall We Preserve Our Forests?," appeared in the Sacramento *Record–Union* on February 9, 1876. Michael P. Cohen, in his excellent new book on Muir (reviewed below), states that "Muir's argument [in "God's First Temples"] was based almost entirely on the theories of George Perkins Marsh. . . ." Thus, both Charles Sprague Sargent and John Muir were strongly influenced by the same person (Marsh), at about the same time. For this reason and others, people interested in Sargent's life and career, in the history of the Arnold Arboretum, or in the genesis and development of conservation thought in the United States will find a wealth of information in the flood of new items about Muir that have appeared in the last year or two. Both scholars and general readers should expect the flood to continue over the next many years as additional works based upon newly released primary materials, find their ways into print.

Three Works for General Readers

Three of the new Muir items will be of special interest to general readers: Michael Cohen's *The Pathless Way*, Frederick Turner's *Rediscovering America*, and the *Pacific Historian*'s *John Muir: Life and Legacy*. The first two items are book-length biographies; the last is a series of articles dealing with various aspects of Muir's life and is based on a conference held at the University of the Pacific in 1985 to mark completion of the John Muir Papers Microform Project, a five-year effort to gather, organize, and publish all of Muir's extant journals, correspondence, and holograph manuscripts. Of the twenty-five papers presented at the conference, twelve are published in the volume. Together, the three titles give the general reader a firm grounding in the basic facts of Muir's life; an exploration of the significance, meaning, and consequences of Muir's long campaign on behalf of the American wilderness; and a survey of the more pressing unresolved issues of Muir scholarship.

For several decades after Muir's death in 1914, the public had no alternatives to the two uncritical "official," or "authorized," biographies of him, *The Life and Letters of John Muir* (1923, 1924), by William Frederic Badè, and *Son of the Wilderness* (1945), by Linnie Marsh Wolfe. Though well executed, both were produced under the close scrutiny, if not outright supervision, of Muir's descendants. The two books did serve the important function of presenting the basic facts of Muir's life, however. Unfortunately, once Wolfe's Pulitzer Prize-winning book was in print Muir's papers were locked up by his family, and historians were denied access to them. Not until the early 1970s, when the family began opening up the papers to scholars, was it possible to enlarge the existing body of knowledge about Muir, or to evaluate and interpret the often heroic accomplishments of this important figure in American history. (Californians consider Muir the most important Californian ever to have lived.)

Stephen R. Fox, an independent scholar based in Boston, was the first contemporary writer able to attempt a retelling of Muir's life. His *John Muir and His Legacy: The American Conservation Movement* was published in 1981 by Little, Brown. Only with the appearance of the Cohen and Turner biographies do we have nonderivative, book-length treatments of Muir's life, however, for, while devoted in large part to Muir's life, Fox's volume ranges beyond it, to other individuals and to broader issues. (At least one manuscript biography, long since completed, is currently in search of a suitable publisher.)

Of the two biographers, Turner provides the more factual, or mundane, account; his effort is a much expanded and updated Linnie Marsh Wolfe type of biography. Michael Cohen writes for those already familiar with the principal facts of Muir's life; in a sense, he picks up where Turner leaves off. Alone, neither book would satisfy the nonspecialist reader, but together they complement each other nicely. *John Muir: Life and Legacy* shares characteristics of both books, delving into some important facets of Muir's long, active, and productive life and probing its meaning, puzzles, and paradoxes, but selectively. It does not even begin to exhaust the wealth of questions and issues raised in Cohen's book, however. One of the articles, "John Muir and the Tall Trees of Australia," by P. J. Ryan, will attract the attention of readers with a special interest in plants. It is based on materials in the archives of the Kings Park and Botanic Gardens, West Perth; the Royal Botanical Gardens, South Yarra; and the Sydney Botanical Gardens, among others.

Three Works for Specialists

Fortunately, three specialized Muir items provide scholars with ample resources for attacking the issues Cohen and others raise, and far more besides. Chief and most impressive among them is *The John Muir Papers 1858–1957*, the fruit of the John Muir Microform Project. It consists of fifty-one reels of microfilm and fifty-three cards of microfiche. A related item, *The Guide and Index to the Microform Edition of the John Muir Papers 1858–1957*, catalogs the contents of the *Papers*. While necessarily subordinate to the microform edition, the *Guide and Index* is valuable in its own right, not the least because it allows poor scholars and others for whom the microform edition would be inaccessible, to obtain reels and cards through interlibrary-loan services. The *Guide and Index* also contains a useful chronology of Muir's life, as well as a biographical sketch.

Eleven thousand items were selected for the microform edition: items in the Muir Family Papers at the Holt–Atherton Center for Western Studies at the University of the Pacific and in more than forty other repositories in the United States (including the Archives of the Arnold Arboretum). The edition is published on archivally permanent silver halide film stock. Virtually all of John Muir's surviving papers are included. Linnie Marsh Wolfe's and William Frederick Badè's painstakingly assembled papers also were selected for filming. The microfiche cards consist of thirty-three hundred nature and landscape photographs and illustrations in the Muir collection. Forty-six of the photographs are by Herbert W. Gleason.

There are five series to the *Papers*: "Correspondence and Related Documents, 1858–1914" (seven thousand letters, both incoming and outgoing), "Journals and Sketchbooks, 1867–1913" (eighty-four journals and sketchbooks), "Manuscripts and Published Works, 1856–1914" (notebooks, published and precursor works, unpublished works, and miscellaneous notes), "Pictorial Works, 1854–1914" (the thirty-three hundred photographs, which were taken by nearly two hundred photographers, and other illustrations), and "Related Papers, 1873–1943" (the Badè, Wolfe, Muir Family, Sierra Club, and other papers). Among the many specific items of interest in the *Papers* are Muir's journals of his travels with the U. S. Forestry Commission, of a botanical trip with Charles Sprague Sargent and William M. Canby, and of his world tour, during much of which he was accompanied by Sargent and Sargent's son, Andrew Robeson Sargent. Sketches of fossil plants by Muir are reproduced on the microfiche cards. The *Guide and Index* to the *Papers* contains some nineteen thousand index entries.

Botanists scanning the *Guide and Index* will find many familiar names—Asa Gray, Liberty Hyde Bailey, George Engelmann, William M. Canby, John Torrey, and Sir Joseph Dalton Hooker, for example, in addition to Charles Sprague Sargent. John Burroughs, Edward H. Harriman, Gifford Pinchot, Luther Burbank, David Starr Jordan, J. H. Mellichamp, and Henry Fairfield Osborn make appearances as well. Western botanists, especially, will recognize the names Vernon Bailey, Anstruther Davidson, William R. Dudley, Alice Eastwood, Edward Lee Greene, George Hansen, Albert Kellogg, John G. Lemmon, Sara Allen Lemmon, C. Hart Merriam, Charles C. Parry, and William Trelease. (All, except Davidson, are represented by letters from or to Muir, Davidson by several photographs.) Sargent's correspondence with Muir is among the most extensive: some one hundred twenty-two letters to Sargent from Muir and forty-three from Sargent to Muir. There are fourteen letters from Asa Gray to Muir and nine from Muir to Gray.

The third item for specialists, as well as for general readers who find themselves developing a more than casual interest in Muir, is the revised edition of William and Maymie Kimes's landmark reading bibliography of Muir items. Originally published in 1977 in a limited edition of only three hundred copies, *John Muir: A Reading Bibliography* was sold by subscription for one hundred fifty dollars. The new edition of this definitive work, which is a third again as large as the original, has just been printed in a limited, but larger, edition of seven hundred copies and sells for only forty dollars. Containing six hundred seventy chronologically arranged and annotated entries, the Kimes bibliography is an indispensable tool for anyone hoping to do serious research on Muir. Until now it has been available primarily to those who were able to purchase the first edition or who are near one of the libraries that own copies of it. The Kimeses contributed to the John Muir Microform Project and, fortunately, some one hundred sixteen of the entries in their bibliography are identified by number in the *Index and Guide* to the microform edition. With publication the *John Muir Papers* and republication of the Kimes bibliography the stage has been set for a surge of new insights into the life, career, and achievements of America's premier conservationist.

Historians of the Arnold Arboretum and biographers of Charles Sprague Sargent have emphasized affinities with Europeans and European institutions—Joseph Hooker and Kew, for instance, or Ernest Wilson, Joseph Rock, Frank Meyer, and the St. Petersburg botanic garden—or else with the Far East. The Arboretum's activities in formalized, or academic, botany have justifiably received much attention too, as have its formidable accomplishments in horticulture. Sargent's *Silva of North America* is acclaimed as a classic. The Arboretum's status as an Olmsted park, as a gem in Boston's "Emerald Necklace" of parks, or as an academic institution has been noted time and again. The Arboretum is held up on the one hand as a world-class institution, on the other almost as a strictly local one. Its place as a peculiarly *American* phenomenon is overlooked, ignored, or played down, however, as is Sargent's seminal part in the unfolding of the American conservation movement. Perhaps the prolonged unavailability of the John Muir Papers has been partly responsible for the oversights. If so, then, in time, their publication could prove as momentous for historians of the Arnold Arboretum and biographers of Charles Sprague Sargent as it will for students of John Muir and the Sierra Club. Both Sargent and Muir deserve recognition for their heroic intervention on behalf of America's wilderness and forests. They were worthy opponents of the absurd Bunyanesque notion that forests exist solely to be cut down.—E.A.S.

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