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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.)

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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,

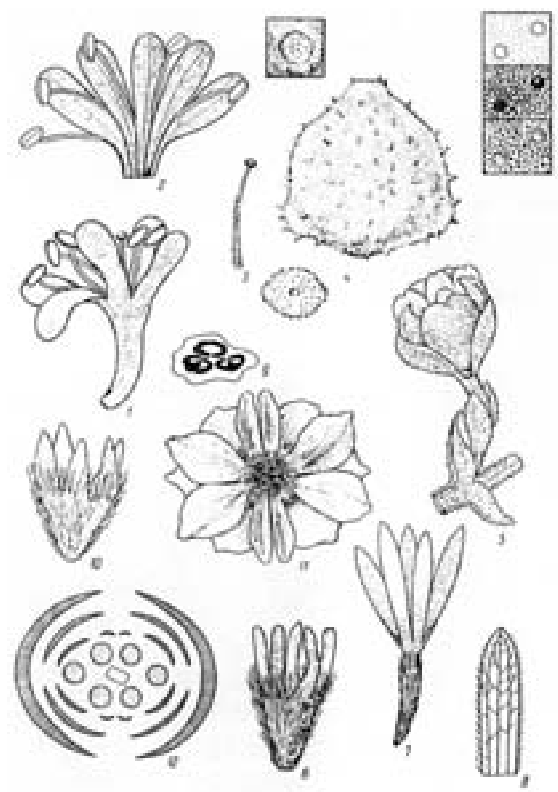
Illustration of an inflorescence, a single flower, and a fruit of Heptacodium jasminoides *as rendered in Volume 4 of* Iconographia Cormophytorum Sinicorum *(see the "Bibliography and Iconography").*

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 Rastenii, *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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Gary L. Koller is Supervisor of the Arnold Arboretum's Living Collections. He writes frequently for *Arnoldia*.

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-

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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.

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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).*

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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.*

PLANT CONSERVATION: PART II

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.

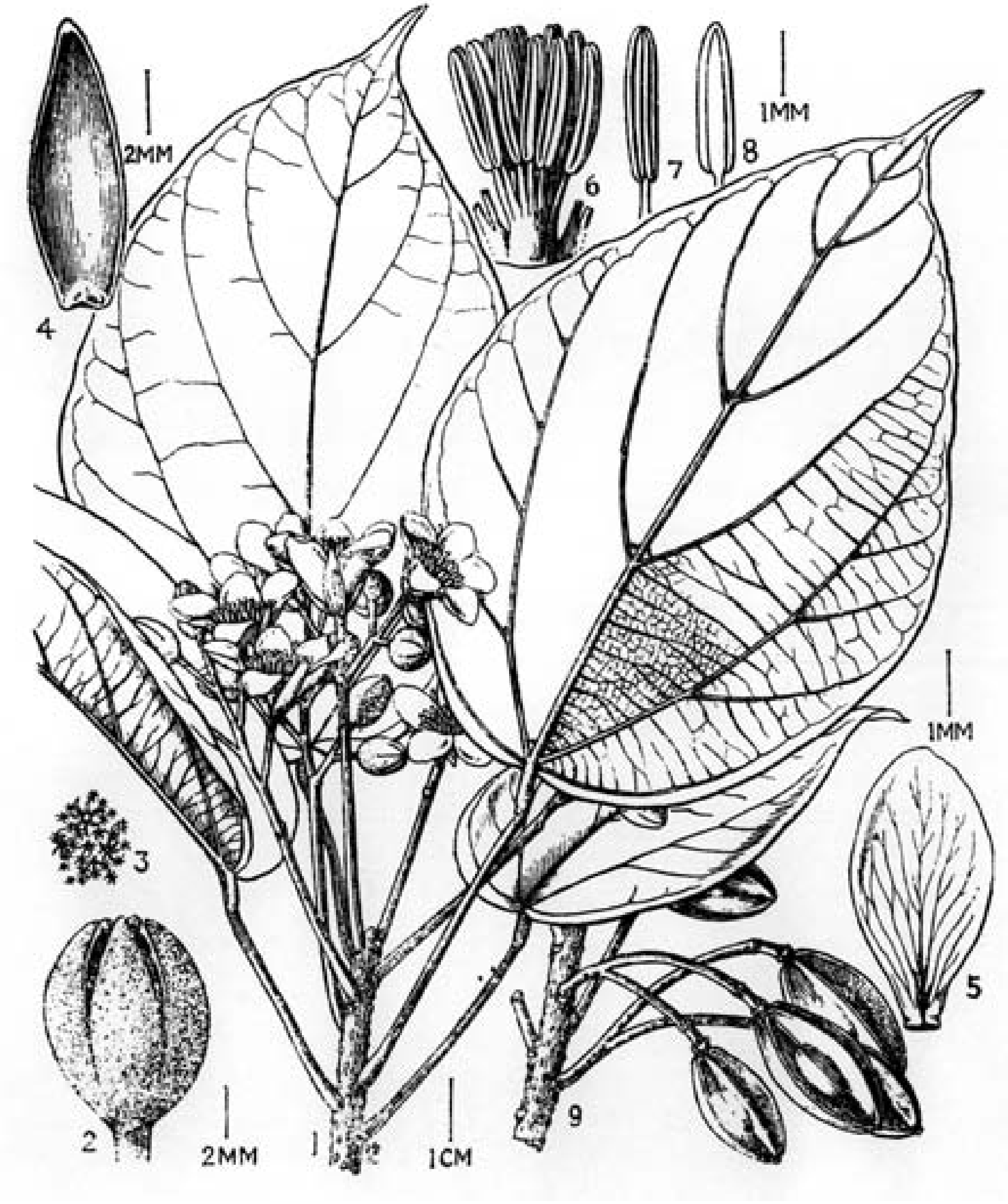
□ *The Tibetan plateau* is a lofty plateau rimmed by even loftier mountains—the Kunlun to the north, the great Himalaya range to the south. The average elevation of the whole region may be taken as from 4,700 to 5,300 meters. Under cold and dry climate, winters are extremely severe; even in summer the 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.

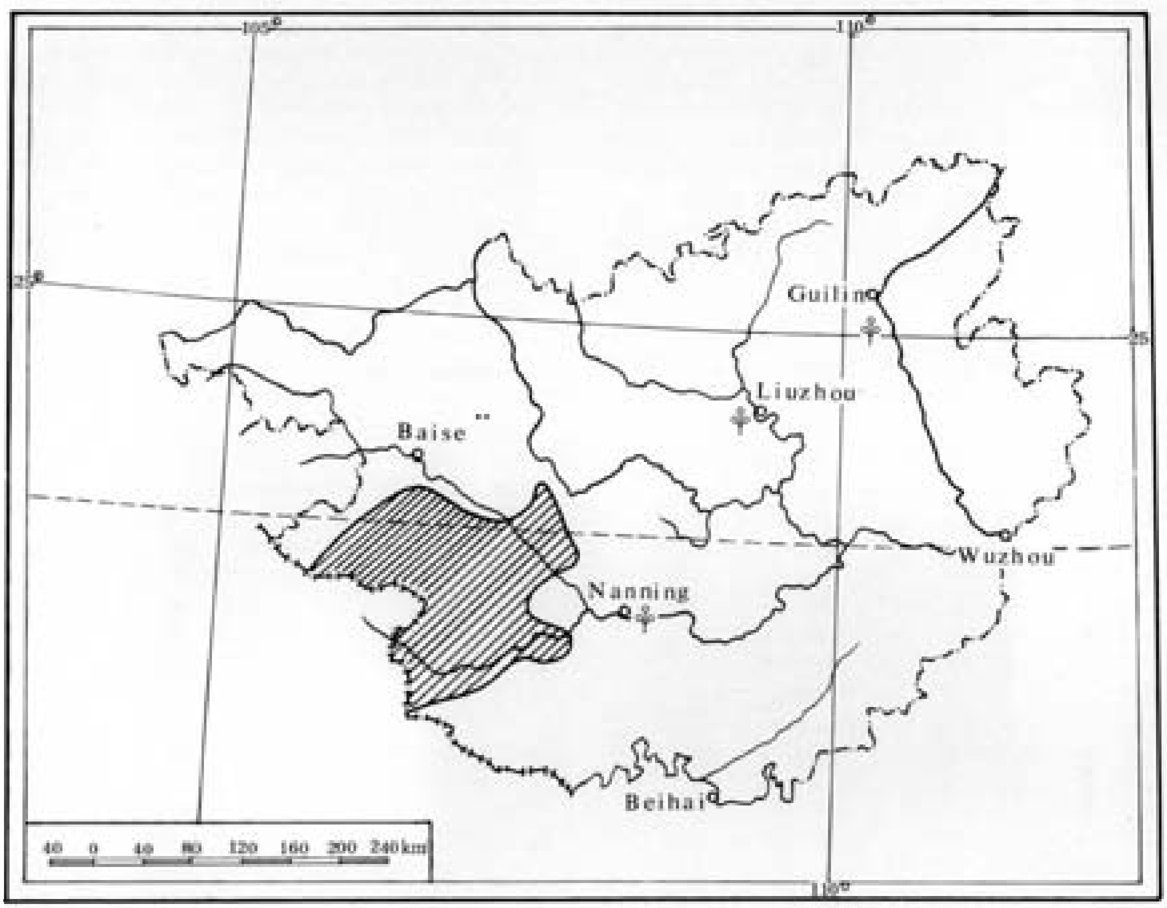
Xianmu is a calciphilous plant, containing little sulfur and manganese but abundant calcium and nitrogen (1.96 percent) in its leaves, which can be used to increase the fertility of soil. If the trees are to be planted in acid soil, the soil must be enriched with manure and supplied with lime beforehand. 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."

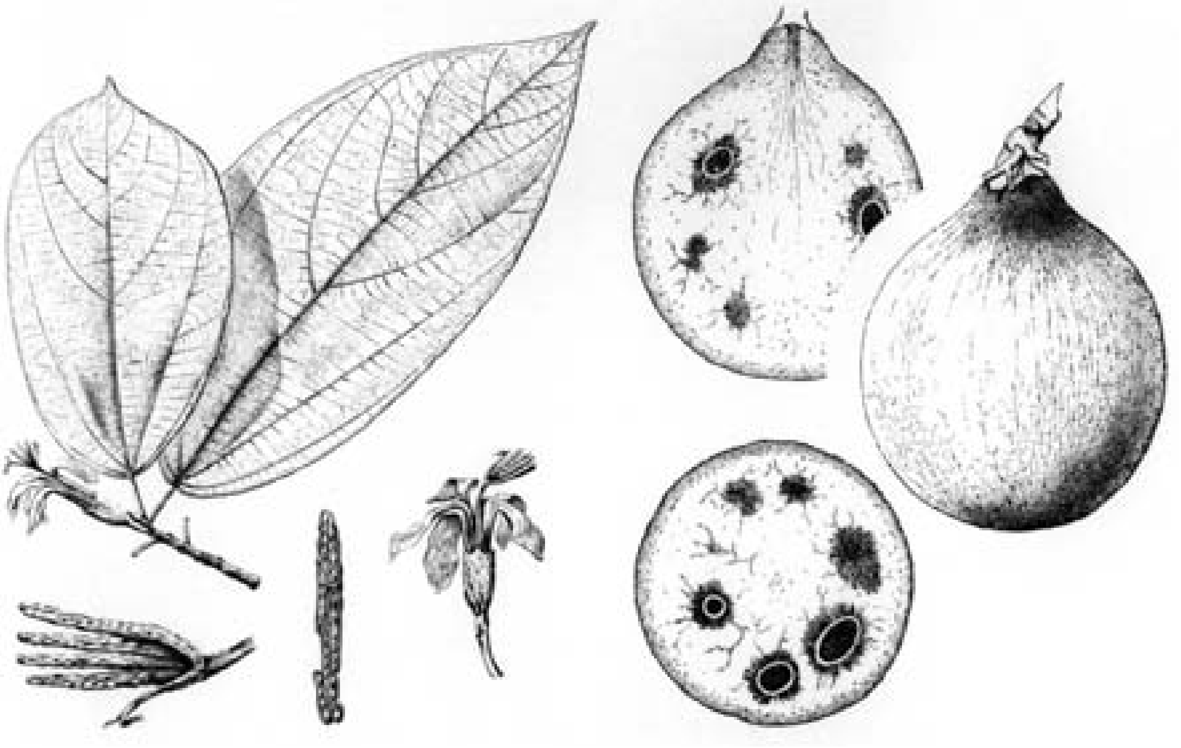
Mainly as a result of the superstitious excesses of medieval European herbal medicine, pharmaceutical science during the last part of the Nineteenth and early Twentieth centuries turned definitely antagonistic to plant medicines. Synthetic chemistry would solve any and all problems, it was believed. 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.

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-

*A heavy-crowned young Pará rubber tree (*Hevea brasiliensis *[Willd ex A. Juss.] Mull. Arg., center) on the banks of the Río Loreto Yacu, Amazonas, Colombia.*

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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Richard Evans Schultes is Professor Emeritus of Biology and Director Emeritus of the Botanical Museum at Harvard University. Born in Boston, he received his undergraduate and graduate degrees from Harvard University. Specializing in Latin American ethnobotany, he has been particularly interested in the narcotics and poisons used by primitive peoples. This is the fourth article Professor Schultes has written for *Arnoldia.*

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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