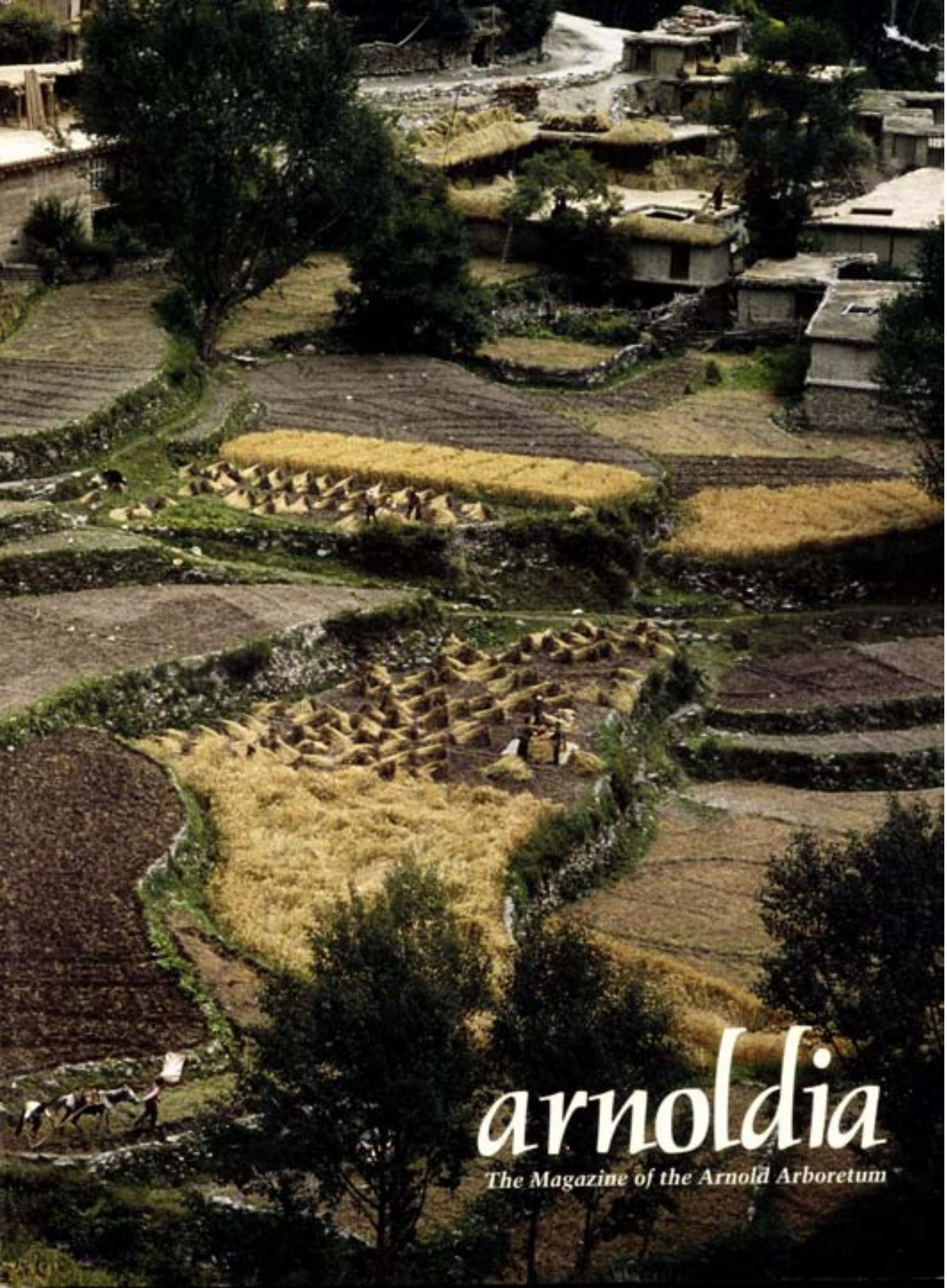

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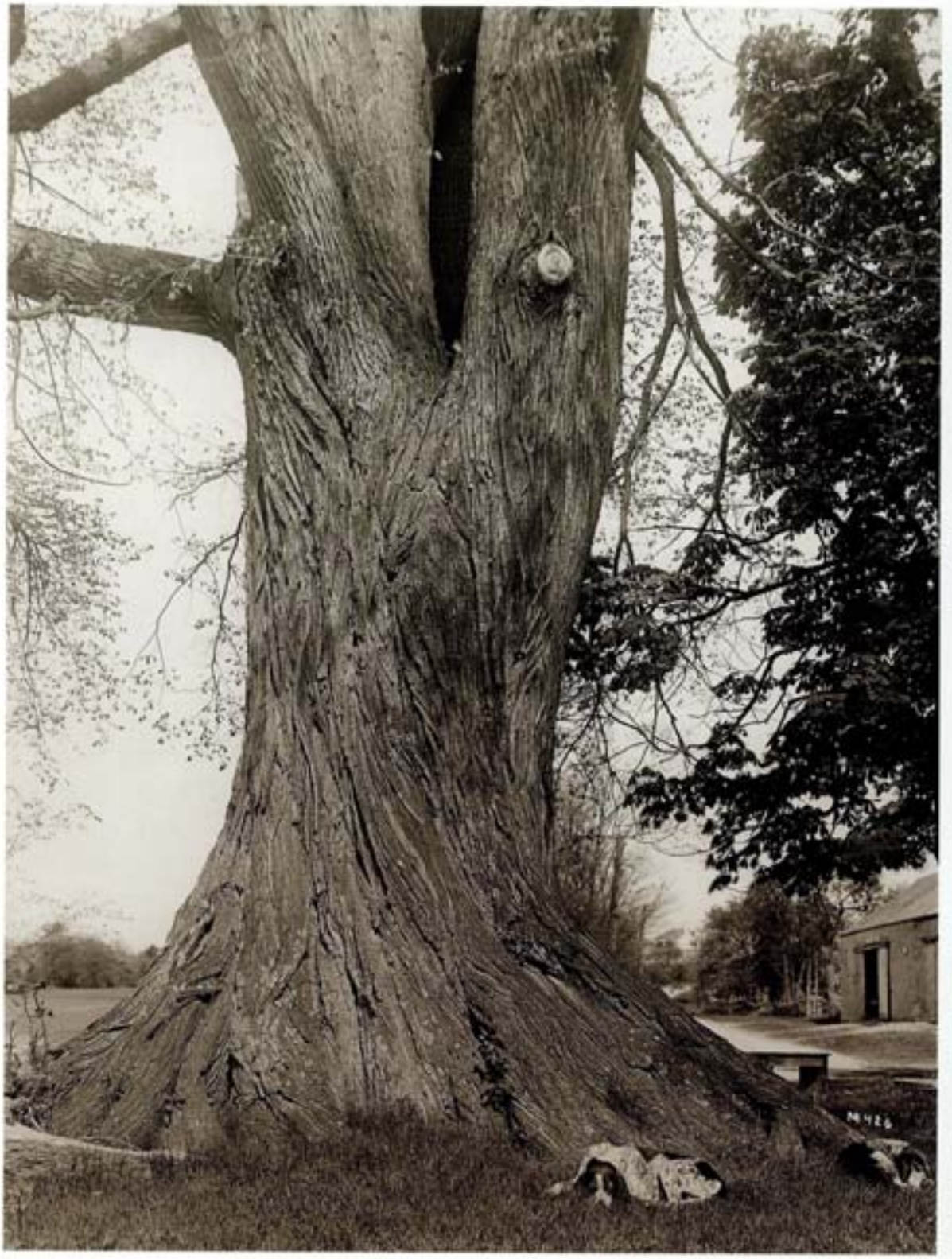

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Front & back cover The barley harvest in southeastern Tibet photographed by Susan Kelley in July 2000. Barley is the only crop that grows at the high elevations of the Tibetan Plateau.

Inside front cover E. H Wilson photographed the "Knight" elm, near Newburyport, Massachusetts, in 1927. He measured its girth at 18 1/2 feet four feet from the ground and 46 feet at ground level. From the Archives of the Arnold Arboretum.

Inside back cover. The "Howard" elm in Ware, Massachusetts, measured over 19 feet in circumference at three feet from the ground and 100 feet through the crown when E. A. Richardson photographed it in 1904. From the Archives of the Arnold Arboretum.

Anachronistic fruits of North America. Photograph by Connie Barlow.

Plant Hunting on the Rooftop of the World

Susan Kelley

Plant exploration has always played an important role in shaping the Arnold Arboretum's collections and has been the driving force behind the many Arboretum-sponsored trips to the Far East and within North America. Living plants grown from seeds gathered on these expeditions grow on the grounds of the Arnold Arboretum, in the collections of other botanical institutions in North America and abroad, in the stock inventories of nurseries across the country, as well as in our own home gardens. Although new plant material from expeditions is added to the living collections each year, the main goal of the majority of Arboretum-sponsored fieldwork is the creation of botanical inventories of eastern and southeastern Asia in the form of herbarium vouchers. In fact, few people familiar with the Arboretum's collections in Jamaica Plain are aware of the institution's collection of approximately 1.4 million herbarium specimens housed in the Harvard University Herbaria in Cambridge, Massachusetts (http://www.huh.harvard.edu/).

In 1997, under the auspices of the Biotic Surveys and Inventory program of the National Science Foundation (NSF), the Arnold Arboretum began a three-year collaborative effort to inventory the plant and fungal diversity in the Hengduan Mountains of south-central China, one of the unique biological regions of the world. Lying at the eastern end of the Himalayas between the edge of the Qinghai-Xizang (Tibetan) Plateau and the central plain of China, these spectacular north-south trending ridges contain the most diverse vascular plant flora of any region of comparable size in the temperate zone. Identified as one of twenty-five biodiversity "hotspots" on earth,[1] this vast region, covering an area of approximately 300,000 square miles (500,000 sq km), contains over 12,000 species of vascular plants, with almost 3,500 endemic species and at least 20 endemic genera.

Although some botanical exploration has previously been carried out in the Hengduan Mountains, the region has never been fully inventoried because of the sensitive political atmosphere in Tibet and because the rugged terrain makes much of the area extremely difficult to traverse. Elevations range from 3,300 feet (1,000 m) to over 25,000 feet (7,556 m) at the summit of Gongga Shan in western Sichuan. Average elevation is 10,000 to 13,000 feet (3,000 to 4,000 m) with precipitous drop-offs of 1,000 to 3,000 feet (300 to 900 m) not uncommon. No one, however, has yet identified the full extent of the geography and plant life of this particular "hotspot."

The term "hotspot," coined in 1988 by British ecologist Norman Myers, is used to designate areas that have a high number of endemic species (those whose distribution is limited to a single region) and that are under severe threat of destruction because of human activities. These threatened regions cover less than two percent of the earth's land area, but are home to more than sixty-five percent of all vascular plant species. Of the twenty-five designated hotspots, the Hengduan Mountains and the California Floristic Province are the only two located in the Northern Hemisphere. All other hotspots, with the exception of central Chile, the Cape Province of South Africa, and southwestern Australia, are located in the tropics.

The Hengduan Mountain region, as currently defined, constitutes only five percent of China's land area, occupying portions of southeastern Xizang (Tibet), western Sichuan, and northern Yunnan, but it contains almost half the total number of all Chinese flowering plant species. The extremes in climate and topography almost certainly contribute to the diversity of plant life

The upper reaches of the Mekong River and one of its tributaries.

The Hengduan Mountain region, one of the twenty-five biodiversity hotspots of the world.

there. More than a quarter of the world's *Rhododendron, Primula, Corydalis, Delphinium, Anaphalis, Gentiana, Saussurea,* and *Sorbus* species and over half the species of *Ligularia, Cremanthodium, Cotoneaster,* and *Pedicularis* have been recorded here. In addition, there may be as many as fifty species of endemic mosses.

A few numbers will illustrate the extent of some particularly species-rich groups in the spectacularly diverse Hengduan region (approximate numbers of species worldwide in parentheses[2]: *Rhododendron*—224 (850); *Androsace*—28 (100); *Primula*—113 (400); *Gentiana*—117 (350); *Saussurea*—101 (300); *Impatiens*—45 (850); *Pedicularis*—250 (350+); *Aconitum*—104 (100+); *Delphinium*—71 (250); *Arisaema*—39 (150); *Cotoneaster*—41 (50); *Astragalus*—98 (2,000); *Ilex*—44 (400); *Corydalis*—85 (300); *Sorbus*—36 (85); *Anaphalis*—33 (100).

The table on the opposite page compares the levels of diversity and endemism in the Hengduan region with those of other nontropical areas, providing another indication of its richness.[3]

Four of the great rivers of Asia, the Yangtze (Jinsha Jiang), the Mekong (Lancang Jiang), the Salween (Nu Jiang), and the Brahmaputra (Yarlung Zangbo Jiang), flow through the valleys of these dramatic mountains. All of these rivers originate on the 16,500-foot (5,000-m) high Qinghai-Xizang (Tibetan) plateau, and, far downstream, all are of great economic importance to the people who live along them. The rapidly increasing human impact on the region threatens not only the diversity of plants and animals there, but also the survival of indigenous cultures that define much of eastern and southeast Asia.

In the summer of 2000, the third year of the NSF project, fieldwork was conducted for two

Three species of Saussurea, *a member of the aster family: above, a cushion form growing on scree slopes at 17,000 feet, left and center, two species grow among boulders at 15,000 feet*

Region	Area (km^2 x 1000)	Number of genera	Genera endemic (%)	Number of species	Species endemic (%)
Hengduan Region	500	1467	20 (1.4)	8559	1281 (15.0)
California	411	878	26 (3.0)	5046	1517 (30.1)
California Floristic Prov.	324	795	50 (6.3)	4452	2125 (47.7)
British Isles	308	545	0 (0)	1443	17 (1.2)
Cape Province, South Africa	0.47	533	1 (0.2)	2256	157 (7.0)
Carolinas	217	819	1 (0.1)	2995	23 (0.8)
Gray's Manual range	3238	849	6 (0.7)	4425	599 (13.5)
Japan	377	1098	17 (1.5)	4022	1371 (34.1)
Texas	751	1075	7 (0.7)	4196	379 (9.0)

months in southeast Xizang (Tibet) by a team of four American, one Tibetan, and four Chinese botanists. Dave Boufford, assistant director of the Harvard University Herbaria and an author of the NSF grant proposal, headed the American team. I was fortunate to be part of that team, along with Rick Ree, who received his Ph.D. from Harvard this year and works on the genus *Pedicularis* (lousewort), and Brian Perry, a doctoral student at Harvard in mycology. Four Japanese botanists traveled and collected with the group as well, but were not working under the auspices of the NSF grant.

The logistics of the expedition were coordinated by Wu Sugong of the Chinese Academy of Science Institute of Botany in Kunming in Yunnan Province. Professor Wu had done fieldwork in the area in the 1970s and 1980s and helped compile the two-volume checklist *Vascular Plants of the Hengduan Mountains.*[4] His position was not an enviable one, since efforts to arrange permits, lodging, and rations were continually complicated and delayed by landslides, broken-down vehicles, massive roadway construction projects, obstinate local officials, and inclement weather.

The expedition team assembled at the Kunming Botanical Garden on June 28, 2000. There we handed over our passports to a young Tibetan woman, Yang Zhen, who was to fly them to Lhasa to obtain permits for travel in the Tibet Autonomous Region. While waiting for her return, we drew up the final itinerary and gathered equipment: plant presses, ventilators, portable dryers, kerosene burners, a fifty-gallon drum of kerosene, food, camping gear, and even an extra pair of springs for the rather rickety bus that was to transport much of our equipment. Little did I suspect how valuable these springs would prove to be weeks later down the incredibly rough road.

Finally, on July 4, with three SUV's and a small bus, we began our journey north. The fully loaded truck remained in Kunming to wait for our passports and the all-important permits to arrive from Lhasa. For the next several days we headed north, stopping in the towns of Dali,

Wu Sugong and Dave Boufford

Zhongdian, and Deqen. In Dali, a popular Chinese tourist destination situated next to Lake Erhai, we encountered a few Tibetan vendors whose wares included fruiting bodies of the *Cordyceps* fungus, a dried tiger penis ("For your health!"), and the antlers of an unidentified antelope. We took advantage of the town's internet café, which would be the last we saw until we reached Lhasa on August 17.

During the eighth and ninth centuries, Dali was the capital of a separate kingdom, Nanzhou. The local Bai people—who ruled from 902 until 1252, when Kublai Khan conquered the area—renamed it the kingdom of Dali. Diancang Shan, an uplifted mountain of granite and marble, rises 13,500 feet (4,100 m) just west of the city. Since most of the remainder of the province of Yunnan is limestone, the flora of Diancang Shan is distinctive and interesting in and of itself. In 1984 Dave Boufford spent six weeks collecting herbarium specimens there; on this trip we could spend only a day on the mountain.

Heading north we saw fields of tobacco, corn, rape seed (used for cooking oil), cabbage, beans, and peas. Large *Populus yunnanensis* grew along the roadsides, but most of the land was stripped completely of woody vegetation. Joseph Rock, the Viennese-born botanist, ethnologist, and linguist, made his home in Lijiang for some thirty years. Between 1924 and 1927, he collected hundreds of herbarium specimens for the Arnold Arboretum and sent back seed of many new plants for its living collections.[5]

For more than an hour the road followed the Yangtze River (Jinsha Jiang), a broad, muddy expanse. The weather was warm, but clouds prevented us from seeing Yulongxue Shan (Snow Mountain), at 18,467 feet (5,596 m) the highest in Yunnan. Growing on the roadside were species of *Philadelphus* (mock orange), *Sambucus* (elderberry), *Pyracantha, Indigofera* (indigo), juniper, and an evergreen oak with a dense covering of yellow-brown hairs on the underside of the leaves. By the time we reached Zhongdian early in the evening, we had gone from an elevation of 7,000 feet (2,100 m) in Dali, to about 10,500 feet (3,200 m).

Zhongdian, close to the Tibetan border, was the first town in which we saw a sizable population of Tibetans. Some of the shops had Tibetan goods for sale, such as silver bracelets, coral and turquoise necklaces, daggers, and clothing. The architecture of the town, however, was typical Han Chinese white tile buildings. Alongside the modern food shops, banks, restaurants, hotels, and CD and DVD shops, pigs ran in the muddy streets and vendors in open-air markets offered housewares, horse blankets and saddles, fresh yak meat, live chickens and fish, vegetables, brooms, baskets, pots and pans. One vendor had

Rheum nobile, *a type of rhubarb (also seen in closeup at right), and several species of* Primula *grow near Tiensi Lake in northern Yunnan.*

stacks of fresh yak butter, which I had tasted that morning in a bowl of tea. In the outlying areas, we saw the first signs of Tibetan architecture, square, two-story stucco structures, painted white but with colorful decorations around the doorways and windows. Buddhist prayer flags flew from the rooftops.

We spent two days in Zhongdian, waiting for Yang Zhen to arrive with our passports and the permits needed to cross the provincial border into Tibet. We spent the time exploring the vegetation in the mountains outside Zhongdian. Lake Tiensi, at 13,500 feet (4,100 m), is a beautiful alpine lake about two hours from Zhongdian. Growing there among grazing yaks, we found *Rhododendron wardii,* a tall rhododendron with pale yellow flowers named for British botanist Frank Kingdon-Ward. Between 1909 and 1957, Kingdon-Ward introduced hundreds of new species into cultivation (rhododendrons, primroses, gentians, the Himalayan blue poppy) from here and other parts of western China and from upper Burma and French Indochina. We also found the distinctive *Rheum nobile,* a rhubarb with large, pale yellow bracts; purple and yellow species of *Primula;* and a yellow *Mecanopsis,* the Himalayan poppy. Two curious Tibetan boys, perhaps nine or ten years old, appeared seemingly out of nowhere. Although initially quite shy, they followed us at a distance and eventually helped our mycologist find several interesting fungi.

Our second day in the Zhongdian area was spent in drizzling rain at Shudu Hu, another alpine lake, this one surrounded by heavily grazed meadows with patches of cut-over spruce forests. Scattered in the meadows were primroses, asters, gentians, and *Stellera chamaejasme,* a member of the thyme family whose corolla color varies from yellow to pink across its geographic range and even in single populations.

From Zhongdian we drove toward Deqen, closer to the Tibetan border. In the early afternoon we reached a 14,000-foot (4,250-m) pass where for the first time we saw Tibetan nomad tents woven of black yak hair, with large branches of juniper propped against the doors for insulation. A few specimens of *Pinus armandii,* almost 60 feet (18 m) high, with bright green, pendulous cones, were growing there along with a few specimens of *P. yunnanensis* and *P. densata,* but most of the woody vegetation had been cut for fuel or lumber. (There is a nice 65-foot [20-m] specimen of *P. armandii* on Peters Hill that was grown from seed collected in 1909 by William Purdom in Shaanxi Province, to the northeast of the Hengduan Mountains.)

On July 11 we finally crossed into the province of Xizang (Tibet), descending from almost 11,000 feet (3,265 m) in Deqen to 7,000 feet (2,100 m) on the banks of the upper Mekong River. The landscape here was dry and sparsely covered with scrubby vegetation, with a few

low, cut-over shrubs and many herbaceous plants growing along the road. Following the road up from the Mekong, we came to the village of Yenjing where we had lunch in a low, dark, wooden dwelling (complete with satellite dish on the roof), with almost unbearable smoke flowing from the cooking area.

Within fifteen minutes of leaving town, we climbed another 1,000 feet (300 m) and soon began seeing mixed broadleaf deciduous and conifer forests of *Salix, Abies, Populus, Cornus,* and *Quercus,* along with many herbaceous alpine plants growing by the roadside. After two hours we reached yet another 14,000-foot (4,250-m) pass, Hong La, and began the descent to the town of Markam. The fifty-four-mile journey from our lunch spot had taken more than three-and-a-half hours over rough, narrow roads that required our drivers to negotiate numerous hairpin turns and the remains of recent landslides overlooking precipitous drops of more than 1,000 feet (300 m).

Dave Boufford bargaining with Tibetan men in Markam.

Markam, lying in a long, wide valley created by a tributary of the Mekong, is truly a Tibetan outpost, a primitive, extremely poor town with red mud everywhere and a wild west look to it. It seemed strange amidst the squalor to hear chants emanating from the walls of a Buddhist temple. While most Tibetan men wore traditional long, fur-lined coats with one sleeve hanging off the shoulder, a few wore Chicago Bulls jackets. The women, in traditional dresses called chhubas, stared at us as we walked down the street. A large group of local people followed us to our Chinese guesthouse. It was a bit unnerving to have five or six of them watching from the doorway, long silver daggers hanging from their belts, as we pressed plants and entered data into our laptop computer. Another guesthouse—a government-sponsored temple-restoration project—and the early-morning radio news that blared out from speakers on tall poles were the only signs of non-Tibetan influence. In fact, this would be the only town in which we saw vestiges of the Tibetan culture, albeit in shambles.

The following day we retraced the road to Hong La (Pass), south of Markam, and made ninety-six collections of vascular plants and mosses in a mixed broadleaf deciduous and conifer forest. Two government officials accompanied us, but they seemed quite uninterested in our work. For two more days we collected in different habitats around Markam. Heavily grazed meadows of grass and *Kobresia,* a type of alpine carex, were dotted with scrubby rhododendrons and remnants of spruce and juniper forests. Many genera were very familiar to Western eyes: *Gentiana, Ligularia, Lonicera, Berberis, Carex, Clematis, Rubus, Anemone,*

A small Tibetan village in a valley near Markam.

Flowers of Clematis *climbing on shrubs at a forest's edge near Nyingchi in southeastern Tibet.*

Trollius, Potentilla, Pedicularis, Picea, Campanula, Cerastium, Polygonum.

Three days and fifty-some collections later, we headed northwest, climbing another pass above the Mekong River. Apricots were ripening above 12,000 feet (3,665 m), as well as dark blue *Delphinium*, tall *Thalictrum*, and several ferns. The landscape was vast, and although a few scattered pine, spruce, and juniper remained, there was much evidence of clear cutting. Our sense of the strangeness of this land was intensified by the sight of three monks on the road in long, heavy carmine robes, making their pilgrimage to Lhasa, some 400 miles (250 km) away.

A species of Meconopsis, *the Himalayan blue poppy, growing at 17,000 feet at Dongda La.*

It was at Dongda La, south of Zogong, that we hiked to 17,500 feet (5,300 m) to collect alpine perennials from the scree slopes. In the level areas of the glacial cirques, we collected two Himalayan poppies (one blue and one an intense yellow), a creeping willow, several species of rhododendron, and dozens of tiny herbaceous plants. The diversity in this barren landscape was amazing: in the three days that we spent around the town of Zogong, we collected 57 flowering plants and over 140 mosses.

While we collected in the field, Wu Sugong drove to Changdu (Qamdo) to obtain permits for traveling west to Lhasa across the northern road of the Plateau. The local officials in Zogong had informed us that a major bridge had washed out west of the town of Bomi, so the southern route would be impossible to negotiate. On July 19 the entire team set out for Changdu, a 45-mile (75-km) trip that would take six hours because of the now familiar delays caused by road construction, landslides, and generally rough roads.

Changdu, the second largest town in Tibet, lies on the banks of the muddy Mekong and was once a thriving population center. Its large monastery complex, dating to 1444, formerly housed more than 5,000 monks. Only a few hundred monks remain today, but the Chinese government is providing funds to restore their living quarters and the many temples of the lamasery. Elsewhere in the town, however, all traces of Tibetan culture are being destroyed to make room for more modern Chinese architecture and goods. Although Changdu lies on the main road from Sichuan and attracts many tourists from that province, its best hotel can offer hot running water for only one-and-one-half hours each night, and even that isn't guaranteed. Massive construction projects throughout the city often disrupt the basic services that Westerners take for granted.

Our group was able to spend only one day collecting along the Mekong River south of Changdu. The dry slopes and ravines harbor a xeric shrub vegetation dominated by herbs and grasses. Among the thirty-four species we collected were *Salweenia wardii*, an endemic member of the pea family, and *Tribulus terrestris* (devil's thorn), which grew for many years in California as a noxious weed that has only recently been eradicated.

Most of the expedition's fieldwork had been scheduled to take place around the southern townships of Bomi, Yigong, and Nyingchi. The news about bad road conditions west of Bomi now made a long stay there unfeasible if we were to arrive in Lhasa on schedule, but we were determined to spend at least a few days in the area.

The trip to Bomi from Changdu took ten days, but along the way we collected in a number of interesting habitats. On the outskirts of Banda, a tiny outpost consisting of two restaurants, a few shops, a primitive guesthouse, and a Chinese army base, we collected for two days. We spent the first day along a steep, gravelly mountain slope (15,700 feet; 4,760 m) and at the crest of a limestone ridge in a Kobresia meadow with *Potentilla, Sibiraea, Rhododendron,* and *Salix* shrubs interspersed with species of *Corydalis, Lonicera, Caragana, Spiraea, Paraquilegia, Lepisorus, Cryptogramma, Pedicularis,* and *Draba.* On the second day we ventured east of Banda to a dry ravine and slope just above the Mekong River. There we encountered a family of Tibetan children collecting firewood, and throughout the day we could hear them laughing, talking, and singing. The woody plants had all been cut by the local people, but a rich flora remained. Among the fifty taxa we collected that day were *Gentiana, Geranium,* ten species of *Pedicularis, Ranunculus, Stipa, Rheum, Allium, Artemisia, Silene,* and *Astragalus.*

On July 24 we began our serious push west to Bomi. Our caravan and the other vehicles traveling along this road were forced to negotiate around numerous landslides and road construction projects. Indeed, the sixty-mile journey to the town of Baxio took almost ten hours. Having crossed several more mountain passes, we were now in the Salween River valley. The Salween is as muddy a river as the Yangtse or the Mekong, but the land around it is as dry as any desert, and the vegetation is sparse.

In the small village of Rawu we saw evidence that deforestation was occurring to the west. Large trucks were unloading logs up to three feet (one m) in diameter in the local lumberyard. Our accommodations in Rawu were in the military compound, where we took our meals with members of the Chinese army and watched them perform their early morning drills. We spent four and a half days in and around this beautiful valley: on the moist, open slopes along Rawu Lake; in alpine meadows; on grazed slopes dotted with *Juniperus, Rhododendron, Salix, Sorbus,* and *Potentilla glabra;* on a boulder-strewn mountain slope along the Palongzang River; and in a broad, gravelly floodplain dominated by small specimens of *Hippophäe.* (This genus, a member of Elaeagnaceae, contains three species. The Arboretum has made several attempts to grow *H. rhamnoides* (sea buckthorn) and *H. salicifolia,* but conditions in the Boston area do not appear to be ideal for these taxa.) One particularly cold, miserable day, we were invited into the tent of a Tibetan family to sit by an open fire and drink fresh, hot yak milk and eat tsampa, a mixture of ground, roasted barley and warm yak milk. We watched with fascination as the family made fresh yak cheese and accepted their gracious offer to share it with us.

The region around Bomi, which we finally reached on July 30, supports mixed semi-humid broadleaf forests of deciduous species such as

Two species of gentian, both growing in thin mountain soils The blue flowers, in photo at right, are scarcely larger than one centimeter across

A hospitable Tibetan family boiling fresh yak milk inside their tent.

Betula, Alnus, and *Sorbus.* Conifer forests at higher elevations are dominated by *Abies, Tsuga,* and *Pinus densata.* Other familiar taxa we saw included *Rosa, Populus, Lonicera, Ribes, Rubus, Primula, Gentiana, Rhododendron, Cornus, Potentilla, Sambucus, Viburnum, Berberis, Rhus, Elaeagnus, Quercus, Philadelphus, Clematis, Prunus,* and *Daphne.* One nice surprise was finding *Lindera obtusiloba* growing wild. (A 100-year-old specimen of this species, grown from seed collected in 1892 in Japan by Charles Sargent, stands across from the lilacs in the Arboretum.) Unfortunately, an unwelcoming attitude on the part of local officials forced us to cut short our time in Bomi; nevertheless, we collected about 125 taxa in the course of our three days there.

Fruit of a Viburnum *growing at the edge of a forest near Bomi.*

On August 4, we retraced our steps toward Banda and then headed north again to Changdu, where we remained for two days while Wu Sugong again met with local officials and made plans for the difficult road ahead. The five-day, 750-mile (465-km) journey from Changdu to Lhasa featured several of the by-now-all-too-familiar hazards of bad roads and washed-out bridges. Twice (once in the dark) we were forced to ford rivers so deep that the water poured over the hood of the vehicles and then rose up through the floorboards. After one night in Lhasa we headed southeast, back toward the Bomi region, to spend four final days in the field.

The more than 6,700 specimens (18,883 sheets) collected over the course of this three-year NSF project will no doubt help to define more precisely this critical biodiversity hotspot. All of the collection and locality data, as well as the images from these trips and others in the region, are linked to a geographic information system (GIS) and are available over the worldwide web (http://maen.huh.harvard.edu:8080/china). Specimens collected earlier in the region and now housed in the Harvard University Herbaria will be entered into a database and linked to the website in the near future. By providing training and computer equipment for American and Chinese students and professionals, the project laid the foundation for future long-term research projects on China's biodiversity. In addition, the research may have paved the way for conservation efforts and for detailed analyses of biogeographic patterns and processes of diversifica-

Fruit on stump sprouts of a Sorbus *species growing on grazed slopes near Rawn*

The author collecting in a meadow outside Markam.

tion in the region. Conservation International (http://www.conservation.org/xp/CIWEB/home), an organization that is currently working closely with Chinese botanists and government officials in western Sichuan to prioritize areas for conservation, has sought the expertise of Dr. Boufford, who has over twenty years of field experience in China.

Now, after a year's work, we have finished sorting these specimens and dividing them into sets for distribution to over a dozen other botanical institutions. The hardships of the trip are long forgotten, and the magic and richness of this remote, exotic land once known as Shangri-La beckons again. Who knows what other botanical treasures are still to be discovered on the rooftop of the world?

Notes

[1] N. Meyers, 1988, Threatened biotas: 'Hot spots' in tropical forests, *Environmentalist* 8: 187–208; E O. Wilson, 1992, *The Diversity of Life*, Harvard University Press (Cambridge).

[2] From D. J. Mabberley, 1987, *The Plant Book*, Cambridge University Press.

[3] P. H. Raven and D. I. Axelrod, 1978, Origin and relationships of the California flora, *University of California Publications in Botany* 72.

[4] W. T. Wang, S G. Wu, K. Y. Lang, P Q Li, F. T. Pu, and S. K Chen, eds., *Vascular Plants of the Hengduan Mountains*, 1993, Vol. 1, Pteridophyta, Gymnospermae, Dicotyledoneae (Saururaceae to Cornaceae); 1994, Vol. 2, Dicotyledoneae (Diapensiaceae to Asteraceae) to Monocotyledoneae (Typhaceae to Orchidaceae).

[5] S. B. Sutton, 1974, *In China's Border Provinces the Turbulent Career of Joseph Rock*, Hastings House, (New York).

Susan Kelley is an associate curator and responsible for managing and developing the Arnold Arboretum's digital mapping system, which tracks the ca 15,000 plants in the living collections. Her previous experience plant-hunting in Asia was in the central mountains of Taiwan

Anachronistic Fruits and the Ghosts Who Haunt Them

Connie Barlow

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Reunited: osage orange and mastodon. Shown here is surely the first time in thirteen thousand years that the fruit of osage orange, Maclura pomifera, *has touched a molar of its missing partner in evolution,* Mammut americanum.

Thirteen thousand years ago, the Age of Great Mammals came crashing to a close in the Western Hemisphere. Lost were the giants of the elephant clan: the mammoths, mastodons, and gomphotheres, which had maintained a presence in North America for twenty million years. The native horses, a tall camel, and all but one species of pronghorn—each group from a lineage thought to have originated in North America—vanished from the plains. Gone, too, were the strange beasts that had evolved in South America during millions of years of continental isolation: ground sloths as massive as elephants, hippo-like toxodons, and lumbering, spike-tailed glyptodonts, which looked uncannily like the ankylosaurs that had shared the Cretaceous landscape with T. rex.

These large herbivores (along with the biggest bear, the biggest canid, and several big cats, all of which depended upon the plant eaters) disappeared in a geological instant. Evidence is mounting that newly arrived humans with formidable stone-tipped spears of Clovis design were to blame.[1] This "extinction of the massive" that marks the end of the Pleistocene epoch ravaged the megafauna. What happened to the plants?

We cannot be sure. Leaves and flowers and seeds are not preserved as readily as bone. Plant lineages restricted to upland habitats may come and go without a trace. Bogs and lakes, of course, receive a shower of pollen, often from vast distances. But detectable quantities of pollen preserved in sediments are restricted to wind-pollinated plants—notably, grasses, conifers, and many deciduous trees of our temperate forests. (And of these, some produce pollen that can be distinguished only at the genus or even family level.) Indeed, fossil pollen from stratified bog and lake sediments is the primary evidence used to reconstruct the vegetational shifts that accompanied the repeated coolings and warmings of the Pleistocene epoch.

The Pleistocene pollen record shows only one tree extinction (a species of spruce) in North America near the end of the epoch.[2] Is there reason to suspect that plants pollinated by insects, birds, or bats—that is, plants with little or no pollen record—might have been more vulnerable to extinction?

The answer is yes, but vulnerability to extinction in this case has nothing to do with the mode of pollination. Many plants that are pollinated by animals rather than by wind produce fleshy fruits whose seeds are dispersed by other, larger animals. Plants dependent on megafauna for dispersal would indeed have been vulnerable to range reduction or even outright extinction when their partners in evolution and ecology vanished.

Riddle of the Rotting Fruit

Ecologist Dan Janzen speculates that although fossil evidence is lacking, some fruit-bearing plants probably did follow the megafauna into extinction.[3] These plants would have begun to decline when their megafaunal seed dispersers vanished. Some might have gone extinct relatively soon after losing their partners. Others, especially the long-lived and those that regenerate clonally from their roots as well as from seed, still survive but may ultimately be on track for extinction. Still others have been regenerated as domesticated cultivars by humans fond of their fruit or other botanical qualities. But by and large Janzen thinks that those that are still here today suffered significant reductions in range when important members of their disperser guilds were extinguished.

The narrowly restricted ranges of some of today's big-fruited plants suggest that Janzen may be right: plant extinctions may, in fact, have stemmed from the animal extinctions. An indicator that something is amiss is evident in the case of trees whose fleshy fruits fall and rot beneath the canopy of the parent. It was this "riddle of the rotting fruit" that captured Janzen's attention twenty-five years ago while he was studying the ecology of Costa Rican plants. It made no sense for plants to waste energy by building pulp that attracted few if any dispersers. Worse, in the case of many fleshy fruits, when the pulp rots, the embedded seeds are killed as well. What was going on here?

In 1982 Dan Janzen, with paleoecologist Paul Martin, published a paper in the journal *Science* titled "Neotropical Anachronisms: The Fruits the Gomphotheres Ate."[4] Janzen had carried out field studies in Costa Rica to learn whether introduced livestock (horses and cattle) served as surrogate Pleistocene megafauna for the bereft plants. The result: a list of some thirty species of trees and vines of the Costa Rican dry forest whose fruits bear the physical and ecological characteristics of "ecological anachronisms."[5] These plants are living in a time warp; they are adapted for a lost world. Their missing animal partners are "the ghosts of evolution."

Anachronisms and ghosts caught the early attention of Robert E. Cook, who is the director of the Arnold Arboretum. Citing Janzen and Martin, Cook published an essay in 1982 in *Natural History* that described the avocado, *Persea americana*, as an ecological anachronism that has been stunningly successful in attracting a replacement dispersal agent: us.[6] Within the past few hundred years, avocado has been taken from the New World tropics to orchards in Florida, California, northern Mexico, and far beyond this hemisphere. Wild elephants who raid village fruit trees in Africa are now "planting" American avocado on that continent.[7]

In their landmark paper, Dan Janzen and Paul Martin concentrated on Costa Rican plants. But in the final paragraph they extrapolated the anachronism concept to large-fruited plants of

Strategies of the megafaunal dispersal syndrome. Domesticated varieties of three tropical fruits native to the New World demonstrate a range of pulp attractions and seed defenses Ripe papaya fruit, Carica papaya, *is soft enough to mash rather than chew, so the tiny seeds require no physical protection A mammal that inadvertently crushes a papaya seed is, however, deterred by a sharp, peppery flavor—and thus the toxins so signaled. Primate fruit thieves (like us) can eat around and discard the concentration of seeds, thus foiling the papaya's intent Avocado,* Persea americana, *produces a slippery and dense seed, whose potent toxins taste bitter to mammals In contrast, the seeds of the canistel tree,* Pouteria campechiana, *have a mild flavor and are protected instead by a tough coating. All but the biggest frugivores could be expected to eat around or spit the seeds of avocado and canistel*

Honey locust and her new partner in evolution. Strung along the top are the usual number of seeds in a honey locust pod, such as the one resting on the author's arm.

The most anachronistic legume in North America. The ripe pod of kentucky coffee tree is toughened by resins, and the seeds are invulnerable to insect attack The green pulp is sweet but reputedly poisonous to humans Early colonists in Kentucky roasted and ground the seeds to make a coffeelike brew. The ground "coffee" shown here is courtesy of Carl Mehling.

the eastern and central United States: kentucky coffee tree *(Gymnocladus dioicus)*, honey locust *(Gleditsia triacanthos)*, pawpaw *(Asimina triloba)*, persimmon *(Diospyros virginiana)*, and osage orange *(Maclura pomifera)*.

To a plant lover, the notion that ghosts may be haunting some of the most magnificent native fruits of one's homeland is a revelation. It was quite a surprise, therefore, when I began the library research four years ago for my book *The Ghosts of Evolution* (2001) to discover that virtually no effort had been made to test these five temperate plants or to identify other possible anachronisms in the forests and fields of North America. Indeed, scientists currently breeding honey locust trees to increase the fodder value of their pods, and those developing improved pawpaw cultivars and promoting the use of their fruit, have been doing so unaware that the fruits are anachronistic.

Osage Orange—An Extreme Anachronism

Recently, I spoke with an archeologist, Frank Schambach, who felt frustrated because nowhere in the published literature could he find the information he needed to solve the ecological puzzle of osage orange—information crucial for validating his thesis that before settlers began rearranging the landscape, the wood of this tree, highly valued for making hunting bows, may have been traded far and wide in North America under the complete control of a single indigenous tribe.[8] Schambach suspected that osage orange (also known as bois d'arc, "wood of the bow") occupied a very constricted range that could in fact be claimed by a single tribe.

Osage orange would more appropriately have been named osage breadfruit. A close relative to *Maclura*, of America, and to its sister genus *Cudrania*, of eastern Asia, is the breadfruit genus, *Artocarpus*. All are linked through the mulberry family, a largely tropical family dominated by the figs and striking for its members' compound fruits and the white latex some exude when cut. Osage orange was named after the Osage Indians of Missouri, who first introduced white traders to this strange fruit—the color of a glow-green tennis ball and about the size and firmness of a softball.

Inhabitants of the plains and prairie states know this fruit by another name: hedge apple. Until the invention of barbed wire in 1874, there was no more effective or economical way to fence free-ranging livestock out of one's vegetable garden or cornfield than to plant a hedge of thorny osage orange stems, later interweav-

An elephant fruit in a land without elephants The bright green fruit of osage orange was shaped by the now extinct megafauna of North America.

ing the abundant root suckers that the trees send up in response to severe pruning. Thus osage orange gained a replacement dispersal agent, and its range expanded rapidly.

Maclura pomifera, a wind-pollinated tree, is known from pollen samples to have been wide ranging in North America during earlier ice-free phases of Cenozoic history. But by the time of European contact, its range had shrunk considerably: just before its transformation into a common hedge plant, it inhabited only a small stretch of the Red River watershed near the junction of Texas, Oklahoma, and Arkansas. Frank Schambach suspects that at its nadir the range was even more restricted—possibly limited to the Bois d'Arc tributary of the Red River in Texas and nearby creeks of the adjacent Blackland Prairie. Such isolation would explain how a single tribe—the Spiroans of Mississipian culture—could have controlled the entire bow wood trade. And this, in turn, would explain the archeological evidence of extraordinary wealth accumulated by this people in the centuries prior to European contact.

What ecological information did Schambach need to solve his archeological puzzle? He wanted to know whether horses spread osage orange—that is, do horses eat the fruit and defecate viable seeds? If so, then by the time naturalists got around to documenting the geographic reach of osage orange, its renaissance had already been initiated by horses, which had been reintroduced into North America in the sixteenth century. Surely amateur naturalists and people living wherever osage orange and ranch horses co-exist know the answer to the question—it seems to be yes. But the matter isn't discussed in the published literature. Thus a core contention in Schambach's "Spiroan trader" theory rests on what he has been able to glean from Red River ranchers and his own casual observations.

The search continues. A year after publication of his "Spiroan trader" theory, Schambach obtained crucial anecdotal information: "A volunteer at my dig this summer lives on a ranch on the Blackland Prairie in east Texas," Schambach wrote me. "She has a small herd of horses which, she assures me, routinely eat osage orange fruits on their own. Furthermore, she knows for a fact that horses spread the tree via their manure because when she and her husband acquired their property there was no osage orange growing on the upland (prairie) parts of it, only in the bottomlands along the creeks. But soon after they began pasturing horses on the land, the osage orange began to migrate out of the bottoms, and it is now growing all over their prairie areas, to their dismay."

Here's another intriguing story that came my way while I was writing this article—this one from Robert M. Timm, professor of ecology and evolutionary biology at the University of Kansas. Timm has horses and one mule on his farm in Kansas. They all "love the fruits" of osage orange, he wrote me. "The mule is the best at locating them, but if you are experienced with mules that wouldn't be a surprise. They are always much more curious and more exploratory than horses. I'd say of all the natural foods around here, osage orange fruits are the mule's favorite. He seems to remember them from one year to the next, but that too is typical of mules. I have no doubt that Pleistocene horses would have long-term memory of favorite trees to feed at every fall."

Timm is very familiar with Dan Janzen's anachronism theory and has been casually observing mice, rabbits, and tree squirrels feed-

ing on the pulp and seeds. "They don't cache osage orange," he observes, "they eat it on the spot." Most intriguing is his discovery of large quantities of shredded, freshly fallen fruit in the stomachs of deer. All these mammals great and small are indeed eating the fruit, but are they dispersing the seed? Timm concludes no.

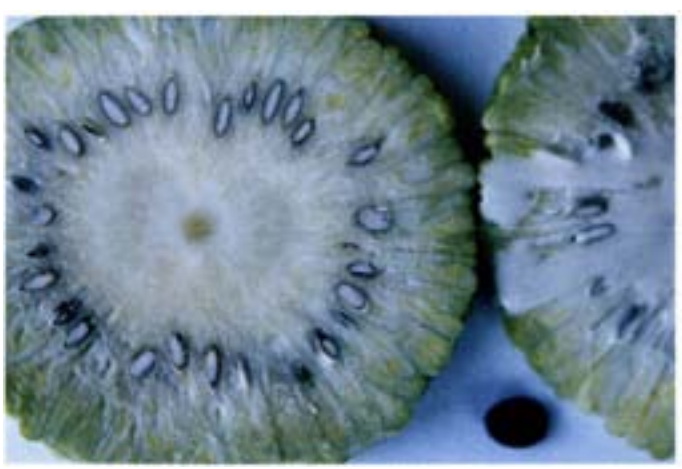
Timm acquires buckets of osage orange fruits from neighbors and spreads them on the unpastured sections of his own property as supplemental feed for wildlife. Nevertheless, he has encountered no seedling trees. "I picked up another five gallon bucket of fruits this morning," Timm wrote me as this article went to press, "and I'll check here in a few weeks to see if the seeds make it intact through a mule's digestive tract. I'll pull the mule and horses off the pasture later this month and keep them in a paddock for the winter and give the mule fruits where it will be easy for me to retrieve the seeds."

Overall, anachronism theory seems to be anecdotally well supported for horses as dispersal agents of osage orange. Are there any other plausible ghosts to pair with this native fruit besides Pleistocene horses?

Paul Martin and I had a chance to test osage orange vicariously on a much bigger Pleistocene surrogate: African elephants at the Brookfield Zoo in Chicago. Almost surely this was the first time since the Pleistocene that the fruit of *Maclura pomifera* had met the molar of a proboscidean. I sent a box of freshly fallen fruit to Martin, which he in turn forwarded to the Brookfield Zoo. After a search of the literature, zoo staff decided that there was no danger in offering the elephants a few fruits.

The results were inconclusive. At first, the youngest two elephants didn't want to even touch the fruits offered by their keepers. Finally, each curled a trunk around a sphere and hurled the offensive object out of their habitat. The matriarch, however, chose to sample the first fruit offered, chewing and swallowing. But she would then accept no more.

Herbivores are known to be wary of novel foods. Cultural knowledge of gastronomic possibilities, passed from one generation to the next in social animals, would not be available to zoo elephants. Then too, well-fed captive animals will often turn up their noses at foods that their wild counterparts would happily consume. The case is therefore still to be made that Pleistocene mastodons and mammoths would have joined horses in dispersing osage orange fruits in North America. But it will be a most interesting hypothesis to pursue—for anyone excited by the theory and who has access to elephants!



An extreme anachronism. Osage orange is one of North America's most anachronistic fruits. Freshly sliced fruit oozes a white latex, which has been wiped clean from the slice on the left. Honey locust seed (1 cm) for scale

Powers of Persistence

It is perhaps no coincidence that the five species of temperate American trees judged anachronistic by Dan Janzen and Paul Martin are all prodigious cloners. Vegetative means of reproduction would have helped these trees persist for the thirteen thousand years that sexual reproduction has been disrupted for want of adequate seed dispersal.

Kentucky coffee tree, honey locust, pawpaw, persimmon, and osage orange all send up root suckers—prolifically so when the main stem is pruned or otherwise damaged. Kentucky coffee and pawpaw are extraordinarily skilled in growing lateral root runners that sprout new stems many meters from the elder stem, supported by photosynthates supplied by the parent. Indeed, a few years ago when a pawpaw tree "died" of old age in the Arnold Arboretum, more

than a hundred fresh stems popped up almost immediately from a vast network of root runners. And although the Arboretum isolates its mature kentucky coffee specimens by encircling the trees with a wide buffer of mowed lawn, grounds staff must periodically rid neighboring beds of the vigorous fresh stems emanating from hidden root runners.

As the ice retreated from its last southward advance, which peaked about twenty thousand years ago, four of the five above-mentioned anachronistic trees of eastern and central North America would have been helped to reclaim former territory by newly arriving humans. Pawpaw and persimmon fruits would have been carried back to camp, their seeds removed or spit out at the time of eating. Honey locust pods would have been opened and licked for their sweet matrix, the hard seeds discarded. Kentucky coffee trees were valued not for their fruit but for their large, nearly spherical seeds, which took a lovely polish and were used for gaming tokens. Although the wood of osage orange was highly prized and known to have been traded across great distances in the time just prior to European contact, the fruits held little if any value. Does this perhaps explain why the range of osage orange became so constricted?

Is the Endangered Torreya Tree Anachronistic?

Coming to terms with the likelihood that native horses almost certainly and elephants probably were effective seed dispersers of osage orange during the Pleistocene and for several tens of millions of years before that provides fresh insights into how to rescue from extinction a severely endangered American tree, *Torreya taxifolia* (florida torreya). *Torreya* is a conifer of the plum yew family, Cephalotaxaceae, and thus bears no fruit as botanically defined. Nevertheless, the fleshy design of its diaspore—ecologically a fruit—is an obvious lure for animals. Like a yew or a ginkgo, torreya produces single large seeds enveloped in what ought to be viewed as fruits by vertebrate dispersers.

The proximate cause of *Torreya taxifolia's* imminent extinction, and thus the cause that gets all the attention, is disease. Some thirty pathogens are known to infest it, but no single disease seems to be the culprit.[9] Once common in the rich soils of the Apalachicola River of northern Florida, adult specimens growing in the wild suddenly began to die in the 1950s, and none remain today. Like the American chestnut that was destroyed by (an imported) blight during the early years of the twentieth century, torreya survives only because new stems keep sprouting from the same rootstock. Sadly, each fresh sprout of torreya is doomed to die before it is old enough to produce pollen or ova. Energy stored in the roots will eventually give out, since new starts in the shady forest may consume more photosynthate than they can return to the roots before their demise.

The genus *Torreya* was once distributed throughout the Northern Hemisphere. Range fragmentation has created distinct species in eastern China, patches of the Coast Range and the Sierras of California, and the Apalachicola of Florida. The geographic range of the Florida species is today restricted to the cool ravines along the east side—only the east side—of a 22-mile (35-km) stretch of the Apalachicola River in northern Florida. During the coldest times of the Pleistocene, the Apalachicola, with its moderate climate and rich soils, was a refuge for the trees and forbs that now enrich the Cove Hardwood forest of Great Smoky Mountains National Park, 375 miles (600 km) to the north. After the ice retreated, most of the plants hitched rides from wind and animals and moved back north to their pre-glacial home. Torreya seems to have been left behind.

Some experts confirm that the tree's troubles may have begun for want of a disperser.[10] Global or regional extinction of an animal partner (or partners) may be the root cause of the tree's current distress. Torreya is probably not ideally suited for the warmth and humidity of today's Apalachicola region. It wants to head north, but it hasn't found a vehicle.

That florida torreya may be haunted by the ghosts of extinct dispersers is suggested by a host of clues. First, the diaspore of all species of *Torreya* is distasteful or toxic to many (possibly all) mammals who normally consume fruits. The pulp has a high terpene content and it leaves a sticky residue on one's skin. Squirrels treat the fruit as they treat ginkgo fruit in New

A florida torreya photographed well north of its "native" grounds, near Philadelphia, Pennsylvania, at the Henry Botanic Garden, near Gladwyne.

York City's parks: they discard the flesh and steal the seeds. Squirrels that fed on torreya seeds on the east side of the river would be unable to carry them across water to the west side, and if the rich soils of the Apalachicola are isolated from rich soils to the north by a barrier of sandy soils, then the squirrels would also be unable to disperse the seeds farther north. Squirrels may thus be a disperser, but they apparently are not the right disperser for helping this tree reclaim its pre-glacial range. This explanation would account for the seemingly paradoxical fact that until the 1950s, florida torreya was the seventh most abundant tree species in an astonishingly small patch of "native" habitat.

Perhaps the best evidence that florida torreya may be suffering from an inability to track climate change is that before the blight took hold, this tree was planted hundreds of miles north of its Florida habitat in the mountains of North Carolina, near Asheville. There, on the Biltmore Estate, the torreyas are thriving, and the females produce abundant seeds. "Flower beds often abound with seedlings 'planted' by squirrels," reports Bill Alexander, landscape historian at the Biltmore. During his 23 years there, Alexander has watched the torreyas stand up well to a five-year drought. And in the winter of 1985 the thermometer plunged to minus-20 degrees Fahrenheit, yet "our trees smiled right through," he told me.

For a number of years, Alexander had been thinking that "florida" torreya really belonged back in North Carolina. So he was delighted to hear of the lost-disperser theory. A megafaunal ghost? If so, the ghost may well be a large extinct tortoise, I suggested, as reptiles are far more tolerant of plant terpenes than are mammals, and as the thin "shell" protecting the large single seed of this conifer offers scant protection against molars.

One must not, however, ponder the plight of the florida torreya in isolation from its sister species. In contrast to *Torreya taxifolia,* California's torreya *(Torreya californica)* is maintaining its population, as are the several Asian species of *Torreya*—all of which bear nearly identical propagules. Nevertheless, all occupy restricted geographic ranges. What if the entire genus lost its key dispersers and now depends on the local activities of squirrels?

Bill Alexander and I easily came up with two plausible explanations for the differences in endangerment, based strictly on geographic differences. In eastern North America, the climatic effects of the Ice Sheet reached much farther south than was the case in either western North America or eastern Asia, forcing the Appalachian species to take refuge at a lower

latitude. Perhaps even more significant is that latitudinal migration was the only option for florida torreya as the climate warmed. In contrast, torreya species in California and in Asia could head upslope. These torreyas are native to mountainous regions, where altitudinal gain facilitated by nothing more than squirrels could help the trees keep pace with a warming climate.

Such unsubstantiated and untested leaps of speculation are normally not well received within the scientific community—but these are not normal times. Without some drastic breakthrough in the management of Florida's wild population of torreya trees, *Torreya taxifolia* will, within fifty years, almost surely be extinct outside of botanical gardens. Perhaps it is time to help this torreya gain rootholds of wild populations in the mountains of North Carolina.

Such is not, alas, how things are done with endangered species—the exception being the recent return of the california condor to its Pleistocene home near the Grand Canyon. Native territory is regarded as the last best place to be. But what is "native"? How far might we justifiably reach back in time for a benchmark?

In a study of endangered species published in 2000, Rob Channell and Mark Lomolino concluded that "most species examined persist in the periphery of their historical geographic ranges."[11] If habitat at the periphery of historical range is adequate but not ideal, then the last place a troubled species is found may not, in fact, be the best place to assist its recovery.

Transplantation across great distances is an uncommon and controversial technique for biodiversity conservation today. But as the greenhouse effect ratchets up temperatures and reroutes rainfall, and as botanical preserves become even more isolated islands in a sea of human development, long-distance transplantation will become the norm. If gardening a few local patches of endangered plants is tough today, it's going to get a lot tougher when, like it or not, we become gardeners of the planet.[12] Helping plants track climate change from one patch of habitat to another will be a routine tactic for conserving biodiversity decades hence. Is it too early to begin now with florida torreya?

Notes

[1] In the June 8, 2001, issue of *Science*, two papers confirmed the "overkill hypothesis" of end-Pleistocene extinctions, one for Australia and the other for North America. The North American paper is John Alroy, 2001, "A multispecies overkill simulation of the end-Pleistocene megafaunal mass extinction," 292 1893–1896. A news report by Leigh Dayton published in the same issue (p. 1819), "Mass extinctions pinned on ice age hunters," suggests that this view is now the majority position.

[2] Stephen T. Jackson and Chengyu Weng, 1999, "Late Quaternary extinction of a tree species in eastern North America," *Proceedings of the National Academy of Science* 96. 13847–14852.

[3] Dan Janzen's suggestion that fleshy-fruited plants may have gone extinct since the end of the Pleistocene is in Connie Barlow, 2001, *The Ghosts of Evolution* (New York: Basic Books), 88

[4] D H. Janzen and P. S Martin, 1982, "Neotropical anachronisms: The fruits the gomphotheres ate," *Science* 215: 19–27.

[5] For the story of how Janzen and Martin developed their ideas and conducted their fieldwork, see chapters 1–3 of the author's *Ghosts of Evolution*, op cit.

[6] Robert E. Cook, 1982, "Attractions of the flesh," *Natural History* 91(1): 20–24.

[7] Martin N. Tchamba and Prosper M. Seme, 1993, "Diet and feeding behavior of the forest elephant in the Santchou Reserve, Cameroon," *African Journal of Ecology* 31: 165–171.

[8] The theory that osage orange, prior to European colonization, occupied a very restricted range is presented in Frank F. Schambach, 2000, "Spiroan traders, the Sanders Site, and the Plains Interaction Sphere," *Plains Anthropologist* 45 7–33.

[9] Mark W Schwartz, Sharon M. Hermann, and Philip J. Van Mantgem, 1999, "Population persistence in Florida Torreya," *Conservation Biology* 14. 1023–1033.

[10] See p. 229 of *The Ghosts of Evolution.*

[11] Rob Channell and Mark V. Lomolino, 2000, "Dynamic biogeography and conservation of endangered species," *Nature* 403: 84–86

[12] D. H. Janzen, 1998, "Gardenification of wildland nature and the human footprint," *Science* 279: 1312–1313.

Acknowledgments

I wish to thank Dan Janzen, Paul Martin, Bill Alexander, Robert Timm, and Frank Schambach for helpful critiques, comments, and anecdotes.

Connie Barlow is a science writer and author of *The Ghosts of Evolution Nonsensical Fruits, Missing Partners, and Other Ecological Anachronisms*, published in 2001 by Basic Books.

Pastures of Plenty: A Case Study in Field Biology

P. L. Marks

Cow pastures are taken for granted in rural parts of the northeastern United States, where they are common. We don't think of them as special habitats, yet they are. Cow pastures have been present in the northeastern landscape since the earliest farm families first carved agricultural lands from the forests. The best land in terms of soil fertility and drainage generally became arable fields, whereas more marginal lands went into pastures. Other marginal lands, often wetter, steeper, or more remote from the main property, were left as forest. But historically, every dairy farm had at least one pasture.

Field biologists work to discover patterns in nature—usually by observation—and then to understand the causal influences behind those patterns. More often than not, the explanations for patterns in nature are complex, a result of multiple factors interacting in various ways over time. Often it is not possible by observation alone to fully understand the cause of a given pattern.

Cow pastures are interesting from a scientific point of view because one factor—the presence of many large, hungry cows—is of overriding importance in determining the abundance and kinds of plants that occur. Whether a pasture began as a natural meadow or as planted forage, the grazing and trampling activities of cows, carried out over years or decades, produce a habitat of closely cropped edible plants interspersed with taller plants that are avoided by the cows due to their physical or chemical properties.

Pastures can be surprisingly beautiful, perhaps because they take on some of the features of landscaped yards and public gardens: large areas of mowed green grass with scattered drifts of taller herbs and small flowering trees—sometimes dramatically pruned into unusual shapes. How does this happen?

In active pastures, the most conspicuous plants are those not eaten by cows. A striking feature of many of these plants is the presence of thorns or their equivalent. Thistles (*Circium* spp.) are common in many pastures. And among woody plants that tend to catch our attention visually, wild or volunteer (not planted) apple trees (*Malus* spp.) and hawthorns (*Crateagus* spp.) stand out. Apple trees do not have true thorns, but their short side branches are sharp at the tips and function as thorns. These distinctive thorny woody plants allow many pastures to be recognized as such as we drive or walk along country roads. Pastures with hawthorns are especially easy to recognize at a distance because the hawthorn bark is light gray and the branches are horizontal in orientation, producing a distinctive growth form. Because they persist for many decades after a pasture is abandoned, the apples and hawthorns also provide a diagnostic legacy of former land use.

We now have a pattern to explain. Why are thorny woody plants so common in cow pastures? An obvious and important first thought is that the thorns prevent or reduce cows' feeding on these plants. This is consistent with other related observations. One is that a variety of non-thorny woody plants invade abandoned pastures, but not pastures where cows are still present. Another observation is that the apples and hawthorns that commonly invade pastures do so when the pastures are active. However, other thorny plants, such as multiflora rose *(Rosa multiflora)*, invade a variety of open habitats, not just active pastures.

The implication is that pasture cows are a dominant influence. In their presence thorny plants hold an advantage, whereas on the same land without cows non-thorny plants have the edge. Presumably, plants without thorns cannot invade active pastures because cows eat them. In pastures abandoned for decades one can sometimes see both thorny and non-thorny woody plants. There are dense patches of thorny scrub where plants that started when the pasture was active have grown larger and taller; here few other woody plants have been able to invade.

An active cow pasture in spring, showing cows, closely cropped grass, and a mixture of apple and hawthorn trees. The apple trees range from closely pruned cones to larger trees in flower.

Other areas, where no apples or hawthorns were present at the time of abandonment, now have a variety of non-thorny trees and shrubs such as white ash *(Fraxinus americana)* and gray dogwood *(Cornus racemosa)*.

A careful accounting of plant ages should reveal differences between the groups: the thorny plants that invaded when the pasture was active should be ten or more years older than the non-thorny trees that invaded after its abandonment. But inferring plant ages from plant sizes can be misleading. Decades after pasture abandonment, ash trees, which grow faster than apples, will be taller but younger.

Although thorns reduce the feeding pressure from cows, they do not prevent feeding altogether. Indeed, the closely pruned hawthorn and apple plants are perhaps the most spectacular aspects of an active pasture. From a distance, it is difficult to believe these are wild plants, so exquisitely shaped are their crowns. Many look like inverted bowls or cones, whereas others look like old-fashioned hourglass timers. Closer inspection reveals that these geometrical shapes are made up of a proliferation of branches caused by the repeated release of side branches, which, in turn, is caused by cows eating the branch tips year after year. The resulting protective matrix of short, interwoven branches is so dense and rigid that cows can feed only on the plant bits that protrude from it. Conversely, leaves that are near the exterior of the matrix

A typically cone-shaped, closely pruned apple tree, photographed in winter, resides in an active cow pasture. The glove in the foreground provides scale.

The top part of this apple tree, now beyond the reach of hungry cows, shows a spurt of new growth, the tree takes on a characteristic hourglass shape

but recessed from the edge are protected from cows while still exposed to sunlight. The densely cropped apples and hawthorns and the cows achieve a kind of equilibrium, with the cows unable to penetrate the "shell" and the plants unable to grow beyond it. One of my students proposed the term "bovine bonsai" to describe this lovely piece of pasture horticulture.

The balance between the growth of plants and the cropping by cows sometimes tips in favor of the plants—though just barely. Some thorny woody plants in active pastures expand the volume of their crowns slightly each year, despite the bovine pruners. Much of this growth occurs in the lower half of the crown so that after twenty or thirty years of modest annual gains plants attain an inverted cone shape. Eventually, this slow lateral expansion reaches a point where cows can no longer reach the tops. This marks an important transition in the lives of these plants. After decades of tortuously slow growth, plants whose tops are beyond the reach of cows suddenly escape much of the bovine influence. Rapid shoot growth begins atop these plants and, in subsequent years, lateral growth increases once it is above the reach of the cows. Eventually a bizarre new growth form is achieved: the shape approximates an hourglass, consisting of a lower inverted cone whose closely cropped outer surface is still maintained by the cows, an upper upright cone that has rapid growth on the inside where the cows cannot reach, and a smoothed lower outer surface where protruding twigs are removed by the cows.

I have walked through a number of pastures, making observations and trying to understand more about the issues discussed above. In active pastures in early spring I have seen seeds from non-thorny trees like white ash scattered within the close cropped turf. Yet seedlings of the same non-thorny species are notably absent, suggesting that the bottleneck for the establishment of these plants is at the seedling stage. In contrast, seedlings of apples and hawthorns must at least occasionally become established in pastures in order to account for the larger plants that are so conspicuous later on. Interestingly, hawthorn and apple seedlings lack thorns. Why then can these seedlings survive in active pastures while other non-thorny seedlings cannot? Why doesn't eating and trampling by cows eliminate apple and hawthorn seedlings, as it apparently does the seedlings of non-thorny species? We don't know all the answers, but our understanding of how young plants get started in pastures is more complete for apples than for hawthorns.

Many pastures have apple trees around the edges or a few large, old apple trees within the pasture proper. In autumn, the fruits ripen and cows eat the apples that fall to the ground. The seeds pass through the cow unharmed and are deposited in "cow pies," where they spend the winter. Come spring, these seeds germinate into seedlings that grow directly from the cow pies. The rotting manure provides a locally fertile environment for apple seedlings in cow pastures. In addition, cows typically do not feed on plants growing in or near cow pies. This reprieve from feeding damage, which may last through the first growing season, allows apple seedlings to grow and create energy reserves so that they are more likely to recover the first time they are eaten or trampled upon by cows.

Since not all pastures have apple trees, and since only those cow pies produced when apples are ripe contain seeds, most cow pies do not have apple seedlings. But examining many cow pies in the spring should yield some with apple seedlings, which are recognizable by their two large rounded seed leaves, or cotyledons. One study conducted by Cornell thirty years ago found as many as 250 apple seedlings in a single cow pie!

I once harvested a closely cropped apple tree about five feet (1.5 m) tall in order to estimate its age by counting the annual growth rings on a cross section of the trunk. (Gaining access was not easy—I had to saw a hole in the side of the dense, rigid, sharply tipped branch matrix before I could reach the trunk.) The tree was about thirty years old, which was consistent with the ages reported in the Cornell study. However, even more interesting was the new dimension of pasture ecology it revealed: inside the protective branch shell of this apple tree grew several non-thorny woody plants.

I have since found a number of non-thorny woody species, including white ash, honeysuckle (*Lonicera* spp.), and chokecherry *(Prunus virginiana),* growing inside the protective shell of several apple and hawthorn trees in pastures. These species of trees and shrubs are among the same species that invade abandoned arable fields and pasture. In active pastures, species intolerant of cattle grazing can generally grow only within the refuge provided by pruned apples and hawthorns.

This essay focuses on cow pastures in central New York State, but the issues raised here apply, to some extent, to cow pastures around the world. Elsewhere there are species equivalent to our hawthorns and apples, such as junipers. There are other kinds of pastures as well, and what is true of cow pastures is not necessarily true of sheep or horse pastures. Both the number of animals and the continuity of the grazing can influence the numbers and kinds of plants that are able to invade. Finally, the function of cow pastures seems to be changing in the Northeast as dairy farming becomes more intensive. Historically, pastures provided forage for dairy cows during the warm parts of the year. On today's large dairy farms, cows may not be pastured at all, and since many dairy cows now receive all their food indoors, cows that are pastured may not crop apples and hawthorns as closely as they did in the past. Even so, evidence of former pastures still remains in the large plants left behind.

Apple seedlings emerging in spring from cow manure deposited the preceding fall.

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Henry David Thoreau and the Yankee Elm

Thomas J. Campanella

THE American elm *(Ulmus americana)* has always occupied a hallowed place in the pantheon of our native trees, and nowhere was its presence greater than in New England. Planted by the thousands on streets and town commons throughout the region, the elm was a defining symbol of Yankee life. Charles Joseph Latrobe, a Briton who toured New England in the 1830s, summed it up best when he christened the Yankee elm "the glory of New England."[1] Indeed, elms moved pens. Paeans to the tree and its beauty abound in the literature of nineteenth-century New England. Hawthorne, Lowell, Longfellow, Holmes, and Henry James all penned eloquent tributes to the tree. So did literary visitors such as Trollope and Dickens.

But no writer who lifted pen to elm did so with more grace and insight than the bearded scribe of Walden Pond. Henry David Thoreau was the poet laureate of the Yankee elm. A prolific writer, Thoreau's pen roved far beyond his celebrated sojourn at Walden. His journals record nearly twenty-five years of observation and bristle with exacting detail. These books map the geography of Thoreau's intellect, a terrain well timbered with elms.

To Thoreau, elms consecrated the landscape. Mircea Eliade has written in *The Sacred and the Profane* that we "found" the world by investing it with religious meaning, and fix sacred space with signs and totems.[2] In the traditional New England landscape, writes John Stilgoe, meetinghouse spires and church steeples functioned as architectural exclamation points that "made the cellular countryside intelligible to resident and traveler alike."[3] Thoreau's leafy steeples were rougher hewn, but they too linked earth and soul. For in Thoreau's church of nature, elms were the beacons of moral and spatial order.

If they rose more leisurely to the sky, once there the elms challenged the lofty white spires themselves. "Some are so lifted up in the horizon," he wrote of elm crowns spied from afar, "that they seem like portions of the earth detached and floating off by themselves into space." Below, Thoreau imagined harmony and spatial order, for where elms brushed the sky, below lay a town or home. "When I see their magnificent domes, miles away in the horizon, over intervening valleys and forests," wrote Thoreau, "they suggest a village, a community, there." Spying the "dark little dome" of a far-off elm, Thoreau was reminded of the "rural and domestic life passing beneath it."

> Homestead telegraphs to homestead through these distant elms seen from hilltops. I fancy I hear the house-dog's bark and lowing of the cows asking admittance to their yard beneath it. The tea-table is spread; the master and mistress and the hired men now have just sat down in their shirtsleeves.

In summer the great canopies cast shelter over house and town, harboring a chorus of insects whose gentle hum induced in Thoreau "contemplation and philosophic thoughts."

The "Washington" elm (a misnomer; see Sheila Connor, *New England Natives*, page 111) on Cambridge Common, Massachusetts, and the "Whitfield" elm on the right, photographed in 1860. From the Archives of the Arnold Arboretum.

But Thoreau's tree was no mere totem of pastoral retreat from the "great world." For him, elms objectified a range of human values. He saw in the elm stoicism, perseverance in the face of adversity. Elms "adjourn not night nor day," he wrote, "they stand for magnificence; they take the brunt of the tempest; they attract the lightning that would smite our roofs, leaving only a few rotten members scattered over the highway." Thoreau was hardly a misanthrope—he attended dinner parties even during his Walden sojourn—but he did favor the company of trees.

When comparing elms with men, however, Thoreau could not help but see the former as more worthy. "I have seen many a collection of stately elms," he confided to his *Journal* in January 1856, "which better deserved to be represented at the General Court than the manikins beneath." Elms may have been set out by villagers, but they towered—literally and figuratively—above mere mortals. "I find that into my idea of the village," he wrote, "has entered more of the elm than of the human being." Indeed, the elms were "worth many a political borough," and certainly more than most politicians.

> The poor human representative of his party sent out from beneath their shade will not suggest a tithe of the dignity, the true nobleness and comprehensiveness of view, the sturdiness and independence, and the serene beneficence that [the elms] do. They look from township to township. A fragment of their bark is worth the backs of all the politicians in the union.

Thoreau then extended his metaphor far beyond the environs of Concord. Elms became a medium through which he channeled his outrage over slavery, particularly over the Fugitive Slave Law, which authorized federal agents to return to their owners slaves who had escaped to north of the Mason-Dixon line, and the Kansas-Nebraska Act, which cleared the way for extending slavery into territories not yet granted statehood. Passage in 1854 of the Kansas-Nebraska Act prompted outbreaks of violence across Kansas and drew an impassioned response from Thoreau—"Slavery in Massachusetts"—which he delivered to a convention of abolitionists.[4]

In Thoreau's writings, the Concord elms are a metaphor for the abolition movement, particularly for the Free Soil Party, which had been formed in response to the indecisiveness of the Whigs and Democrats on the expansion of slavery.[5] In a remarkable passage, Thoreau implores the freedom-lovers to remain true to their principles and to seek equilibrium between old and new, past and progress, conservative and radical. The elms, writes Thoreau, "are free-soilers in their own broad sense."

> They send their roots north and south and east and west into many a conservative's Kansas and Carolina, who does not suspect such underground railroads—they improve the subsoil he has never disturbed—and many times their length, if the support of their principles requires it. They battle with the tempests of a century. See what scars they bear, what limbs they lost before we were born! Yet they never adjourn; they steadily vote for their principles, and send their roots further and wider from the *same centre*. They die at their posts, and they leave a tough butt for the choppers to exercise themselves about, and a stump which serves for their monument.

Writing of the relationship between the living sapwood (alburnum) and the dead heartwood (duramen), Thoreau continues to develop his metaphor. The elms "combine a true radicalism with a true conservatism." Yet,

> Their radicalism is not cutting away of roots, but an infinite multiplication and extension of them under all surrounding institutions. They take a firmer hold on the earth that they may rise higher into the heavens. Their conservative heartwood, in which no sap longer flows, does not impoverish their growth, but is a firm column to support it; and when their expanding trunks no longer require it, it utterly decays. Their conservatism is a dead but solid heart-wood, which is the pivot and firm column of support to all this growth, appropriating nothing to itself, but forever by its support assisting to extend the area of their radicalism. Half a century after they are dead at the core, they are preserved by radical reforms. They do not, like men, from radicals turn conservative. Their conservative part dies out first; their radical and growing part survives.

In the end the elms (and Free Soilers) will "acquire new States and Territories, while the old dominions"—the slaveholding South—"decay, and become the habitation of bears and owls and coons."

On most days, however, the elms of Concord were simply Thoreau's companions, soul mates he loved and mourned. In January of 1856 Thoreau witnessed the felling of a great elm. The tree, which measured more than fifteen feet in circumference, had made creaking noises in a recent storm, frightening neighboring homeowners into believing that the great mass of wood was about to crash onto their roofs. For Thoreau, the destruction of this tree represented the slaughter of a priceless witness to the history of the community.

"I have attended the felling," he wrote in his *Journal*, "and, so to speak, the funeral of this old citizen of the town . . . I have not known a fitter occasion for a sermon of late." Having "taken the measure of his grandeur," Thoreau spoke "a few words of eulogy at his grave, remembering the maxim *de mortuis nil nisi bonum* (in this case *magnum*)" [speak nothing but good of the dead (in this case *the best*)]. But only the woodchoppers and passersby heard his words. The shattered tree had hardly come to rest than the "axe-boys had climbed upon it like ants" and begun hacking at its limbs. "How have the mighty fallen!" eulogized Thoreau, "Methinks its fall marks an epoch in the history of the town."

> How much of old Concord falls with it! The town clerk will not chronicle its fall. I will, for it is of greater moment to the town than that of many a human inhabitant would be. Instead of erecting a monument to it, we take all possible pains to obliterate its stump, the only monument of a tree which is commonly allowed to stand. How much of old Concord was cut away with it! A few such elms would alone constitute a township. They might claim to send a representative to the General Court to look after their interests, if a fit one could be found, a native American one in a true and worthy sense, with catholic principles.

"Our town," concluded Thoreau, "has lost one of its venerables." The woodcutters "have laid the axe . . . to one of the king-posts of the town." "Is it not sacrilege," he asked, "to cut down the tree which has so long looked over Concord beneficently?"

Once the tree had been felled, its great size awed even Thoreau. His fellow Concordians seemed oblivious to the glory of the living elm and would not appreciate this magnificent specimen of plant life until it lay prostrate on the earth. At a dinner party shortly before the woodchoppers laid low the tree, he tried to convey the sense of wonder that the behemoth stirred in him. "I surprised some the other day," he wrote in his journal, recounting the incident, "by saying that when its trunk should lie pros-

trate it would be higher than the head of the tallest man in the town, and that two such trunks could not stand in the chamber we were then in, which was fifteen feet across; that there would be ample room for a double bedstead on the trunk, nay, that the very dinner-table we were sitting at, with our whole party of seven, chairs and all, around it, might be set there."

Just as he had plumbed the depths of Walden Pond, Thoreau recorded the girths of the elms of Concord.[6] These records were for him "the quantitative expression of his immersion in Nature," writes Alfred Kazin, "proof positive that he touched Nature on every side."[7] In the winter of 1846, Thoreau had measured the waters of Walden Pond, in part to prove that local wisdom regarding its depth was utterly in error. "It is remarkable how long men will believe in the bottomlessness of a pond," he wrote, "without taking the trouble to sound it."[8]

With its annual rings exposed by the axe, the trunk of the great elm offered a precise record of the tree's journey in time. Yet it seems that only Thoreau possessed the imagination to count them. "Men have been talking now for a week at the post office about the age of the great elm," he wrote, "as a matter interesting but impossible to be determined." Even the very men who felled the tree "stood upon its prostrate trunk and speculated upon its age, as if it were a profound mystery." He endeavored to show them that in fact there was no mystery at all, but his words fell on deaf ears.

By Thoreau's measure, the elm had lived 127 years, but no one took seriously his method or his result. Some villagers insisted that the tree was 200 years old; one maintained it was closer to 150 years, having spent 50 years growing, another 50 standing still, and a final 50 dying. ("Wonder what portion of his career he stood still!" Thoreau wrote.) As with the storied depths of Walden Pond, Thoreau was incredulous that men would choose to remain ignorant when the truth lay within easy reach, requiring but a simple act of measurement to bring forth. "Truly they love darkness rather than light," he wrote in his *Journal.*

> They dwell within an integument of prejudice thicker than the bark of the cork-tree, but it is valuable chiefly to stop bottles with. Tied to their buoyant prejudices, they keep themselves afloat when honest swimmers sink.

Mary Emerson alone offered this rational poet a measure of consolation: "It was not the fashion to be so original when I was young," she told Thoreau, before agreeing that indeed the fallen elm had revealed its truths only to him.

The autumnal elm, with its "early and golden maturity," made a particularly strong impression on the Concord naturalist. "It would be worth the while," he wrote in *Autumnal Tints,* "to set out these trees, if only for their autumnal value."

> Think of these great yellow canopies or parasols held over our heads and houses by the mile together, making the village all one and compact—an *ulmarium,* which is at the same time a nursery of men! And then how gently and unobserved they drop their burden and let in the sun when it is wanted, their leaves not heard when they fall on our roofs and in our streets; and thus the village parasol is shut up and put away!

Thoreau saw autumn as symbolic of the glorious destiny he predicted for the United States. It was an appropriate metaphor, for the vibrant colors of the northern deciduous forests rank among North America's greatest natural wonders. The seasons of human progress had brought the American to these autumnal shores, where a rich bounty would be harvested as its people grew in wisdom and maturity.[9]

The great fall of elm leaves in October transformed Concord into "a scene of a great harvest-home," its paths and walks strewn with the summer's spent array. In their form and color, the great yellow masses reminded Thoreau of sheaves of wheat; it was "as if the harvest had indeed come to the village itself." Now, he suggested, "we might expect to find some maturity and *flavor* in the thoughts of the villagers at last." Would there be, he wondered, an "answering ripeness" in the lives of the men who lived beneath these glorious domes. He found it untenable that such beauty could accompany mean and illiberal thoughts. "Under those bright rustling yellow piles . . ." wrote Thoreau, "how can any crudity or greenness of thought or act prevail?" As he watched a farmer disappear beneath the village elms, his wagon creaking beneath the fruits of his summer, Thoreau was tempted to follow the man to the granary, perchance to witness a "husking of thoughts, now dry and ripe, and ready to be separated from their integuments . . . " But he turned away, knowing it would be "chiefly husks and little thought . . . for, as you sow, so shall you reap."

For all his seriousness of purpose, Thoreau never lost his playful, rhapsodic voice. Standing beneath a cluster of October elms, "warm from their September oven," he imagined that he stood "within a ripe pumpkin-rind"; "I feel as mellow as if I were the pulp," he quipped, "though I may be somewhat stringy and seedy withal." For this man, walking beneath the October elms of Concord was itself a harvest—of seeds and thoughts he had sown himself—and which many generations would reap.

NOTES

Unless otherwise noted, quotations from Henry David Thoreau can be found in the Riverside editions of *The Journals of Henry David Thoreau*, VIII (Nov. 1, 1855–Aug. 15, 1856). 117, 130–132; 139–142; X (Aug. 8, 1857–June 29, 1858): 89 (edited by Bradford Torrey and Francis H Allen, Boston: Houghton Mifflin, 1906); and "Autumnal Tints" in *Excursions* (Houghton Mifflin, 1883), pages 233–234.

[1] Charles Joseph Latrobe, *The Rambler in North America*, vol. 1 (New York: Harper & Brothers, 1835), 43–44.

[2] Mircea Eliade, *The Sacred and the Profane* (New York: Harcourt Brace, 1959), 20–31.

[3] John R. Stilgoe, *Common Landscape of America* (New Haven: Yale University Press, 1982), 57.

[4] William Howarth, ed. *Walden and Other Writings* (New York: Modern Library, 1981), xxiv

[5] Robert L. Gale, *A Cultural Encyclopedia of the 1850s in America* (London· Greenwood Press, 1993), 139–140 The Free Soilers, established in 1848, "adopted a platform with three main planks. no slavery in the territories, no slavery in any new state, and free homesteading rights for public domain settlers. The spirited slogan of the new party—'Free Soil, Free Speech, Free Labor, Free Men'—gave the party its name."

[6] Thoreau made the following entry on 23 January, 1856: "Holbrook's elm measured to-day 11 feet 4 inches in circumference at six feet from ground, the size of one of the branches of the Davis elm . . . Cheney's largest in front of Mr. Frost's, 12 feet 4 inches, at six feet, 16 feet 6 inches, at one foot. The great elm opposite Keyes's land, near by (call it the Jone's elm): 17 feet 6 inches, at two behind and one plus before; 15 feet 10 inches, at four, 15 feet 5 inches, at six; 16 feet at seven and a half, or spike on west side. At the smallest place between the ground and branches, this is a little bigger than the Davis elm, but it is not so big at or near the ground, nor is it so high to the branching . . . nor are the branches so big, but it is much sounder, and its top broader, fuller, and handsomer." See Thoreau, *Journal*, 135-136.

[7] Alfred Kazin, *A Writer's America Landscape in Literature* (New York: Alfred A. Knopf, 1988), 61.

[8] Henry David Thoreau, "The Pond in Winter," in *Walden and Other Writings*, William Howarth, ed. (New York: Modern Library, 1981), 256.

[9] William Howarth, xxvii.

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The Arnold Arboretum

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Projects, Programs, and Research: Planning for the Future

Robert E. Cook, Director

Rising out of the ground below the Dana Greenhouses is a visible harbinger of change at the Arnold Arboretum. On a sloping, three-acre site, massive fieldstone walls that were constructed over the summer have formed a series of terraces to hold a new collection of sun-loving shrubs and vines Soon a steel-framed, wood-covered pavilion will be erected to provide a shady resting place overlooking the collection beds and the great lawn that runs down the center of the garden. This project is one of several major landscape improvements that will be completed over the next two years.

These physical transformations will be accompanied by other significant changes in the programs and operations of the Arboretum. New goals, consistent with our traditional mission of research and education, are emerging from the long-range planning process that have engaged the staff over the past ten months. One goal will include a renewed commitment to improve the physical setting and, therefore, the image of the Arboretum in the eyes of the public. The shrub and vine garden described above will set a new standard of excellence to be followed in renewing the older parts of the grounds—the gates and walls, the benches and pathways, location and directional signage.

We are also contemplating a significant expansion of the Arboretum's public and professional education programs. The Radcliffe Institute (formerly Radcliffe College) has approached us about the possibility of merging their programs in landscape design and landscape design history with our existing adult education programs. Through a series of rigorous courses and studios, the Radcliffe programs have for 35 years offered part-time and continuing education students a curriculum that leads to a certificate in landscape design and landscape design history. Providing a home at the Arboretum for the programs would greatly enhance our educational activities.

Finally, the planning process has revealed significant dissatisfaction with the future prospects for scholarly work at the Arboretum, which currently includes research on the living collections in Jamaica Plain, herbarium and library research in Cambridge, and research conducted in foreign settings such as the tropical forests of Southeast Asia. It is unclear that the existing criteria for research appointments and the related support systems truly serves the long-term interest and international reputation of the institution.

Alternative configurations of the research model are not easy to envision because of the complicated relations between the Arboretum and academic units at Harvard At the very least, the long-range plan will include a call for change in the model and an outline of the benefits that such a change might bring to our programs of research and education on woody plants around the world.

Mary Gibson Henry Medal Honors Carroll Wood

Carroll E. Wood, Jr., professor of biology emeritus at Harvard University, is among the first recipients of the Mary Gibson Henry Medal, presented on September 7 at the Henry Botanic Garden in Gladwyne, Pennsylvania.

Dr. Wood has enjoyed a long association with Harvard Univer-

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JON HETMAN • EDITOR

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sity and the Arnold Arboretum. He received a master of arts from Harvard in 1947 and a doctorate in 1949. After serving as a biology instructor for the Faculty of Arts and Sciences from 1949 to 1951, Dr. Wood became an associate curator for the Arboretum in 1954 and a curator in 1970, a position he held until his retirement in 1988. He lectured on taxonomy at Harvard between 1964 and 1972, when he was named a professor of biology. Dr. Wood continues to focus his energies on the completion of his *Generic Flora of the Southeastern United States.* Since its beginning in 1954, 162 papers of this prodigious work have been published, both in the *Journal of the Arnold Arboretum* and the *Harvard Papers in Botany.*

While a student at the University of Pennsylvania in 1942, Dr. Wood became acquainted with Mary Gibson Henry during a collecting trip for the University's *Flora of Pennsylvania.* Their common interest in native plants kept them in contact over the years, beginning with a gift of Arizona yuccas and cacti he sent to Mrs. Henry during the war years. Later, he provided scientific support for some of her plant discoveries, including writing the Latin description for *Lilium iridollae,* the pot-of-gold lily. (See Mary Harrison's article "Mary Gibson Henry, Plantswoman Extraordinaire" in *Arnoldia,* vol 60, no.1.) Around the time of Mrs. Henry's death in 1967, Dr. Wood became a member of the Board of the Henry Foundation for Botanical Research and has been instrumental in the acquisition of additional land and of nonprofit status for the Foundation's gardens.

The Henry Botanic Garden honored Dr. Wood and three other medal recipients with a ceremony and reception at the Henry Foundation for Botanical Research, where, on 50 acres, a wide variety of plants grow in naturalistic woodland and hillside settings and research gardens promote genetic diversity. Dr. Wood, who contributed wild-collected plant material to the garden's collections, was cited for his "extraordinary contributions to botanical research."

Albert J. Fordham, 1911–2000

Al Fordham, who retired in 1976 as head propagator and research horticulturist of the Arnold Arboretum, passed away last December at the age of 89 in Norwood, Massachusetts. He had been affiliated with the Arboretum for nearly 50 years. Al will be remembered for his many contributions to horticulture, including the many new cultivars of dwarf conifers he developed and his work on woody plant seed germination.

Al began his career at the Arboretum in 1929 as a student intern to propagator William H. Judd. In 1936 he spent a year studying European horticultural practices at the Royal Botanic Garden in Kew. After three years of service in the U.S. Army Infantry during World War II, Al returned to the Arboretum as assistant superintendent of grounds. From 1958 to 1976, he was the sole plant propagator at Harvard University, and it was during this period that the propagation department of the Arboretum was reorganized and the Dana Greenhouses were designed and built.

Al's work was distinguished by a willingness to test new methods of propagation and by his fastidious recording of experimental results. In addition to teaching and lecturing extensively on propagation, he published more than 100 research papers between 1958 and 1975, many in the pages of this magazine. His research topics included the barriers that hinder

germination of woody plant seeds, the role of physiological juvenility in plant propagation, and methods of seed dispersal. He also studied microclimates as they relate to plant survival.

In 1963 Al began collecting and experimenting with seed from witches' brooms, which resulted in the introduction of several new cultivars of *Pinus banksiana*, *P. strobus*, and *P. resinosa*. He gave his cultivars native American names such as "Merrimack,"

•• *continued on page 3*

IMLS Grant Integrates Past and Present Collections

The Arnold Arboretum was recently awarded a $49,000 conservation support grant from the federal government's Institute of Museum and Library Services in Washington, D.C. As outlined in the proposal, written by Jianhua Li and Peter Del Tredici, the grant will be used to finish integrating data from the Arboretum's herbarium specimens into the living collections database (BG-Base).

The project will proceed in three interrelated steps. The first is to enter information into the database from each sheet (voucher) of specimens that have been collected on the Arnold Arboretum's grounds. The staff will then be able to generate a list of plants that have not been vouchered or whose specimens do not include diagnostic structures (mostly flowers and fruits), leading to the second step: specimen collection, preparation, and data entry for those plants. In the third step, data will be entered for existing herbarium specimens representing plants no longer growing on the grounds.

At its most basic level, the project will allow the staff to learn which plants now growing on the grounds are not adequately represented by specimens in the herbarium. In addition, it will expand the database to include not only plants currently living on the grounds, but also those that have ever grown here and are represented by an herbarium specimen. Our services to botanical and horticultural communities at home and abroad will also be enhanced since the database will be one of the most comprehensive voucher systems for large living collections in the world, a crucial component of meaningful scientific research. The Arboretum staff have been working slowly and deliberately to achieve this goal for over ten years, but the IMLS grant will allow us to incorporate the last 24,000 herbarium specimens into the living collections database in timely fashion.

The project team, to be coordinated by Jianhua Li, will include Kyle Port, Susan Kelley, Irina Kadis, and Sara Straate.

Botanical drawing of *Salisburia adianthifolia (Ginkgo biloba)* from Siebold and Zuccarini's *Flora Japonica*, courtesy of the Arnold Arboretum Library.

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"Chippewa," and "Neponset" in recognition of New England's tribal heritage. In 1985 Al himself was recognized for his pioneering work with conifers by the naming of *Pinus parviflora* 'Al Fordham'.

Over the years, Al was honored for his achievements by a number of amateur and professional organizations. He was an honorary member of the Massachusetts Horticultural Society, which awarded him its Jackson Dawson Medal in 1965. Other honors included awards of merit from the International Plant Propagators Society (1971), from the International Lilac Society (1973), and the American Conifer Society (2000). He also received a professional citation and certificate of appreciation from the American Horticultural Society.

In 1976 Al retired from his Arboretum duties but continued his horticultural research as well as writing, lecturing, and consulting. Among other post-retirement achievements, he published the *Arnoldia Manual of Propagation of Selected Conifers* in 1977 as a separate issue of this magazine.

Al Fordham's expertise and his insatiable curiosity about all aspects of plant development proved a timely fit for an institution that required a master propagator and a steady stream of new material for its living collections. Through his published work, his classes, and his lectures, he taught a generation of New England gardeners about plant propagation and left a legacy to horticulturists throughout the world.

Summer Interns

The 2001 Summer Interns in the Arboretum's largest white oak *(Quercus alba),* from left to right: John Backer, Rose Morgan, Sarah Carter, Sara Straate, Dan March, Bethany Knorr, Emma Stark Schiffman, Kim Rennick, Steve Egger, Nicole Napoleon, Marissa Farris, Whitney O'Hanian. Not pictured: Jean Gauthier.

Tides Foundation to Receive Plant Sale Donation

The Tides Foundation's 9/11 Fund will receive $5,000 from the Arnold Arboretum to support relief efforts for the events of September 11. Director Robert E. Cook announced at the annual fall plant sale that proceeds from the live auction would be donated to assist those immediately affected by the tragedy, and that a *Quercus coccinea* (scarlet oak) would be planted on Peters Hill to commemorate the victims. The Tides Foundation was chosen by Arboretum staff as the recipient of the Arboretum's gift.

The Tides 9/11 Fund was established to meet immediate and long-term needs in the wake of September 11 and to promote a just and peaceful national response to this crisis. As of October 22, over $335,000 had been raised for this fund, and $215,000 in grants had been allocated to 18 organizations. In crafting their grant-making strategy, the Tides Foundation has worked to blend their core values of social and economic justice with the pressing needs created in the aftermath of the attacks.

For more information about this fund or for a complete list of grantees, contact the Foundation at info@tides.org.

The James Arnold Society

The Arnold Arboretum is proud to announce the formation of the James Arnold Society, named for the benefactor whose bequest made possible the Arboretum we value so much today. This new society will recognize those who have made life income gifts or bequest provisions for the Arnold Arboretum. If you have included the Arboretum in your long-term charitable plans, we would like to welcome you into this special group.

Members of the James Arnold Society will be invited to events at the Arboretum and receive a complimentary invitation to any one of the Harvard University-sponsored financial and estate-planning seminars.

Please contact Anne McClintock or Amy Goldman of University Planned Giving at 800.446.1277 or pgo@harvard.edu to discuss your current gift arrangements or to explore ways to benefit the Arboretum through a life income gift or bequest. Your inquiry will be held in the strictest confidence.

For more information, please visit www.haa.harvard.edu/pgo.