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Front cover: An ancient plant of Euonymus fortunei growing wild near the summit of Tian Mu Shan, Zhejiang Province, China. Photograph by Peter Del Tredici.

Back cover: Chionanthus retusus in fruit at the Arnold Arboretum. Photograph by Al Bussewitz.

Inside front cover: The highlands of Peru contain more than 1.5 million acres of terraces, most constructed in prehistoric times. Those shown here are located in Lurao, Peru, near Lima. Photograph by A. Cardich.

Inside back cover: Chionanthus virginicus in bloom at the Arnold Arboretum. From the Archives of the Arnold Arboretum.

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Lost Crops of the Incas

National Research Council Panel on Lost Crops of the Incas

These long-forgotten plants may play a key role in diversifying the world's food supply in years to come.

At the time of the Spanish conquest, the Incas cultivated almost as many species of plants as the farmers of all Asia or Europe. On mountainsides up to four kilometers high along the spine of a whole continent and in climates varying from tropical to polar, they grew a wealth of roots, grains, legumes, vegetables, fruits, and nuts.

Without iron, wheels, or work animals for plowing, the Indians terraced and irrigated and produced abundant food for 15 million or more people—roughly as many as inhabit the Andean highlands today. Throughout the vast Inca Empire, sprawling from southern Colombia to central Chile—an area as great as that governed by Rome at its zenith—storehouses overflowed with grains and dried tubers. Because of the Incas' productive agriculture and remarkable public organization, they were said to maintain three to seven years' supply of food in storage.

But Pizarro and most of the later Spaniards who conquered Peru repressed the Indians, suppressed their traditions, and destroyed much of the intricate agricultural system. They considered the natives to be backward and uncreative. Both Crown and Church prized silver and souls—not plants. Crops that had held honored positions in Indian society for thousands of years were deliberately replaced by European species (notably wheat, barley, carrots, and broad beans) that the conquerors demanded be grown.

Remaining in obscurity were at least a dozen native root crops, three grains, three legumes, and more than a dozen fruits. Domesticated plants such as oca, maca, tarwi, nunas, and lucuma have remained in the highlands during the almost five hundred years since Pizarro's conquest. Lacking a modern constituency, they have received little scientific respect, research, or commercial advancement. Yet they include some widely adaptable, extremely nutritious, and remarkably tasty foods.

This botanical colonialism closed off from the rest of the world a major center of crop diversity. Food plants of Asia, Mexico, and especially of Europe became prominent; those of the Andes were largely lost to the outside world.

It is not, however, too late to rescue these foods from oblivion. Although most have been hidden from outsiders, they did not become extinct. Today in the high Andes, the ancient influences still persist with rural peasants,

*The Inca Empire measured more than 4,000 kilometers from end to end. Superimposed on a map of modern South America, it would begin on Colombia’s southern frontier, stretch southward along the coast and highlands of Ecuador and Peru, sprawl across highland Bolivia into northwestern Argentina, and reach down into central Chile to just below Santiago. This vast territory was probably the largest ever formed anywhere based on a “Bronze Age” level of technology.*
who are largely pure-blooded Indian and continue to grow the crops of their forebears. Over the centuries, they have maintained the Incas’ food crops in the face of neglect, and even scorn, by much of the society around them. In local markets, women in distinctive hats and homespun jackets (many incorporating vivid designs inspired by plant forms and prescribed by the Incas more than five hundred years ago) sit behind sacks of glowing grains, baskets of beans of every color, and bowls containing luscious fruits. At their feet are piles of strangely shaped tubers—red, yellow, purple, even candy-striped, some as round and bright as billiard balls, others long and thin and wrinkled. These are the “lost crops of the Incas”

That these traditional native crops have a possible role in future food production is indicated by the success of the few that escaped the colonial confines. Among the Incas’ wealth of root crops, the domesticated potato, an ancient staple previously unknown outside the Andes, proved a convenient food for slaves in the Spanish silver mines and sailors on the Spanish galleons. Almost inadvertently, it was introduced to Spain, where, over several centuries, it spread out across Europe and was genetically transformed. Eventually, the new form rose to become the fourth-largest crop
on earth. Other Andean crops that reached the outside world and enjoyed spectacular success were lima beans, peppers, and the tomato. In light of this, it is surprising that more than thirty promising Inca staples remain largely restricted to their native lands and unappreciated elsewhere. Given research, these too could become important new contributors to the modern world's food supply.

The Andean Environment

The Andean region became an important center for domestication of crop species in large part because of its striking geographical contrasts. Along its western margin stretch narrow coastal deserts that are all but uninhabitable except where some forty small, fertile river valleys cross it. Behind this mostly barren plain towers the world's second-highest mountain range, the Andes, reaching an average of over 3,000 meters elevation. Its glacial heights were also uninhabitable, but intermontane valleys and basins are well suited to human occupation, and these became the home of the Inca rulers. Beyond the mountain valleys, on the eastern face of the Andes, are found subtropical cloud forests gently sloping into the Amazon jungle.

The Andean region was quite unlike the other regions where clusters of crops were domesticated. Here were no vast, unending plains of uniformly fertile, well-watered land as in Asia, Europe, or the Middle East. Instead, there was an almost total lack of flat, fertile, well-watered soil. Andean peoples grew their crops on millions of tiny plots scattered over a length of thousands of kilometers and perched one above another up mountainsides rising thousands of meters.

This complicated ecological mosaic created countless microclimates, including some of the driest and wettest, coldest and hottest, and lowest and highest found anywhere in the world. Perhaps no other contiguous region has such a broad range of environments as in the ancient Inca Empire. And the region is so fragmented that rainfall, frost, sunlight, and soil type can vary over distances less than a meter.

For instance, a valley floor may have thick soils, abundant sunshine in the daytime, and severe frost at night, whereas immediately adjacent slopes may be thin-soiled, shaded, and frost-free.

To protect themselves against crop failure, ancient Andean farmers utilized all the microenvironments they could. Conditions causing poor harvests in one could produce bumper crops at another. Farmers deliberately maintained fields at different elevations, and this vertically diversified farming fostered the development of a cornucopia of crop varieties, each with slightly different tolerances to soil type, moisture, temperature, insolation, and other factors.

The resulting diversity of crops served as a form of farm insurance, but the differing growth cycles of different habitats also permitted work to be staggered and therefore more area to be cultivated.

The zapallo (Cucurbita maxima) is only one of many squashes native to the Andes. This species, noted for its rich diversity, has given rise to numerous commercially successful squash varieties, including Acorn, Banana, Buttercup, and Hubbard.
Inca Agriculture

Western South America’s dramatic stage—coast, valleys, highlands, and cloud forest—formed the setting for the evolution of Andean civilization, which emerged some 4,500 years ago. On the semiarid coast, up the precipitous slopes, across the high plateaus, and down into the subtropical jungles of the eastern face of the Andes, dozens of cultures flourished and faded before the rise of the Incas about A.D. 1400.

The Incas inherited and built upon the products of thousands of years of organized human endeavor. It was they who, through military and diplomatic genius, first united a vast realm running the length of the Andes. Employing an inspired, if rigid, administration, they promulgated a social uniformity from their capital, Cuzco. The entire empire was a single nation, governed by the same laws, privileges, and customs.

The union within the Inca Empire was surprising because the various lands it covered were so vastly different: seared desert, saline flats, vertical valley walls, windswept barrens, triple-canopy jungle, glacial sands, floodplains,

Recreating Prehistoric Abundance

About 3,000 years ago, an ingenious form of agriculture was devised on the high plains of the Peruvian Andes. It employed platforms of soil surrounded by ditches filled with water. For centuries this method flourished because it produced bumper crops in the face of floods, droughts, and the killing frosts of those 3,800 meter altitudes. Around Lake Titicaca, remnants of over 80,000 hectares (200,000 acres) of these raised fields (waru waru) can still be found. Many date back at least 2000 years.

Now, in a dramatic resurrection, modern-day Peruvians working with archaeologists have reconstructed some of the ancient farms, and the results have been amazing. They have found, for instance, that this method can triple the yield of potatoes. In at least one experiment, potato yields outstripped those from nearby fields that were chemically fertilized. As a result of such observations, local farmers have begun restoring the ancient waru waru on their own. Government-sponsored restoration projects are also under way.

The combination of raised beds and canals has proved to have remarkably sophisticated environmental effects. For one thing, it reduces the impacts of extremes of moisture. During droughts, moisture from the canals slowly ascends to the roots by capillarity, and during floods, the furrows drain away excess runoff. For another, it reduces the impact of temperature extremes. Water in the canals absorbs the sun’s heat by day and radiates it back by night, thereby keeping the air warm and helping protect crops against frost. On the raised beds, nighttime temperatures can be several degrees higher than in the surrounding region.

For a third, it maintains fertility in the soil. In the canals, silt, sediment, nitrogen-rich algae, and plant and animal remains decay into a nutrient-rich muck. Seasonal accumulation can be dug out of the furrows and added to the raised beds, providing nutrients to the plants.

The prehistoric technology has proved so productive and inexpensive that it is seen as a possible alternative for much of the Third World where scarce resources and harsh local conditions have frustrated the advance of modern agriculture. It requires no modern tools or fertilizers; the main expense is for labor to dig canals and build up the platforms with dirt held in by blocks of sod on the sides.
saline crusts, perpetual snow, and equatorial heat. This diversity is reflected in the Incas’ own name for their empire: Tahuantinsuyu—Kingdom of the Four Corners—coast, plateau, mountain, and jungle. Yet the Incas learned to manage the desolation and the variety of these most demanding habitats, and they made these regions bloom.

This success was owing to several factors. First, the Incas were master agriculturalists. They borrowed seeds and roots from their conquered neighbors and forcibly spread a wealth of food crops throughout their empire, even into regions where they were previously unknown. To enhance the chances of success, the Incas purposefully transplanted the plants with their farmers, thereby spreading both the species and the knowledge of how to cultivate them.

Second, the Incas created a vast infrastructure to support (or perhaps to enforce) the empire’s agriculture. For example, they modified and conserved steeply sloping erodible terrain by constructing terraces and irrigation works, and by fostering the use of farming systems that attenuated the extremes of temper-
ature and water. These included, for example, ridged fields and planting in small pits. In some areas, Inca terraces and irrigation systems covered thousands of hectares. Many are still in use.

Third, contributing to the infrastructure were roads and footpaths that provided an extensive system for transporting products to all corners of the realm. As a result, massive amounts of food could be moved on the backs of llamas and humans—for example, corn into the highlands, quinoa to the lowlands, and tropical fruits from the eastern jungles to the heights of Cuzco. To implement this superb organization without paper or a written language, a mathematical system was developed that used knots tied in strands of yarn (quipu). The code of the knots was memorized and so can never be solved. Today, they cannot be "read," but they resemble the digital system of computers; the Incas could maintain highly elaborate and complex records and accounts.

Further, the roads and footpaths made possible the exchange of information. Instructions and advice were carried quickly throughout the empire by an organized corps of runners. In this way, Inca sages sent predictions of the weather for the upcoming cropping season to and from all regions. The predictions were based on natural indicators such as the behavior of animals, the flowering of certain plants, and the patterns of the clouds and rainfall. The Incas were familiar, for example, with the phenomenon known as "El Nino" that periodically changes the ocean currents off the coasts of Peru and Ecuador, wreaking havoc with regional weather.

The Incas' Descendants
For all its size and splendor, the Inca Empire endured for only a century, and it was crumbled by fewer than two hundred Spanish adventurers. Today the region of the empire—the highlands from Colombia through Chile—is one of the world's most depressed areas. The infant mortality rate is one of the highest on the South American continent—more than one-fourth of the children die before their first birthday, a rate more than twice that of Latin America at large and about fifty times that of Sweden. Only one in seven homes has potable water, and only one in forty has indoor plumbing. Add to this the disruption caused by guerrillas, who have launched an armed campaign of terror in the Peruvian highlands, and it is no surprise that massive migration from the countryside to the cities has occurred.

Exacerbating the highlands' difficulties are cultural and ethnic divisions. The Indians, who make up about half of the population, live a life apart from the modern sector. Most still speak Quechua, the "lingua franca" of the Incas; a few around Lake Titicaca on the Peru-Bolivia border speak Aymara, an even older language. The Indians' rural lives have not changed appreciably for generations.

On the other hand, the whites and mestizos (persons of mixed European and Indian ancestry), who make up the other half of the population, speak Spanish and live in a modern urban world that is undergoing rapid change. The classes, therefore, are separate and unequal. And a concomitant notion is that their food plants are separate and unequal as well. It may seem irrational, but crops the world over are stigmatized by the prejudices held
The giant Colombian blackberry (Rubus macrocarpus) is one of the biggest berries in the world, almost too large to be taken in a single mouthful. Photo by Wilson Popenoe © National Geographic Society, 1926.

against the peoples who use them most.

Over the centuries, the Spanish view that native crops are inferior to such European crops as wheat, barley, and broad beans has persisted. Indian foods are still equated with lower status. The conquistadores would undoubtedly be amazed to see potatoes, tomatoes, peppers, and limas contributing significantly to modern Spain's cuisine. But they would see that their prejudices against oca, tarwi, quinoa, and dozens of other Inca foods are still largely in place in South America.

Future Beyond the Andes
It is in the Andes that the plants have their greatest potential, especially for developing food products for malnourished segments of the population. However, they also promise to become useful new crops for other developing regions of the world, such as the tropical highlands of Asia, Central Africa, and Central America. In addition, they have notable promise for some industrialized regions, such as the United States, Europe, Japan, and Australasia. In fact, one country outside the Andes already has had considerable experience and success with them—New Zealand.

The reason these plants could have this wide ecological adaptation is that, although the Inca Empire stretched across the equator, a majority of its peoples actually dwelt more than three kilometers above sea level where bone-cracking cold descends at sunset, and the climate is more temperate than tropical. As a result, these crops in general have many
Ahipa (Pachyrhizus ahipa) is one of the least known, but most interesting, of the plant kingdom’s edible roots. The plants shown here were grown in Denmark, an indication that ahipa probably can be produced as a food crop in many places outside the Andes. Photo by F. Sarup.

Characteristics that have adapted them for cultivation in regions well outside the heat of the tropics. However, additional uncertainties exist when a crop is to be transplanted from one part of the world to another—for example, day length (photoperiod) dependence, which could be particularly troublesome.

Because the plants are native to latitudes near the equator (where the day and night lengths are equal year-round), some will not reach maturity during the long summer and fall days of the temperate zones. This difficulty has proved surmountable for potatoes, tomatoes, peppers, and lima beans, but it still could take growers some time to locate varieties or genes that can allow each of the crops described below to be grown as far from the equator as North America, Europe, Japan, and Australasia.

Difference in sensitivity to cold is another possible problem. Although the temperature variation in the Andean highlands often runs from a few degrees of frost at night to shirt-sleeve temperatures at midday, the frosts in the Andes are extremely dry, and they rarely form ice on the plants. Therefore, whether frost-tolerance data recorded in the Andes can be extrapolated to other areas is uncertain.

Nonetheless, the global promise of these plants is very high. In the last few centuries the tendency has been to focus on fewer and fewer species, but today many ancient fruits, vegetables, and grains are finding new life in world markets. This is heartening, because to keep agriculture healthy and dynamic, farmers everywhere need plenty of options, especially now when markets, climates, national policies, scientific understanding,
and technologies are changing at a rapid pace.

The necessary next steps toward crop development and exploitation are often interdisciplinary, involving diverse interests such as genetics, processing, marketing, advertising, and technical development from the farm to the exporter.

Developing the lost crops of the Incas is the kind of research that scientists should undertake. In the process, they will rediscover the promise of these crops the Spanish left behind. The Inca Empire's grains, tubers, legumes, fruits, vegetables, and nuts are an enduring treasure for the Andes and for the rest of the world. Millions of people should quickly be introduced to these neglected foods of a remarkable people.

A summary follows of the "lost crops" of the Incas, selected by the National Research Council Ad Hoc Panel.

ROOT CROPS

**Achira** (*Canna edulis, Cannaceae*). Achira looks somewhat like a large-leaved lily. Its fleshy roots (actually rhizomes), sometimes as long as an adult's forearm, contain a shining starch whose unusually large grains are actually big enough to see with the naked eye. This starch is easily digested and is promising for both food and industrial purposes.

**Ahipa** (*Pachyrhizus ahipa, Leguminosae*). Ahipa is a legume, but unlike its relatives, the pea, bean, soybean, and peanut, it is grown for its swollen, fleshy roots. Inside, these tuberous roots are succulent, white, sweet, pleasantly flavored, and crisp like an apple. An attractive addition to green salads and fruit salads, they can also be steamed or boiled and have the unusual property of retaining their crunchy texture even after cooking.

**Arracacha** (*Arracacia xanthorrhiza, Umbelliferae*). Above ground, this plant resembles celery, to which it is related. Below ground, however, it produces smooth-skinned roots that look somewhat like white carrots. These roots have a crisp texture and a delicate flavor that combines the tastes of celery, cabbage, and roasted chestnut. They are served boiled or fried as a table vegetable or are added to stews.

**Maca** (*Lepidium meyenii, Cruciferae*). Maca is a plant that resembles a radish and is related to cress, the European salad vegetable. Although its edible leaves are eaten in salads and are used to fatten guinea pigs, it is most valued for its swollen roots. Resembling brown radishes, the roots are rich in sugars and starches and have a sweet, tangy flavor. Dried, they can be stored for years.

**Mashua** (*Tropaeolum tuberosum, Tropaeolaceae*). The well-known garden nasturtium was a favorite Inca ornamental, and at high altitudes in the Andes, its close relative, mashua, is a food staple. Farmers often prefer mashua to other tubers because it requires less labor and care to grow, and it can be stored in the ground and harvested when needed.

**Mauka** (*Mirabilis expansa, Nyctaginaceae*). Mauka has thick stems and yellow or salmon-colored fleshy roots that make it a sort of cassava of the highlands. The plant was unknown to science until "discovered" in Bolivia in the 1960s, and it now has also been found in remote mountain fields of Ecuador and Peru. If placed in the sun and then put in storage, the tubers turn very sweet, like sweet potatoes.

**Oca** (*Oxalis tuberosa, Oxalidaceae*). An exceptionally hardy plant that looks somewhat like clover, oca produces an abundance of wrinkled tubers in an array of interesting shapes, and in shades from pink
to yellow. In the Andean highlands, it is second only to the potato in amounts consumed, and is still a staple for Peruvian and Bolivian Indians living at high altitudes. The firm white flesh has a pleasant, sometimes slightly acid taste.

**Potatoes (Solanum species, Solanaceae).** The common potato became one of the twenty or so staple crops that feed the whole world. Collectively, these are adapted to a wide array of climates and provide a genetic source of diversity, disease resistance, and new crops. Many have unusual and marketable properties. Some are golden yellow inside, a number have a decidedly nutty taste, and almost all have more concentrated nutrients than the common potato.

**Ulluco (Ullucus tuberosus, Basellaceae).** Some of the most striking-looking roots in Andean markets are ullucos. They are so brightly colored—yellow, pink, red, even candy-striped—that their waxy skins make them look almost like plastic imitations. Once a staple in the Inca diet, ulluco is one of the few indigenous crops that has increased its range over the last century. In some areas, it vies with the potato as a carbohydrate staple.

**Yacon (Polymnia sonchifolia, Compositae).** Yacon is a distant relative of the sunflower. Grown in temperate valleys from Colombia to northwestern Argentina, it produces tubers that on the inside are white, sweet, and juicy, but almost calorie-free. Because of their succulence, they are eaten raw and are pleasantly refreshing; they are also eaten cooked. In addition, the main stem is used like celery, and the plant shows promise as a fodder crop.

**Mashua tubers (Tropaeolum tuberosum) thrive in the high cold altitude of the Andes. The plant requires little care and can be stored in the ground for months. Photo by Wilson Popenoe © National Geographic Society, 1926.**

**GRAINS**

**Kaniwa (Chenopodium pallidicaule, Chenopodiaceae).** This broad-leaved plant produces one of the most nutritious of all grains, with a protein content of 16 to 19 percent and an unusually effective balance of essential amino acids. It flourishes in poor rocky soil at high elevations, usually surviving frosts that kill other grain crops, and outyielding them in droughts. Incredibly, it thrives where frosts occur nine months of the year.

**Kiwicha (Amaranthus caudatus, Amaranthaceae).** The seeds of the amaranth, an almost totally neglected grain crop, have high levels of protein and the essential amino acid, lysine, which is usually lacking in plant protein. Kiwicha protein is almost comparable to milk protein (casein) in nutritional quality, and it complements the nutritional quality of foods that normally would be made from flours of corn, rice, or wheat. This makes kiwicha particularly beneficial for infants, children, and pregnant and lactating women.

**Quinoa (Chenopodium quinoa, Chenopodiaceae).** Although the seed of this tall herb is one of the best sources of protein in the vegetable kingdom, quinoa is hardly known in cultivation outside its upland Andean home. However, experience in the United States and England shows that the grain is readily accepted by people who have never tasted it before. Quinoa can be grown under particularly unfavorable conditions, at high elevation, on poorly drained lands, in cold regions, and under drought. Much has already been learned about this plant, which is becoming a commercial success outside the Andes.

**LEGUMES**

**Basul (Erythrina edulis, Leguminosae).** Basul is a common leguminous tree of the Andean highlands. It is unusual in that it produces large edible seeds and is one of the few trees that produces a basic food. Accordingly, it has promise as a perennial, high-protein crop for subtropical areas and tropical highlands. Beyond its use in food production, it is also a promising nitrogen-fixing tree for use in reforestation, beautification, erosion control, and forage production.

**Nunas (Phaseolus vulgaris, Leguminosae).** The nuna is a variety of the common bean, but it is the bean counterpart of popcorn. Dropped into hot oil, nunas burst out of their seed coats. The popping is much less dramatic than with popcorn but the product has delightful flavor and a consistency somewhat like roasted peanuts.
Basul (Erythrina edulis) is a bean that grows on trees. Its extremely large seeds have a pleasant, slightly sweet flavor and are usually eaten like lima beans. They are also used in candies. Photo by Wilson Pope-noe © National Geographic Society, 1926.

Tarwi (Lupinus mutabilis, Leguminosae). This lupin is one of the most beautiful crops, and its seeds are as rich as, or richer in protein than peas, beans, soybeans, and peanuts—the world's premier plant-protein sources. Also, they contain about as much vegetable oil as soybeans. Tarwi has been held back mainly because its seeds are bitter. The Indians soak them in running water for a day or two, to wash out the bitterness. Geneticists in several countries have recently developed bitter-free varieties that need little or no washing.

VEGETABLES

Peppers (Capsicum species, Solanaceae). Chilies and sweet peppers have become the most widely used spices in the world, but hidden in the Andes are several more domesticated peppers as well as some wild species. All of these are employed by local people, and they promise to add new pungency, new tastes, and new variety to many of the world's cuisines.

Squashes and Their Relatives (Cucurbita species, Cucurbitaceae). Several of the fruits variously known as pumpkins, squashes, gourds, or vegetable marrows have their origins or greatest development in the Andes. These and some lesser-known botanical relatives are robust, productive crops, especially suitable for subsistence use. Many are little-known elsewhere and offer promise of new and better foods for scores of countries.

FRUITS

Berries. Along the length of the Andes are found several dozen localized berry fruits. These include relatives of raspberry and blackberry (Rubus species, Rosaceae), blueberry (Vaccinium species, Ericaceae), and some small berries (Myrtus species, Myrtaceae) that are rather like mini guavas.

Capuli Cherry (Prunus capuli, Rosaceae). The black cherries that are found throughout the Americas reach their best development in the Andes, where the capuli is a popular city and backyard tree. The cherrylike fruits are found in the markets three or four months of the year. Some are large, sweet, fleshy, and said to be at least as good as the traditional cherry.

Cherimoya (Annona cherimola, Annonaceae). Of all the Inca fruits, only the cherimoya is cultivated substantially outside the Andes. It is grown commercially in Spain, southern California, and a few other places. Such interest is understandable. Inside the thin greenish skin of the cherimoya is a delicious, sweet, and juicy flesh with a creamy, custardlike texture. Its unique flavor tastes like a subtle blend of papaya, pineapple, and banana.

Goldenberry (Physalis peruviana, Solanaceae). A relative of the North American husk tomato, the goldenberry is fresh-tasting and makes one of the world's finest jams. Growing under harsh conditions, it provides a wealth of yellow, marble-sized fruits that are beginning to attract international acclaim for their flavor and appearance.

Highland Papayas (Carica species, Caricaceae). Although the papaya is one of the premier fruits of the world, its botanical cousins of the Andes are all but unknown. They, too, have much promise, and they may extend the cultivation of papaya-like fruits into cooler areas than is now possible.
Although many species of wild berries are found in the Andes, the mora de Castilla (Rubus glaucus) is the most famous and popular. This Andean counterpart of the loganberry could have a bright future. Test samples of its high-quality, deep-red juice have been well received at a large U.S. fruit-drink corporation. This product might prove valuable for giving pallid juices a rich ruby red color. Photo by Wilson Pope-noe © National Geographic Society, 1926.

Lucuma (Pouteria lucuma, Sapotaceae). This fruit can be considered a “staple fruit.” Unlike oranges or apples, its fruits are dry, rich in starch, and suitable for use as a basic, everyday carbohydrate. It has been said that a single tree can feed a family year-round. The fruits are often eaten fresh and are very popular in milkshakes, ice cream, and other treats. Dried, they store for years.

Naranjilla (Solanum quitoense, Solanaceae). Related to, but wholly unlike, tomatoes, this fruit is highly esteemed in Peru, Colombia, Ecuador, and Guatemala, but virtually unknown elsewhere. The delicious, refreshing juice of the naranjilla is one of the delights of the northern Andes, and it could become popular in African and Asian tropics, where the plant could conceivably flourish.

Pacay (Inga species, Leguminosae). Among the most unusual of all fruit trees, pacay produces long pods filled with soft white pulp. This pulp is so sweet that the pods have been called “ice-cream beans.” Not only are the fruits attractive and popular, this nitrogen-fixing tree is extremely promising for reforestation, agroforestry, and the production of wood products.

Passion Fruits (Passiflora species, Passi-floraceae). This exotic fruit is becoming popular in Europe, North America, and other places. With its concentrated perfume and flavoring ability, passion fruit “develops” the taste of bland drink bases, such as apple juice or white grape juice. So far, all commercial developments have been based on a single Brazilian species. In the Andes there are scores of other species, some of which are reputed to be superior to the Brazilian one.

Pepino (Solanum muricatum, Solanaceae). A large, conical, yellow fruit with jagged purple streaks, pepino's mellow flesh tastes like a sweet melon. It is beginning to enter international commerce. Already gaining popularity in New Zealand and Japan, the delicate pepino seems destined to become a benchmark for premium fruit production.

Tamarillo (Cyphomandra betacea, Solanaceae). Inca gardens high on the mountainsides contained small trees that bore large crops of egg-shaped "tomatoes." Today these tree tomatoes remain one of the most popular local fruits. They have bright, shiny, red or golden skins and can be eaten raw or cooked or added to cakes, fruit, salads, sauces, or ice cream. The succulent flesh looks somewhat like that of the tomato, but it is tart and tangy and has a piqunacy quite its own.

NUTS

Quito Palm (Parajubaea cocoides, Palmae). The streets and parks of the city of Quito are lined with an elegant palm that seems out of place because Quito is one of the highest cities in the world and has a cool climate. The palm produces many fruits that look and taste like tiny coconuts. They are so popular that only early risers can find any left on the streets.

Walnuts (Juglans neotropica, Juglandaceae). While most walnut species are natives of the Northern Hemisphere, a few occur in the Andes. They are common backyard and wayside trees, and at least one of these is a promising timber and nut tree. In New Zealand, this species has grown unusually fast for a walnut, and its nuts have a fine flavor.
The cherimoya (Annona cherimola), universally regarded as a premium fruit, has been called the "pearl of the Andes," and Mark Twain declared it to be "deliciousness itself!"
Tian Mu Mountain, located approximately 90 kilometers west of the city of Hangzhou, is the tallest mountain in Zhejiang Province, China. Rising 1506 meters above sea level, Tian Mu Shan is well known throughout China for its scenic beauty and for the diversity of its flora. It has a long and rich history, and has been visited by monks, herbalists, poets, botanists, and tourists for close to a thousand years. From a utilitarian point of view, the mountain is noted for exporting four comestible products: "cloud and fog tea," collected from *Camellia sinensis* growing wild on the cool slopes; "dried bamboo," derived from the young shoots of the locally abundant *Phyllostachys pubescens*; "hickory nuts," the sweet seeds of *Carya cathayensis*; and lastly the numerous medicinally important herbal plants that were once widely collected.

The most prominent symbol of Tian Mu Shan's long human history is Kaishan Temple, located two-thirds of the way up the mountain, at 1020 meters. Built by Buddhist monks in 1279, this small temple serves as a focal point for visitors, who often spend the night in order to view the sunrise the following morning. A second temple, Chanyuan, was built in 1665 and is located at the base of the mountain, at 330 meters.

The topography of Tian Mu Shan is diverse enough to support a wide variety of plant associations. The subtropical evergreen forests typical of south China commingle with the warm temperate deciduous forests of the north on the slopes of Tian Mu Shan, resulting in a flora of some 1530 species of vascular plants, one of the richest in the temperate world. Beginning in the 1920s, Chinese botanists, recognizing the uniqueness of the Tian Mu Shan flora, collected and described many distinct species from the area. Today at least three species are recognized as endemic to the mountain, and a total of thirty species growing within the reserve are included in Volume 1 of the *Plant Red Data Book* of rare, endangered, and threatened plants of China.

In 1960, the Chinese government, recognizing the uniqueness of Tian Mu Shan flora, established a 1000-hectare reserve (400 acres) on the south-facing slope of the west peak, designed to preserve and protect the plants. In addition to its high species diversity, Tian Mu Shan is also famous for its exceptionally large trees. Foremost among them is *Cryptomeria japonica* var. *fortunei*, the cryptomeria, of which there are 398 individuals with diameters greater than one meter. The golden larch, *Pseudolarix amabilis*, also grows wild on Tian Mu Shan, with some 98 individuals larger than half a meter in diameter. Most interesting of all are the large specimens of *Ginkgo biloba*, the ginkgo, growing in isolated valleys and on steep cliffs. According to the only published report on the population, 244 trees were located, with a mean diameter of 45 centimeters and a mean height of 18 meters. Whether these trees are truly wild or are the escaped offspring of trees cultivated by monks has been debated by botanists for years. Researchers have yet to reach a clear consensus on the answer to this question.

In addition to these three rare gymnosperms, exceptionally large specimens of *Torreya grandis*, *Liquidambar formosana*, *Nyssa sinensis*, *Cyclocarya paliurus*, *Litsea*
Ginkgo biloba in silhouette at 980 meters elevation.

*auriculata,* and *Emmenopterys henryi* are also common. In the fall of 1989, I had the good fortune to visit Tian Mu Shan in the company of two very able Chinese botanists, Professor Ling Hsieh of the Zhejiang Institute of Forestry and Mr. Yang Guang of the Jiangsu Institute of Botany. From October 6 to 15, the three of us tramped up and down the mountain mapping and measuring all the ginkgo trees we could find. It was a memorable time for me and one that I hope is captured in the following photographs.
Professor Ling and a large specimen of Pseudolarix amabilis, the golden larch, 42 meters tall, with a diameter at breast height of 112 centimeters.
Yang Guang with the “living fossil” ginkgo in the Tian Mu Shan reserve. This ancient ovulate tree occupies an area of approximately 20 square meters and consists of 15 stems greater than 10 centimeters in diameter. The largest trunk has a diameter of 110 centimeters. The Chinese describe this tree, perched on the edge of a steep cliff at 950 meters, as “an old dragon trying to fly.” The fence protecting the tree was built in 1980.
Cryptomeria japonica var. fortunei is the dominant tree on Tian Mu Shan. Here it is growing in association with a large specimen of Magnolia denudata, the yulan magnolia.
Several Cryptomeria japonica var. fortunei demarcate the stone path that leads to Kaishan Temple. About 300 years old, these trees may well have been planted for the purpose of erosion control.
Very common on Tian Mu Shan, Liquidambar formosana, the oriental sweet gum, is a very large tree. Here it is growing amidst a clump of Phyllostachys pubescens, a timber-producing species of bamboo.
Chionanthus retusus at the Arnold Arboretum (AA #13051). Top, the tree in full bloom; bottom, the winter silhouette. Photos from the Arnold Arboretum Archives.
fissured with streaks of reddish-brown when older. The leathery leaves are opposite, narrow elliptic to obovate-oblong, with entire margins, and are a shiny dark green above and pale dull green below. Fall color tends toward yellow, and the fruit is plum-like in color and shape, a half-inch drupe held singly or in clusters.

The flowers of Chionanthus virginicus are, without a doubt, its most ornamental feature. In Boston they are in full bloom in early June, making an effective spectacle for about two weeks. Flowers are held on elongated panicles 10 to 20 centimeters long (4 to 8 inches), and these panicles can vary in appearance from slightly upright to slightly drooping. Flower petals are pure white, narrow, and straplike, measuring 2 to 3 centimeters (1 inch), and usually number four. Individually they are only mildly interesting, but as they are produced in great number on each panicle, and the panicles in turn blanket the tree, the effect is astounding. Because flowering begins before the leaves are fully extended, the plant initially appears as a fleecy mass of white, punctuated by a few spots of fresh green. During the bloom period, the leaves become more developed and the plant gives a more dappled effect. Close up, the flowers impart a spicy privet-like scent, and from underneath it seems as though one is looking up through a cloud of mist. As one walks farther from the plant, the airy white panicles coalesce, and the plant reads as a solid white mass.

Chionanthus can be dioecious, with distinct male and female plants, or polygamodioecious, that is, individual plants have predominantly pollen-bearing or seed-producing flowers but may also have a few bisexual flowers or flowers of the opposite sex. Male plants of C. virginicus, some authors say, produce a more spectacular floral display, but no data have been published to support this, and I could not see significant differences in our few plants.

The greatest drawback to the use of the plant in New England is that it begins its spring performance long after others have hit the stage. The plants at the Arnold Arboretum, sited among the lilac collection, are almost always naked during "Lilac Sunday," usually the third week of May. Amidst the spectacle of color, they seem almost embarrassed, a gray suit at the Mardi Gras. But as lilac-blooming season begins to wind down, they come alive and are in full flower in early June.

Some horticulturists recommend using the American fringe tree as a focal point, a specimen tree for terraces or patios. In areas such as New England, however, the late appearance of its foliage and bloom makes it look awkward when featured, and I suggest using it as a lawn tree or along the edges of a property. As many members of the Oleaceae have been used for hedges, this might make an interesting

The American fringe tree is far hardier than its native range might suggest. The largest tree I know, 8 meters high (25 feet) by 10 meters broad (30 feet), grows on a lawn in Shelburne Falls, Massachusetts, a town just below the Vermont border, in USDA Zone 5. The owner of this specimen thought it was planted around the turn of the century and was proud to point out that, when in full flower, it has been known to stop busloads of Japanese tourists.

I have seen Chionanthus virginicus twice in the wild, in remarkably dissimilar habitats. In Stokes County, North Carolina, I was drawn to the banks of the Dan River, along with the local plant hunter Richard Schock. Our quarry was a purported population of Stewartia malacodendron, the silky stewartia, an unusual occurrence for the foothills of the Appalachians. As it turned out, the herbarium specimen that led us to this locale was a misidentified sheet of Stewartia ovata, which was the plant we found. On the moist, humusy slope grew a canopy of American beech and Canadian hemlock, with the understory a tangle of Rhododendron maximum. Both the Stewartia and Chionanthus were occasional small shrubs that managed to rise above the Rhododendron and persist in the fairly dense shade. In its autumn colo-
ration, *Chionanthus* did not distinguish itself, and Richard actually had to point it out to me.

A few years later, while collecting *Torreya taxifolia* in the Apalachicola bluffs of northern Florida, I was surprised to find the fringe tree in much different circumstances. The bluffs are dissected by steep ravines harboring at their base a forest adapted to moist, humid conditions. The bluff tops, however, are quite dry and sunny, and are dominated by *Pinus palustris*, the longleaf pine. At the crest of the slope, I found *Chionanthus* along with *Quercus laurifolia*, the laurel oak, *Vaccinium arboresum*, *Oxydendron arboreum*, and *Callicarpa americana*.

A variant, variety *maritimus*, has been described on the basis of its more pubescent leaves, but perhaps the most intriguing form was described in 1812 by B. S. Barton: “I am assured that Mr. Clayton discovered in Virginia and cultivated in his garden, a species, or variety of Fringe-tree, with rose-colored blossoms. I presume it is nothing but a variety of common *Chionanthus virginica*: and it is said that similar specimens of this shrub have been observed in other parts of the United States.” Unfortunately, this rosy mutation has been lost to horticulture.

**The Pygmy Fringe Tree**

The other North American species of *Chionanthus* about which there is general taxonomic agreement is *Chionanthus pygmaea*. This is native only to the sandy soils of central Florida and is listed nationally as endangered. It was first described by J. K. Small, an American botanist who collected the type specimens “on the ancient sand-dunes between Avon Park and Sebring, Florida, May 23, 1921 [flower] and August 30 and 31, 1922 [fruit].” Small reported that the shrub had an average height of about one-third of a meter [one foot], spread by underground stems, and was very floriferous. Though its flowers are only half the size of *Chionanthus virginicus*, its fruits are nearly twice as large, up to a monstrous 2 centimeters long (0.8 inches) on one herbarium specimen I saw.

Another herbarium specimen collected by J. D. Ray describes the habitat of *C. pygmaea* as a “yellow sand dry ridge with open shrubby covering of *Quercus chapmanii*, *Quercus geminata*, *Sabal etonia*, *Befaria racemosa* and *Cyrilla arida.*”

Sue Wallace of Florida’s Bok Tower Gardens has worked on the propagation of the species and has seen the plant in its native environs. She has seen plants up to 2 meters tall (6 to 7 feet) and feels it is difficult to distinguish them from *C. virginicus*, except by their radically different habitats. She relates that *C. pygmaea* grows in almost desert-like conditions in deep sterile white sand.

Dr. Dick Lighty has experimented with cultivating the plant at the Mt. Cuba Center in Greenville, Delaware, and considers it a shrub with outstanding ornamental potential. For him, *C. pygmaea* grows to be a medium-sized shrub with heavy, waxy, magnolia-like leaves.
It bloomed at a very young age from seed and has withstood temperatures of -25 degrees C (-13 degrees F). Because the plant is endangered, it is illegal to collect specimens without permit, and because stocks of cultivated plants are still being increased, the plant is hard to find in nurseries. Clearly this rare southern gem is one of the plants of the future.

The Asiatic Fringe Trees

*Chionanthus retusus*, the Chinese fringe tree, is found in China, Japan, Korea, and Taiwan, and was introduced to the West by Robert Fortune in 1845. The cultivated Chinese fringe tree differs from our native fringe tree by its smaller, more leathery and elliptic leaves, its shorter, wider flower petals held in more upright panicles, and its later period of bloom. It flowers also on current season’s growth rather than on previous season’s growth, and the fruit, like that of the American fringe tree, is an oblong, blue-black drupe—but only two-thirds the size. It grows in both shrub and tree forms attaining a maximum height of 25 meters (80 feet). Like its North American relatives, it occurs in a variety of habitats producing a wide variety of leaf and floral forms.

In China, *Chionanthus retusus* is known to grow in a great many provinces, and can be found from near sea level to over 3,500 meters (11,000 feet). Our herbarium includes over sixty sheets of wild-collected material—a number that vividly demonstrates the baffling diversity contained in this species.

According to C. W. Wang, one example of a habitat in which *Chionanthus* is found is the deciduous oak forest of Hebei. The upper canopy is dominated by *Quercus aliena*, *Fraxinus chinensis*, and *Evodia danielli*, while Chinese fringe tree, although rare, can be found in the subcanopy layer, along with *Acer mono*, *Tilia mandshurica*, *Tilia mongolica*, *Sorbus alnifolia*, *Celtis bungeana*, and *Ulmus japonica*.

In the coastal province of Zhejiang, the species has been reported on Tiantai Shan, a mountain with a mixed mesophytic forest, including *Sorbus alnifolia*, *Stewartia sinensis*, *Acer davidii*, *Acer palmatum*, *Cornus kousa*, *Betula luminifera*, *Nyssa sinensis*, *Magnolia officinalis*, and *Malus hupehensis*. In China, *Chionanthus* reaches its greatest altitude in the mountains of northwest Yunnan. Trees 10 to 13 meters high (30 to 40 feet) were found by Joseph Rock and George Forrest at altitudes between 2500 and 3000 meters (8000 and 9500 feet).

Among the specimens at the Grey Herbarium, the most illuminating were collected by Joseph Hers, a Belgian who lived in China in the early twenties. His collections include a
dozen sheets from north Henan, south Shanxi, and north Jiangsu. He even photographed one specimen at Lushih, Henan, an upright 10-meter-tall (33 feet) specimen quite different in habit from the Arnold Arboretum's mature vase-shaped specimen. His collections help to show the diversity of leaf size, shape, and character found in just one province. Leaf tips can be acute, blunt, or notched (with two different leaf shapes on one branch), and leaf margins can be smooth or have quite large serrations. According to H.-F. Chow, the only economic use for *Chionanthus* in China is culinary. Young shoots and leaves are eaten and the young leaves are used as a substitute for tea, called lung-tsing.

In contrast to the situation in China, *Chionanthus retusus* in Japan is extremely localized, growing in just two areas. Between Korea and the main large island of Honshu lies a set of islands called the Tsushima Islands. It was here that E. H. Wilson found the plant while collecting for the Veitch Nursery in 1905. Of Japan's four main islands, the fringetree can only be found on Honshu, in the Mino-Mikawa floristic region, east of the metropolis of Nagoya. This is a region of botanical relics found nowhere else in Japan and includes among its rarities *Rhododendron makinoi, Acer pycnanthum* (a maple very similar to our *Acer rubrum*), *Magnolia stellata*, and *Chionanthus retusus*. Visiting the region for the Arnold Arboretum in 1986, I was able to find *Magnolia stellata* and *Acer pycnanthum*, but did not succeed in finding the fringe tree. According to S. Kurata, the plant prefers sunny and moist conditions in which it can attain a height of 25 meters (80 feet) and a girth of 70 centimeters (2 feet).

It came as a bit of a surprise, when checking the background sources of the Arboretum's *Chionanthus retusus*, that despite its prevalence in China and the all-star cast of collectors who found the plant there, all of our plants were from Japan, Taiwan, and most recently Korea. Our oldest plant (AA #13051), probably the oldest and best specimen in the country, was grown from seed from the Imperial Botanic Gardens in Tokyo. Seed was received in 1901, and the resulting propagule now grows on the Chinese Path of Bussey Hill. It measures, after 89 years, 10 meters high (33 feet) with a spread of 11 meters (35 feet) and a circumference of 2 meters (6.5 feet) at its base. At about a meter from the ground, the trunk splits into nine sharply ascending trunks. This past severe winter seems to have inflicted some dieback on the newer branches (its first winter damage in memory), and no flowers were produced this spring.

*Chionanthus retusus* is also native to Taiwan and Korea where separate species and varieties have been described. From Taiwan, *C. serrulatus* was described by B. Hayata in 1913 and segregated on the basis of its serrate leaf margins and shorter petiole. More
recently, H.-L. Li, former Director of the Morris Arboretum, downgraded this species to a variety, while T.-S. Liu reduced it to synonymity with *C. retusus*. Based on the herbarium specimens I've examined, it appears that serration is found throughout the range and not limited to Taiwan, or to immature plants, as some authors have claimed.

In Korea, the Forest Research Institute reports that *Chionanthus retusus* can be found growing from near sea level to over 900 meters (3000 feet). A separate species, *C. coreanus*, was described from herbarium specimens of J. Taquet by H. Leveille in 1910. It was found on Quelpart Island, a home to many endemics, at the Htepyang Falls, and is distinguished by its lanceolate foliage. Modern treatments reduce this form to a variety of *retusus*.

When one compares the two major species of *Chionanthus*, it is best to keep in mind the limited amount of germplasm of *C. retusus* in cultivation before making sweeping generalizations. But based on the few Chinese fringe trees I have seen, I would say I prefer it to its American cousin. The ninety-year-old specimen at the Arnold Arboretum is one of the outstanding ornamental trees in the country and almost every photo of *C. retusus* in publication depicts this tree. While in bloom, its slightly tiered, vase-shaped habit becomes covered in fleecy white blossoms, and it transforms itself to "the snow tree" that the Dutch so long ago called *Chionanthus*. I also find the naked architecture of *C. retusus* more interesting than the gangly, shrubbier *C. virginicus*.

**Propagation**

Should a genus be highly ornamental, yet no cultivars exist, one has a sure signal that problems exist with vegetative propagation. This is indeed the case with *Chionanthus*, as few records of successful experiments with cutting propagation have been reported. One experiment set up by Arnold Arboretum Propagator Jack Alexander compared the rooting behavior of *C. retusus* and *C. virginicus* under mist using a medium consisting of half peat and half perlite. Although ten different lots of hormone treatment were tried, none of the *C. virginicus* cuttings rooted, and a 30 percent take was the best result with *C. retusus* (in a lot treated with 1 percent indolebutyric acid in a solution of 50 percent ethanol and 50 percent water).

Seed is the most dependable means of propagation, although this results in a plant of unpredictable characteristics. *C. virginicus* has seed that are doubly dormant and seem
to require two warm/cold stratification cycles before germination occurs. After the first warm/cold cycle, a radicle will emerge from the hard seed coat and drive itself downward into the soil. Following the second warm/cold cycle, the shoot will emerge. Our records indicate that *C. retusus* will germinate in high percentages after a single cycle of warm/cold stratification.

The Arnold Arboretum is pleased to offer to our Friends plants of both *Chionanthus retusus* and *Chionanthus virginicus*. The *C. virginicus* seedlings are generally 6 to 12 inches tall, and the *C. retusus*, 8 to 24 inches. Donation, payable upon receipt of the two plants, is $35.00. Shipment will be in the spring of 1991.

**Chionanthus Distribution**
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The Hunnewell Pinetum: A Long-Standing Family Tradition

Interview by Judith Leet

The collection of conifers begun by Horatio Hollis Hunnewell of Wellesley, Massachusetts, is now maintained by his great-grandson, Walter Hunnewell.

In 1866, Horatio Hollis Hunnewell mentions in his diary, where he recorded the ongoing improvements to his country property in Wellesley, Massachusetts, that he has prepared the ground for a Pinetum—for a collection of all the cone-bearing trees that he can make grow in New England. Since he had already planted conifers on the grounds of his estate for fifteen years or so, one might argue that the Hunnewell arboretum was already well under way before it was officially started. Or one might date the beginning of the Pinetum as 1852, the year that Hunnewell's imposing white country house was completed and he and his family moved to Wellesley from Boston for long summer stays. Whether it is 125 or 140 years old, the Pinetum has been continuously maintained as a private arboretum by H. H. Hunnewell's family for four generations, and is now cared for knowledgeably by his great-grandson, Walter Hunnewell. In recognition of this contribution, the Massachusetts Horticultural Society recently awarded the “Hunnewell Family” its highest award, the 1990 George Robert White Medal of Honor.

The Pinetum was already a significant collection before the Arnold Arboretum was established in 1872, and Charles Sprague Sargent consulted with his older mentor H. H. Hunnewell and benefited from his experiences with the hardiness of plants in Massachusetts as Sargent made plans for what was to become the Arnold Arboretum.

A Simple Purpose
To learn more about the present condition of this unusual, if not unique, family arboretum, we went to Wellesley to speak to Walter Hunnewell, H. H. Hunnewell's great-grandson, on a sunny summer morning. A hands-on gardener, he greeted us from his perch on a one-seater power mower, after putting in a few early hours at work on the grounds—peaceful lawns enlivened by well-cultivated and mature specimen trees.

Entering the cool, spacious hallway of the main house, we were temporarily deflected from our purpose by a display of orchids too handsome to pass by unnoted; it turns out that Walter Hunnewell, a retired executive of the Gillette Company, now divides the year between his two major horticultural pursuits—indoors in winter with his orchids and outdoors in summer in the Pinetum. Whereas he has someone to help with the orchids in the greenhouse (some of which he collected in the wild as a young businessman traveling widely in Latin America), he almost single-handedly maintains the 360 or so towering conifers now growing in the Pinetum—with what he acknowledges as the
indispensable help of power rotary motors.

Until about ten years ago, Walter Hunnewell lived close to the family home overlooking Lake Waban and would stop by to help his aging mother care for the Pinetum. His father, Walter Hunnewell, Jr., who died in 1964, had assumed responsibility for the family Pinetum in 1921 and had maintained it attentively for forty years; but in the fifteen years that Walter's mother had lived on the property as a widow, the condition of the Pinetum had gradually declined. “She was interested in it because her husband had been interested, but she was not personally interested and she was already eighty when her husband died,” Walter Hunnewell explained. “I lived next door and would come over to do some work, as did my brother Willard and sister Jane, who lived nearby; but basically the Pinetum went downhill. The grass wasn't cut as often, and weed trees sprouted up.”

When Walter Hunnewell moved into the family home in 1980 upon the death of his mother, much restoration of the collection needed to be done. “We had to do relabeling, and Steve Spongberg of the Arnold Arboretum, starting about 1974, was very helpful in identifying trees where the labels had disappeared, as were Rich Warren and Zsolt Debreczy, later on.

“Identification is tricky because botanists can't seem to make up their minds: for example, Picea bicolor was renamed Picea alcoqui-
ana, but then was changed back to *P. bicolor.* And looking at the same tree, experts will have different opinions about what it is, so it's difficult to know whether to change a label or not.

"The simple objective of my great-grandfather, H. H. Hunnewell, was to find out what trees would grow in the climate of Massachusetts. At that time no one had any idea which trees would live here and which wouldn't. 'I'll make a collection of all the coniferous trees that I can find,' he wrote in his diary, 'and see what can grow here.' Of course he could do it on a scale I couldn't possibly do now," said Walter Hunnewell. "He'd experiment with small seedlings, perhaps 50 plants of each species, setting out 2,000 plants at a time. He had a mammoth nursery and would plant them all out, employing perhaps thirty gardeners on his many projects."

**Lessons in Hardiness**

Though he had no formal training in horticulture, H. H. Hunnewell proceeded by observation, trial and error, and patience: if he lost fifty plants the first winter that he experimented with cone-bearing trees from New Zealand, he would plant fifty more the next year. He would continue to experiment doggedly and did not discourage easily. Those seedlings that survived in the sheltered nursery he would eventually plant in the Pinetum; when set out to face their first New England winters, many of the young trees would be winter-killed; over time these many losses narrowed down the selection of plants that he had hoped to introduce.

H. H. Hunnewell had many good growing years up to 1867 and confidently wrote, in the *American Journal of Horticulture,* that his efforts were worthwhile, despite the heavy labor and financial investments: "We have reason for congratulation, upwards of fifty new evergreen trees having been found adapted to our climate." But by the very next year, he recorded in his diary, "The past winter has been very destructive to evergreens—the most so of any I ever experienced." After listing the many species that had been browned or badly injured or killed, he added, "All this is very discouraging."

Walter Hunnewell speaks feelingly of his great-grandfather’s experiments and subsequent losses—sometimes of every single plant: "Eventually, it was found that plants chosen from the northernmost limit of their range—where they had adapted to snow and freezing conditions for many thousands of years—were more hardy, and H. H. Hunnewell began to bring those trees in. Although he tried and tried, he just couldn't grow the cedar of Lebanon, *Cedrus libani,* and wrote in his diary, 'it just isn't hardy here in Boston.' But later, around 1900, a harder variety was found in the mountains of Turkey and introduced by the Arnold Arboretum. Some of these were planted here, one of which is now particularly
The main house built by H. H. Hunnewell in 1851. Photo by Peter Del Tredici.

fine—some say rather better than those in the Arnold Arboretum. The cedars of Lebanon grown in England and Europe have a much broader shape, with spreading branches; the branches dip and turn up—very picturesque; here ours are straight as a beanpole. One explanation is that the hardier ones come from high in the mountains where only straight ones could survive; the spreading ones are sitting ducks for heavy snow."

The Hunnewell family and the Arnold Arboretum have collaborated on plant-hunting projects over the years; the Hunnewells helped support E. H. Wilson's trips to Asia in the early 1900s, and in turn received plant materials for their collection, which now contains some of the oldest surviving examples of Asian introductions. "Our relationship with the Arnold Arboretum goes back to the beginning of the Arboretum," said Walter Hunnewell. "In the beginning, the Arboretum got a lot of good advice from my great-grandfather. He and Professor Sargent were good friends. My great-grandfather was the older of the two and had started first—but the two of them worked together for twenty years, and Hunnewell gave a lot of good advice to Sargent. Since 1900, it's been the other way: for twenty years we helped the Arnold Arboretum; for ninety years, they have helped us," said Walter Hunnewell, amused by the imbalance of favors.

"H. H. Hunnewell wasn't a botanist; he was an amateur who became knowledgeable. He lived to age ninety-three and had a wonderful full life—never was sick. He grew interested in horticulture in the 1840s when he was about thirty-five; he was fifty or so when he started the Pinetum. His life was more than usually interesting."
Horatio Hollis Hunnewell was born in 1810 in Watertown, Massachusetts, the son of Walter Hunnewell, a general doctor, and Susanna Cooke. Invited to Paris by relatives as a boy of fifteen to learn the banking business, Hunnewell labored for years at Welles & Company, a bank that exchanged currency for traveling Americans, and earned a considerable fortune. He fully expected to spend the rest of his life in France, but in the severe financial crisis of 1837, the bank, on the verge of failure, went out of business, and he lost everything. "All my brilliant prospects vanished, and the sleepless nights I passed in thinking what I had best do under these totally unexpected circumstances were many," he wrote in his old age. He returned to America dispirited, believing his productive life was all but over. In time he "drifted into railroads," as he put it, and moved on to far greater financial success than he had ever thought possible.

A Country Place

"H. H. Hunnewell did things very thoughtfully," said Walter Hunnewell. "When his prospects improved in Boston after the failure of the bank in Paris, he determined to build himself a nice house. Most of the land he planned to use for this country house was his wife Isabella's, that is, his father-in-law's land. Throughout the 1840s, he built the boundaries, put up a stone wall on Washington Street, and set out seedlings, thousands of seedlings of all kinds, forest trees, evergreens, fruit trees—apple, pear, cherry."

The house, built from 1851 to 1852, was singled out and illustrated in the 1859 edition of Downing's Theory and Practice of Landscape Gardening, edited by Henry Winthrop Sargent, a good friend and cousin. "H. H. Hunnewell had an idea," Walter Hunnewell said, "of what he wanted to do for the grounds—for the forty acres; and he did it himself, without a landscape architect. In time he bought an additional property of fourteen acres that became the Pinetum. This piece of ground was perfect for the Pinetum because of its gravelly, acid soil and interesting topography.

"The trees have no set arrangement; they are not laid out in rows. H. H. Hunnewell just planted trees of all different shapes and colors, mixed together. To me it looks better than, say, if he had grown all the hemlocks together. When Hunnewell planted an Abies ciliicita, probably in 1860, he might have put out a ten-year-old tree. It is one of the older ones; we know that because it is one of the bigger trees. He didn't keep records; that was not his objective. He didn't particularly care where it came from, or when exactly it was planted, or whether it was a true type specimen—those things that interest us didn't make too much difference to him."

Maintaining the Pinetum

The precise number of trees living in the Pinetum has varied over the years. Walter Hunnewell's computerized printout, as of the summer of 1990, lists 354 trees. At one time the Pinetum had as many as 400 conifers. Some of the new plantings specifically replace trees damaged or destroyed by natural causes. "Back in June of 1988, a Picea pungens was hit by a bolt of lightning, which jumped to an Abies veitchii, and killed both. I planted new trees in the same spots. I let them live in the Pinetum for a year; if they survive, they then make the computerized list. I am horrified to see how small the young plants look in the Pinetum next to the full-grown trees. In the ground they seem minute, no higher than ten inches."

When he sets out new trees, Walter Hunnewell's attitude is much like that of his great-grandfather: "H. H. Hunnewell started the Pinetum when he was forty or fifty. It didn't bother him at all that he wouldn't live to see mature trees. He lived to see them grow for thirty or forty years, and he was planting small trees all the time. And I feel as he did; when I plant young trees, if they do well and grow nicely, it gives me a mammoth kick.

"There is a great temptation to plant them too close together when small. The branches
Abies cilicica, planted in 1870, is the largest conifer in the Pinetum. Walter Hunnewell is standing at the base of the tree. Photo by Peter Del Tredici.

eventually will go out twenty or more feet. I have planted some too close, but on the other hand, all won't grow to be nice trees, so I weed those out. If two particularly good trees are too close together, you have to make a sacrifice. Or let them grow close together. I differ here from H. H. Hunnewell and my father; they wanted a tree with open space all around it, but after all, these are forest trees. Why shouldn't they be close enough together so that, as in nature, they lose their lower branches?

‘I don't like it when they grow—or so it seems to me—unnaturally when planted too far apart. That is, the lower branches hit the ground and root, and in twenty or thirty years, they reroot, distorting the normal appearance of that type of tree. Peter Ashton, the former director of the Arnold Arboretum, remarked on the way a Japanese *Chamaecyparis* had grown unnaturally when all alone. It had a mammoth jungle of young trunks growing around the original *Chamaecyparis*, and I don't like that. I prefer to plant them close enough so that the lower branches get shaded out and eventually die.’

**Clipping the Topiary**

Introducing and collecting conifers was only a part of H. H. Hunnewell's Wellesley garden. He began to introduce many varieties of rhododendrons unknown in New England but widely used on English estates, and in addition to opening his own rhododendrons to the public, he sponsored an exhibition on the Boston Common in 1873 to popularize them. He took boundless pleasure in improving and beautifying his property over the years, creating fanciful gardens—an orangery, a grapery, orchid greenhouses, French- and English-style gardens, as well as lilac and azalea displays. His Italian garden of clipped trees on six terraces—stretching for two hundred yards along the lake below—was all built by hand shovels. ‘I hate to think,’ Walter Hunnewell paused, ‘of the effort involved. But he had plenty of labor to help; photos show him planting with six or eight men.’ For the Italian garden, H. H. Hunnewell experimented with clipping native American evergreens into formal geometric shapes; previously, European species had been used for such topiary effects.

To maintain this steeply terraced topiary garden, Walter Hunnewell's four grown children and a son-in-law now gather every year or two and, working as a team for an entire week, trim the trees. ‘I pick a week in August and hire a tree specialist with a cherry picker to trim the tallest. My children and I set to work on the middle-level trees—still quite tall—and do it the old-fashioned way with a tall ladder, which two or three of us hold upright with ropes twisted around our hips, while someone else is up on the ladder trimming. Those on the ground can move the ladder back and forth and maneuver it around.
There's lots of yelling back and forth—someone's pulling too hard or not hard enough. If the person on the ladder looks down, it's a long way to fall."

For the past fourteen or so years, the Hunnewells, including Walter's wife Maria Luisa, have pruned the topiary garden in this way. "My children have to take a week out of their vacations—but usually all come. One did not come the last time, and there were lots of comments about that. It's a certain amount of fun. They all in a way enjoy it; I get the most pleasure—partially because it gets the job done."

When asked if the succeeding generations had maintained the Pinetum to H. H. Hunnewell's standards, Walter Hunnewell replied, "Very much so. Up until 1929, there was plenty of labor; the workers basically cut the grass and weeds in the Pinetum with a horse-drawn mower or by hand with a scythe; it was labor-intensive and, because the land was steep, difficult work.

"My father struggled through the Depression, and there were times when he had an awful time. The staff was cut; my father, with the head gardener, put the children to work. All four children enjoyed working in the Pinetum, including my sister Jane. We removed the dead wood, trimmed out the dead branches, cut down trees, spread fertilizer, manure. It's fair to say, however, that, overall, the rhododendron were my father's primary interest."

Another Generation
Since he became responsible for the Pinetum, Walter Hunnewell has experimented with

several innovative methods to facilitate caring for the property. “We tried grazing a horse or a cow—to see if that kept the grass down; it didn’t work. Then I found a good mower that hydraulically lifts the rotary blade up and down. That mower has made an enormous difference. In a short time, I can do what it took three or four men all summer long to do. I also have a tractor that comes in with a bigger rotary mower to do the flat areas, and that too has made a great difference. For the steepest slopes, we use a rotary handmower that runs on the end of a rope. Someone can stand on flat ground above and, like a dog on the end of a leash, send it down the bank.

“I can handle the Pinetum with the help of my children; they are good about it although, sometimes, when they are busy with their work, it is difficult to make time. I now do a minimum amount of fertilizing and spraying, but basically the trees are very healthy. I always want to add trees I don’t have; I put them out mainly in the month of April when I dig them out of the nursery and move them to the Pinetum.” Walter Hunnewell consulted his computer printout of trees to determine how many new trees he now puts out each year. “In 1989, I planted eighteen trees—one that I planted out in April was dead by October; in 1990, I planted twelve trees.”

The Pinetum now is very full and Walter Hunnewell will have to determine which trees to remove in the future. “Some are likely candidates, such as an Abies concolor, a white fir, about forty years old, that had its top blown out in a storm. With four leaders broken off, the fir ended up looking like a bush.” Deciding it would never be what it should be, he

*The “Italian Garden” at the Hunnewell estate. Photographed in 1990 by Peter Del Tredici.*
cut it down without compunction. “You can always plant another,” he added, summing up his very reasonable approach to gardening.

Asked about his own children—the fifth generation’s future interest in caring for the Pinetum—Walter Hunnewell said: “All are in a way interested in the place, which is their home; they’d like to keep it going.”

Unlike so many magnificent gardens, constructed with great care and labor, that are abandoned or neglected by later generations, the Hunnewells have carried on devotedly the legacy of Horatio Hollis Hunnewell. In late 1990, the condition of the Pinetum is flourishing and under the capable hands of the fourth generation of a family devoted to its well-being and to excellence in horticulture.

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Master Planning: Looking Ahead to the Next Century

Why, the letter read, are you hiring fancy landscape architects when the original design of the Arboretum by Frederick Law Olmsted is doing just fine?

The writer of this letter was probably aware of our decision to seek an outside consultant to assist us in creating a master plan, the first long-range planning effort since the original Sargent/Olmsted collaboration. After interviewing a number of local firms with experience in planning and the preservation of historic landscapes, we chose Sasaki Associates of Watertown, Massachusetts.

So why are we hiring Sasaki? I can best answer this question by recounting a conversation I had recently over the phone. A woman called me to complain about the number of cars driving through the Arboretum to exit by the greenhouse; they were endangering the many mothers and children who walk the roads during the day. In fact, she said, a schoolbus, no less, had nearly run down her daughter.

She pointed out that drivers prefer to drive through the grounds because it is so difficult to leave by way of the primary entrance on the Arborway. Traffic lanes in the opposite directions are separated by a thin island of concrete and curbing, necessitating a complicated turnaround at the Forest Hills subway station which is further complicated by ongoing constructions. Why, she asked, don’t we simply put a traffic light at our entrance and cut a passage through the concrete island to let cars exit in both directions?

This sounds like a good idea, and it may well be one. But like most good ideas, it is likely to prove more complicated than it initially appears. Should left hand turns across traffic and into the Arboretum be permitted as well? How would the light affect weekend parking that tends to cluster around the entrance? What about pedestrians? And who should pay for all this? Clearly the City of Boston, the Metropolitan District Commission and the Arboretum will all be involved.

Frederick Law Olmsted and Charles Sargent created the Arboretum in a day when the preferred mode of transportation was the horse and carriage. The original design and circulation system has been remarkably well preserved over the years. However, the urban realities of the late 20th century could come to threaten that preservation if we continue to operate without any comprehensive planning. So it is a master plan created with the experience of a firm like Sasaki Associates that will really allow the original Olmsted design to continue doing just fine well into the next century.

Robert E. Cook, Director

PLANT SALE BETTER THAN EVER

Over 8,000 plants were sold and more than $50,000 raised as approximately 2,000 plant buyers and browsers strolled from tent to tent collecting new specimens for their gardens. The larger less crowded sales area in and around the barn and an increased number of cashiers enabled members to select their free plants without the congestion and waiting lines of previous years. Many thanks to the Arnold Arboretum Associates who organized this event and gathered the plants for the Rare and Silent Auctions.
SARGENT'S SILVA

Charles Sprague Sargent, the first director of the Arnold Arboretum, brought together a wealth of information about the known forest trees in the *The Silva of North America*. Undertaken for the Tenth Census of the United States, the fourteen volumes were published between 1890 and 1902. While changes in nomenclature and taxonomic perspective have occurred since its publication, Sargent's *Silva* remains today as the most authoritative and complete work of its kind.

Charles Faxon, botanical illustrator for the Arnold Arboretum at that time, created illustrations which were engraved by the celebrated Parisian firm of Philibert and Eugene Picart and printed by the Riverside Press in Cambridge for inclusion in *The Silva of North America*.

In addition to complete sets of this work in our library, the Arnold Arboretum has the printer’s over-run copies of these 10" x 14" Faxon drawings which are suitable for framing. Beginning in January, 1991, members at the Benefactor level ($1,000 and up) will be offered one of these prints as an annual gift from the Director.

THE CONTRIBUTORY PORTION OF MEMBERSHIP DUES

Internal Revenue Service regulations require that in determining the tax deductible status of a charitable contribution, the “fair market value” of benefits received must be taken into account. Beyond the value of these benefits, your membership dues may be claimed as a charitable, tax deductible contribution.

Previously this contributory portion was determined by subtracting the “fair market value” of all benefits offered to each category of membership. This produced great complexity and confusion. Today only the value of *Arnoldia*, which is available to nonmembers for a yearly subscription rate of $20 ($25 foreign) must be considered “fair market value” of membership benefits and therefore not tax deductible. For members who elect not to receive *Arnoldia*, the total amount of membership dues is tax deductible. Payments for classes, symposia or Bookstore purchases are not tax deductible.

For more information call the Membership Department at 617-524-1718.

Arnold Arboretum Logo

Created in 1980, our logo is an adaptation of the Chinese character for forest. The character contains three identical elements, each meaning tree. The slight variation in the three elements, permissible artistic liberty, is used to achieve a more esthetic overall character.

Although our logo has stylized the original Chinese character almost beyond recognition, it does carry on the tradition of graphic representation so important to the written Chinese language. Where as a reader of Chinese would recognize each of the three elements of the original character as a picture of a tree, untrained American eyes would not. The Arboretum logo recreates the basic elements of the original Chinese character within the more triangular graphic design which Americans have come to recognize as an evergreen tree. If you would like another logo window decal, please contact the Membership Department.

NEW CASE ESTATES MAP

A new Case Estates information brochure and grounds map is available at the Case Estates and the Hunnewell Visitor Center. This brochure includes more information about the history of the Case Estates as well as descriptions of the new display areas.

The new map, adapted from an accurate and detailed base map drawn by Janis Wedmore and John Quinn, was created by Mapworks, Inc. of Norwell, MA. The attractive new representation of the grounds provides clear graphic orientation to the entire grounds.

If you haven’t been to the Case Estates in recent months, please accept our invitation to use this new guide map for a winter walking tour of the new display areas and woodland paths.
Al Fordham, formerly Chief Plant Propagator at the Arnold Arboretum, admires the restructured stream bank and new waterfall where the eroded stream bed had been.

The Donald B. Curran company of Ipswich, Ma. did a superb construction job. Standing on the bridge they built are from left: Front row: David Gordon, Stephen Talbot, Frank McLaughlin; Back row: Donald Curran, Sean Curran, Nobby Mawby, Jere Trask, Henry Vaillancourt.

Arnold Arboretum staff consult with Landscape Architect Julie Messervy and contractors. Maurice Sheehan, working Foreman of the grounds crew (second from left), designed the hen’s tooth puddingstone wall which replaced the metal fence and supervised the project throughout.

Sheila Connor, Horticultural Research Archivist, examines the eroded stream bed prior to work on the project.
"THE ROMANTIC GARDEN"—A NEW SYMPOSIUM

Romance is in the air for gardeners in the bleak month of February, when the Arnold Arboretum presents the first symposium to focus on the new Romantic Design movement. Fashionable, fragrant, and luxuriant, the style is claiming the attention of gardeners throughout the country.

The all-day slide-lecture symposium is being presented in four cities: on Thursday, February 21, at the Chicago Botanic Garden, Glencoe, Illinois; on Saturday, February 23, at the Denver Botanic Gardens, Denver, Colorado; on Tuesday, February 26, at the New York Botanical Garden, Bronx, New York; and on Thursday, February 28, at the Arnold Arboretum, Jamaica Plain, Massachusetts. This is an opportunity for Arnoldia readers outside the Boston area to get up-to-date information on the history, philosophy, design elements, and color schemes of "The Romantic Garden."

Registration fees are $106 for non-members, $96 for members of the participating institutions, and $53 for students with proof of full-time status. For further information or to receive a detailed brochure, call the Arnold Arboretum Education Department at 617-524-1718 or FAX your request to 617-524-1418.

School children learn about the ecosystems of the Arnold Arboretum during school curriculum-based Field Study Experiences. They delve into the structure of a flower with hand lenses, use compasses and maps to hunt for unusual trees from other parts of the world, observe the interplay of plants, animals and man, and feel they have had a wonderful adventure.

Children's Program Guides Needed

Renew your sense of adventure and learn to teach children as they explore the grounds of the Arnold Arboretum. Guide training for spring begins on Thursday, March 21 and continues for five consecutive weeks. Newly trained guides will join the program's staff of 39 volunteers in leading 3rd- to 6th-grade school groups through the Arboretum. Volunteers make their own schedules and teach during the morning.

BECOME A DOCENT

If you would like to join our group of knowledgeable docents and have the opportunity to lead adults on tours of the Arnold Arboretum, consider attending the Docent Training Program this spring. The five three-hour sessions will be given on Wednesday mornings beginning on March 15th. Contact our Tour Coordinator, 524-1718, for more information.

Jim Gorman, Arnold Arboretum Committee president, presents a check for $4500 to Diane Syverson while visiting students from the Joyce Kilmer school look on. The committee's donation will provide scholarships for students from Boston Public Schools to participate in the Arboretum's Field Study Experiences.

Bookstore Offerings

WILDFLOWER CLASSICS:

How To Know The Wild Flowers by Mrs. William Starr Dana. boxed edition, $19.95. A guide to the names, haunts and habits of our common wild flowers; richly illustrated.

The Natural Garden by Ken Druse, $35.00. This volume emphasizes low maintenance and natural beauty; filled with colorful photographs.

Visit the Bookstore daily 10 a.m. to 4 p.m. or call (617) 524-1718 to order these or other books.
At lower elevations on Tian Mu Shan, between 200 and 400 meters, Trachycarpus fortunei, the widely cultivated windmill palm, commonly grows on dry soils in full sun.
The Fringe Tree and Its Far-Flung Cousins

Rob Nicholson

The native *Chionanthus virginicus* and the Asiatic *C. retusus* add an element of drama to the spring garden.

If I had to construct a garden that would feature only one family of plants, the most promising choices would be the Ericaceae (Rhododendron), the Rosaceae (Rose), or the Leguminosae (Legume), all families that display great species diversity. My next choice would be the Oleaceae, the family of ash, lilac, privet, forsythia, and jasmine. In this predominantly spring-blooming garden, imagine a rectangle of high privet hedge encircling a mosaic of lilacs, a high stone wall at one end, topped with cascading hardy jasmine. A few ash trees could provide shade, and for the connoisseur of the unusual, we could include plants of *Abeliophyllum* (the Korean white forsythia), *Fontanesia*, *Parasyringa*, and *Chionanthus*, the fringe tree.

Hardy *Chionanthus*, the subject of this article, has long been appreciated by both oriental and western gardeners for its fleecy white floral display, but still remains relatively underutilized in northern gardens. For hundreds of years, botanists believed the genus *Chionanthus* consisted of two to four temperate species native to eastern North America and Asia. In 1976, William Stearn of the British Museum consolidated the genus *Chionanthus* with the genus *Linociera*, a large tropical evergreen group with about a hundred species. He felt that there were no clear-cut characteristics to distinguish the two genera, and it had become a mere convention to assign temperate species to *Chionanthus* and tropical ones to *Linociera*. The present taxonomic thinking is that the ornamental plants we know as fringe trees in the temperate zone are, in fact, a specialized branch of what is essentially a tropical genus.

The American Fringe Tree

*Chionanthus virginicus*, fringe tree or old-man's-beard, is native from southern Pennsylvania and New Jersey south to Central Florida, and west to eastern Texas, southern Arkansas, and Oklahoma. It can be found along the banks of streams and ponds, usually in a moist, rich soil, although some botanists have found it atop rocky sandstone bluffs in the Ozark Mountains of Arkansas. The species was cultivated in Dutch gardens as early as 1736, where it became known as "sneeuwboom" or snow tree. It was named *Chionanthus* (from the Greek *chion*, snow, and *anthus*, flower) by Linnaeus in his 1737 edition of *Genera Plantarum*.

*Chionanthus virginicus* is an extremely variable species and over the years numerous new species and varieties have been named, although few seem to retain validity over time. Old-man's-beard can take the form of a small, single-stemmed tree or a large, multi-stemmed shrub. Maximum height seems to be around 10 meters (33 feet), and the mature specimens I have seen are usually broader than they are tall. Its bark is similar to lilac, a smooth, brown-gray when young, becoming