

Castanea mollissima: A Chinese Chestnut for the Northeast

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Will the chestnut's future equal its past? Since before recorded history, species in the chestnut genus *Castanea* have been prime sources of food and wood in vast areas of Asia, Europe, and North America. During the 20th century, however, the chestnut's contribution has been reduced drastically by disease and pestilence. In response to these setbacks, chestnut research has increased worldwide (Jaynes 1975). These efforts, combined with the great genetic variability within the chestnut genus, seem destined to reassert the chestnut's preeminence as a forest and orchard tree. Though commercial plantings are still a questionable enterprise in many areas, home production of chestnuts can be highly recommended for suitable sites (zones 5 and 6) in the northeastern United States.

The chestnut genus, which has 12 (Camus 1929) or 13 (Jaynes 1975) species, is in the same family (Fagaceae) as oaks and beeches. The genus originally evolved in the Orient, spreading west to Europe and east to North America via the Alaskan land bridge. The chestnut blight fungus (*Endothia parasitica*) comes from Asia, and *Castanea* species of that region have evolved various degrees of resistance, whereas European and American species are highly susceptible.

Four species of *Castanea* have been com-

mercially successful: *C. mollissima* Blume, the Chinese chestnut; *C. crenata*, the Japanese chestnut; *C. sativa*, the European chestnut; and *C. dentata*, the American chestnut. The Chinese chestnut is cultivated in its native China and Korea. Centuries of seed selection have improved its resistance to chestnut blight and its production of nuts, but its wood remains very lightweight and weak and therefore has no commercial value. Of the north temperate species, it is the most resistant to blight.

The Japanese chestnut, which is also native to southern Korea, has been cultivated in Japan for at least 3000 years and perhaps as many as 7000. The planting of chestnuts in both Japan and Korea has increased in recent decades, yet total production has remained about the same because of increasing damage from a devastating new pest called the gall wasp. In addition to yielding great quantities of nuts (27,000 metric tons annually), the Japanese chestnut produces strong, durable wood that is used in fine woodwork, ships, and railroad ties.

For centuries the European chestnut has been a staple food and export commodity in the rural, hilly areas of southern Europe. Production has been reduced 85 percent since the turn of the century, both because of a decline of agrarianism in the region and

the combined effect of a root-rot disease and the chestnut blight. Even so, over 180,000 metric tons of European chestnuts are produced annually in France and Italy alone. More than 4500 metric tons are currently exported to the United States yearly. The nuts of the European chestnut are similar to those of the Japanese chestnut. Both are relatively starchy, and their sugars are less soluble than those of the other chestnut species.

In this country the American chestnut was the most important deciduous forest tree at the turn of the century. It was valued

highly for its versatile decay-resistant wood, and its nut crops provided food for humans and substantial forage for livestock and wildlife. Then came the chestnut blight in 1904. In that year chestnut trees in New York City were found dying of an unknown cause. Investigations revealed a fungal, bark-canker disease that impeded the flow of sap. Large trees often died within two years of the first infection. The chestnut blight, as the disease was called, spread outward from New York City at the rate of 20 miles per year. Eventually, it completely decimated

Castanea mollissima nut emerging from bur
Al Bussewitz photo



the American chestnut as a commercial forest tree. This pestilence, which was probably introduced from the Orient on nursery stock around 1890, is one of the most devastating epidemics of a plant disease caused by a pathogen from a foreign country.

Because the blight fungus does not live below the ground level, stumps of diseased trees continue sending up healthy sprouts that eventually become infected and die, but in succession these sprouts keep the tree's root system alive for many years. As a result, chestnut saplings are a common sight in native forests. A few mature trees remain, especially beyond the northwestern extent of the American chestnut's range, where the infectious fungus spores are not so prevalent. For instance, over 6000 mature trees have been found in northern Michigan (Buisch 1978).

Oriental *Castanea* species have sufficient resistance to survive the disease. Although infected, the trees seldom die, even though entire limbs may die. For this reason Japanese and Chinese chestnuts have been imported to replace the American species, and breeders are now attempting to combine the blight resistance of the oriental species with the timber form of the American. Some hybrid seedlings among the thousands planted show promise. Richard Jaynes (1979), geneticist with the Connecticut Agricultural Experiment Station, summarized the prospects: "With time and substantial effort it should still be possible to develop clonal selections and even relatively true breeding lines of blight-resistant timber chestnuts for the eastern United States."

In Italy and France control of the blight has been achieved with a virus that infects the blight fungus and renders it incapable of continued attack. Control with this method

is complicated, however, because the different strains of fungus existing in different geographic areas are often incapable of transmitting the virus to one another. Natural spread and long-term control have not been observed in the United States. Again, with further research the viral method could provide practical control in the future (Elliston and Jaynes 1977).

Description

The Chinese chestnut is a coarse-textured, medium-sized tree with a round top. The spreading main branches usually diverge in an irregular pattern near the ground. The growth rate of this species is considered moderate, but both rate and form vary among individual specimens. The glossy green foliage is handsome and disease resistant. Its color in autumn can be described as somewhere between the dull yellow of hickories and the bronze of beeches.

The Chinese chestnut is distinguished from other species by pubescence (presence of hairs) on the undersurface of leaves and on the young branch tips. The winter twigs are buff colored, sometimes with a red tinge on the upper surface, unlike the dark brown to purplish brown of other chestnut species. The leaves of the American chestnut are narrower, with a distinctly toothed margin. The Japanese chestnut leaves are distinguished by a bristle-tipped margin and by small glands appearing as tiny, pale dots on the undersides of young leaves. Crosses between these species have produced hybrid plants with a full range of intermediate characteristics.

The individual flowers are not impressive, but a Chinese chestnut tree in full bloom is

striking. An abundance of long, light yellow catkins offsets the glossy foliage. In Boston flowering occurs in late June and early July. The plants are monoecious (having staminate [male] and pistillate [female] flowers on the same plant). The catkins, which are erect relative to the twig, are borne near the terminal end of the current season's growth. The long (eight-inch) catkins are comprised mainly of strongly scented staminate flowers. One to three pistillate flowers are located at the base of the catkins closest to the terminal end of the shoot. The staminate flowers are frequently visited by bees and other insects, including small beetles, but these agents are not necessary for pollination (Jaynes 1975). The pistillate flowers are inconspicuous, without scent, and have long styles.

Chinese chestnuts adapt to a wide range of well-drained sites, doing best on light-textured, acidic (pH 5.5) soils. They apparently are much more productive in warm soil than in cool, high humus bottomland soil. Vegetation characteristic of such sites is red oak, pine, sassafras, and bitternut hickory. It is commonly stated that Chinese chestnuts are hardy in zone 5, surviving at -20°F . However, the buds near the terminal end of the shoot may be injured by temperatures slightly warmer than that if a rapid decrease occurs (personal communication from Alfred Szego). Since most of the flowers are produced on terminal buds, significant decreases in yield may result in zone 5.

The Japanese chestnut is generally less hardy. However, many variations exist among individual plants. Frost pockets must be avoided because new growth in both species is susceptible to injury from late spring frosts. Partially shaded Chinese chestnut trees at the Arnold Arboretum reg-

ularly mature nuts, but a better crop and denser habit occur in full sunlight. Established trees withstand drought well. The site adaptability, handsome foliage, and the unusual flowering effect of this productive nut tree make it a highly desirable element in the landscape.

Fruit

The developing chestnuts are surrounded by a green, spiny involucre, commonly known as a bur. The spines are soft at first but become stiff and sharp as the nuts inside ripen. There are usually three nuts inside each bur, although one or two often fail to develop. When the nuts are ripe, the burs open and the nuts fall free. The size of nuts from unselected Chinese chestnut seedlings varies widely, but cultivated varieties have large, dark mahogany-colored nuts. The latter are similar in size to the commonly available European chestnut, about one inch in diameter, with 30 to 50 chestnuts comprising a pound. A dark brown leathery seedcoat about one millimeter thick forms the outer covering of the nut. Inside this, a papery thin fibrous brown pellicle (skin) adheres to the nut. The pellicle is more readily peeled from Chinese chestnuts than from European or Japanese chestnuts. Like that of other oriental chestnuts, the Chinese nutmeat has a rich yellow color. The nutmeat of American and European chestnuts is white. The edible portion of a fresh nut is 40 to 50 percent carbohydrate (mostly starch), 5 percent oil, 5 percent protein, and about 50 percent water. Chinese chestnuts are considered generally less sweet and flavorful than American chestnuts but much better tasting than European or Japanese chestnuts.

Chestnut trees in full sun can bear crops annually, in contrast to many other nut trees, which do so only biennially. The flowers appear on the current season's growth well after the danger of frost has passed. At least two seedlings or cultivars must be planted within 100 to 200 feet of each other to ensure cross-pollination and optimal fruit set. Seedlings commonly bear fruit in four to seven years, while grafted trees often bear within two years. Mature trees may yield 35 to 55 pounds of nuts each year.

In the United States commercial plantings of Chinese chestnut trees exist only in the southeastern states. However, observations at Vineland, Ontario, Canada suggest that commercial-size crops are possible in the northeastern United States (Society of Ontario Nut Growers). Seedling trees are widely available from commercial nurseries and state conservation agencies, but cultivars, which are not widely available, are far more valuable as nut producers. Several cultivars worthy of mention for the Northeast are described on page 26.

Propagation

The scarcity of Chinese chestnut cultivars results from the difficulty of propagating these plants vegetatively. Graft-union failures often occur after several years of vigorous growth. The suspected causes are a combination of factors, such as incompatibility between the stock and the scions, lack of stock hardiness, poor grafting technique, and blight fungus in the union. The greatest success is obtained by grafting a cultivar onto its own seedlings.

To do this dormant scions must be collected in late winter. The scion and root

stock diameters should be equal. The scions should be stored with a slightly damp paper towel in a sealed plastic bag at normal refrigerator temperatures. Grafting must be performed after all danger of late spring frosts is past. Because only a single bud occurs per node, no reserved buds are available to break dormancy. The root stock will have leaves at the time of grafting, but all growth within 15 inches below the graft area should be removed. Grafts are most successful when located at least a foot above ground level.

Chestnuts respond well to bench grafting in a greenhouse. Root stocks must be dug as soon as possible in the spring, brought into the greenhouse, and grafted immediately. Successful grafts can grow 20 inches before being moved outdoors in early June.

A simple splice or whip graft is most effective with scions that have the same diameter size as the root stock. When grafting established trees, it is best to splice-graft small stems. Grafts on main scaffold branches usually fail. Summer budding is not successful with chestnuts, but grafting in spring using dormant buds on a growing root stock is common in Europe. Growth from grafted buds is apparently more vigorous than that from grafted scions. Desiccation of the graft union may be prevented by any means except using an asphalt-based compound, to which chestnuts are sensitive. The entire union may be wrapped in a plastic bag that has been sprayed with white paint. This helps retain moisture and keeps the union warmer for optimal healing.

Buds should be rubbed off the root stock at two-week intervals. After a month all materials except the budding rubber must be removed. Scion shoots should be growing at this time. Tying the new shoots to a support-

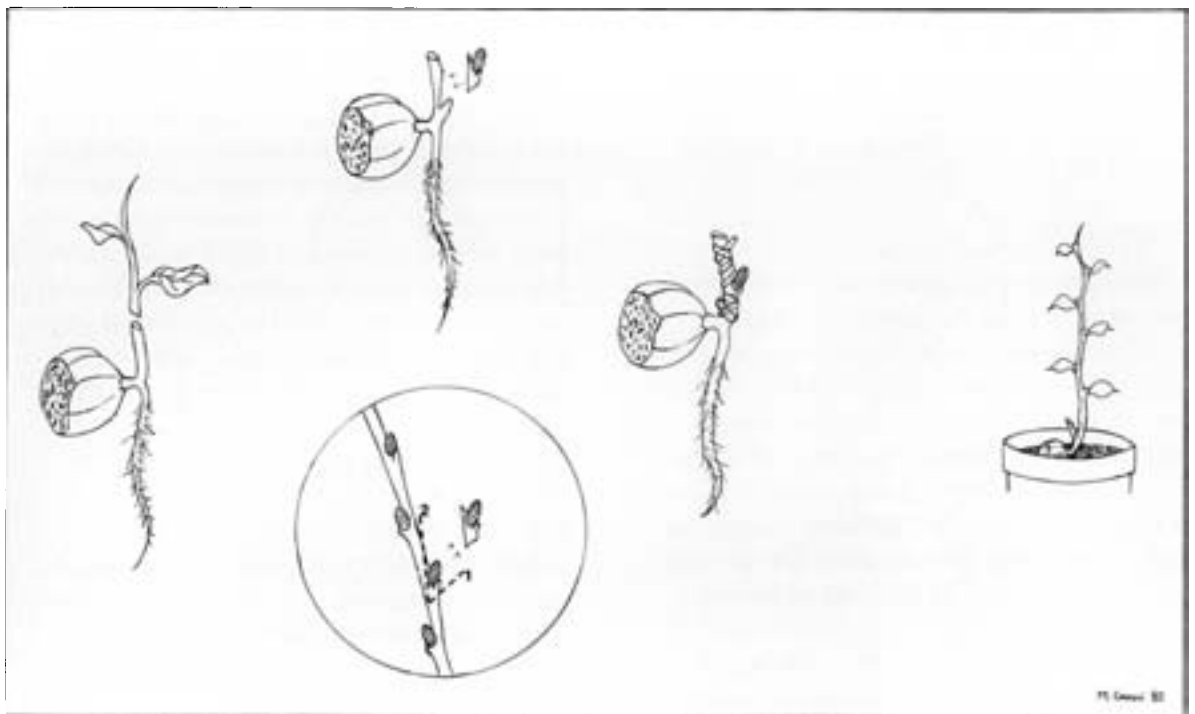
ing splint will protect them from wind damage.

Steps in Propagating Chestnuts by the Chip-Bud Method. 1. Harvest nuts in fall and place in moist, cold storage (32°F to 40°F) for 90 days. 2. Place nuts in moist, warm (70°F to 75°F) germinating medium. 3. When shoots emerge and leaves begin unfolding, remove sprouts from germinating medium and cut off leafy portion of shoot. 4. Cut shield-shaped chip from remaining portion of shoot. 5. On plant to be grafted, cut chip of same size and shape around bud on basal two-thirds of previous year's growth. 6. Bind bud and shoot together in position of maximum cambial contact. 7. Place graft in container deep enough to accommodate tap root. 8. Place container in humidity case at 70°F to 75°F. 9. When graft union has healed and bud is leafing out, begin to reduce heat gradually. 10. Plant outdoors in June. *Drawing by Michael Grassi*

Chip-budding sprouted chestnut seed is a recently developed propagation method with promise for both amateur and professional horticulturists (Jaynes 1980). Using this technique, I successfully grafted 29 plants out of a total of 48. It eases the grafting process somewhat and greatly reduces the amount of time required to produce from seed a grafted plant ready for transplanting (see diagram below).

Despite improvements, vegetative propagation is still considered difficult, and justly so. In contrast, growing plants from seed is relatively simple. Consequently, virtually all of the chestnuts sold or grown in orchards in this country come from seedlings.

Seed should be collected from parent trees that are known for blight resistance, heavy yields, high quality nuts, and good form. The



nuts dehydrate rapidly after releasing from the bur, losing their ability to germinate unless promptly sown or stored at high humidity between 32°F and 40°F. A good method is to mix freshly harvested nuts with an equal amount of peat moss. This mixture should be sealed in a sturdy plastic bag and stored in the crisper in a refrigerator until ready to plant. A few drops of water may be substituted for the peat moss. Condensation on the inside of the bag indicates an over damp condition. Nuts may germinate in storage but if carefully handled may be successfully grown.

The tendency of chestnuts to sprout prematurely makes fall a good time to sow seeds. Even at near-freezing temperatures during late winter and early spring, the nut will germinate and establish its rudimentary root system. There are some pest problems with fall sowing, however. Weevil larvae in the nuts can enter the soil, pupate, and pose a threat to subsequent crops. Another pest is the squirrel. Regardless of the planting time, rodent protection must be provided until the seedlings are about a foot high. Otherwise, the kernel may be dug up and the entire plant killed or stunted. Covering the seeds with woven wire during storage and after the seedlings have germinated will also protect the plants against rodents.

To sow seeds, place nuts on their sides about two inches below the surface of fertile, well-drained soil. A thick insulative mulch will protect the seeds from damage (chestnut seeds are damaged by temperatures below -24°F), but the seeds' location must be carefully marked so the mulch can be pulled back in the spring. About 95 percent of sound chestnut seed can be expected to germinate. It is best to plant as early in spring as possible.

The culture of Chinese chestnuts is similar to that of peaches. Frost pockets must be avoided to protect the easily injured young foliage from late frosts. Light, slightly acidic soils are best, although heavier, calcareous soils are satisfactory if drainage is sufficient. Young chestnut trees are affected by drought conditions. This is unlikely to be a problem in the northeastern United States except during the first growing season.

Dormant chestnut trees transplant successfully. It is important to spread the roots evenly and provide adequate water until they are established. Mulching (after the soil has warmed up) will reduce weeds, conserve soil moisture, and add organic matter to the soil. Spring is the best time for fertilizing, although fertilizing is not necessary in the first year. Since fertilizers may burn the bark, they must not be allowed to come in contact with it.

Mature chestnut trees need approximately a 25-foot space between them. Seedling chestnuts can be planted much closer together until their fruiting characteristics can be evaluated, but the poor producers must then be eliminated. As little as a five- to eight-foot space is sufficient for the first two fruiting years (Jaynes 1979). Seeds can be sown closer, because sick and stunted plants can be eliminated each year as they approach fruiting age. Depending on the parent trees and the grower's standards, up to 10 percent of the offspring will be worth keeping. The pollen parent is equally important for producing superior offspring.

Pruning should be kept to a minimum. In young trees it delays the onset of bearing, and in older trees it can reduce yields. Pruning in early summer will help direct the tree's energy into fruit production rather than stimulate vegetative growth (Society of

Ontario Nut Growers 1980). However, open wounds are more susceptible to infection at this time than during the dormant season (Bey 1979). The best overall tree shape is conical with a central leader and horizontal scaffold branches. This shape serves two functions. First, it allows the most sunlight to reach the fruiting ends of the branches, and second, it provides the most shade to the trunk, which is susceptible to sunscald. Unshaded horizontal or drooping branches retain more carbohydrates and produce more fruit than do ascending branches. The Chinese chestnut's natural tendency for spreading branches may make a central-leader shape impossible to maintain without excessive pruning, however.

Pests

The blight is the most prevalent pest problem of chestnuts in the northeastern United States (Payne and Johnson 1979), but the oriental chestnuts have coevolved with the blight fungus and have developed resistance to it. The Chinese chestnut species is more resistant than the Japanese chestnut, but the resistance of individual plants varies within each species and with site conditions. Chinese chestnuts may become infected but usually heal quickly and are not severely affected.

The chestnut weevil (*Curculio* sp.) can pose a serious problem. Immediate removal of fallen fruit from beneath trees prevents the weevil larvae from pupating in the soil and keeps the population at tolerable levels.

Chestnuts must have adequate zinc, but this should not be a problem in the Northeast. A deficiency will show up as yellow, mottled leaves.

High populations of gypsy moth larvae,

and to a lesser extent Japanese beetles, can cause severe defoliation. Mites can build up to harmful levels if Sevin has been used to control leaf eaters. The southern and western regions of the United States have troublesome pests, and a couple of these — oak wilt and blossom end rot — have been reported as far northeast as Pennsylvania and New York.

The symptoms of blight infection begin with the appearance of bark cankers on stems three or more years old. Cankers on young, smooth bark are orangy brown in contrast to the gray-green normal bark. Tan spore-containing processes extend from these during wet weather. The spores are washed away by rain or carried long distances by birds and insects. Cankers do not show up immediately on older thick bark but appear as abnormal splits and bulges in the bark as the infection advances. Removing the dead bark will usually reveal a fan-shaped pattern of threadlike, fungal growth.

Minimizing bark damage and treating wounds can help reduce infections. The blight rarely reaches more than a centimeter below the soil surface, and many soil organisms (tentatively identified as fungal *Trichoclerna* sp.) are believed to be antagonistic to the blight fungus. Some cankers have been successfully treated with soil compresses (Weidlich 1978). The treatment involves covering the canker with soil and wrapping it in plastic for several months during the growing season. The canker undergoes a complete remission and is sealed off with a healthy callus. Admittedly, this technique is labor intensive and suitable only for a small number of trees.

The chestnut crop ripens in late September and October. Until then the spiny burs remain tightly closed around the nuts.

At this stage gloves are an absolute necessity in handling the burs. As the nuts ripen, the mature nutshells change from white to brown, and the burs begin to split open, allowing the nuts to drop to the ground.

The nuts must not be allowed to lie on the ground, because heat will cause the seeds inside to deteriorate rapidly, and squirrels and other wildlife will quickly carry the chestnuts away. The nuts can be collected without repeated visits to the tree if, when the first burs begin to open, as many as possible are harvested by shaking the limbs and gathering the burs from the ground. A hat, jacket, and gloves are needed to ward off the spiny burs as they fall. The burs should be stored in a cool, humid location, where they will continue to ripen and release their nuts within about a week. The nuts can then be easily separated from the bur chaff.

Uses

The traditional method of preparing chestnuts for eating is roasting in a skillet or oven. The resultant sweet snack has a grilled, tangy flavor. Chestnuts may also be eaten raw after drying the fresh nuts in a cool, airy place for a few days until they feel spongy. This slight drying increases the sugar content, producing a sweet, milky flavor. If they are allowed to, chestnuts will continue to dry until hard. At this stage their primary value is for grinding into flour, which can be used in baked goods, although it may be possible to rehydrate the nuts by steaming them for a half hour (Westwood 1978).

Cold storage at a high humidity level will keep the nuts fresh for at least eight weeks and often much longer, even until the next harvest. These conditions can be achieved

with a plastic bag stored in the crisper in a refrigerator, but no free moisture should be present. The nuts should be checked occasionally and molded ones discarded.

Peeling the leathery seed coat of chestnuts is the first step in any preparation except roasting. The easiest way to do this is to make a slit across the scar side (opposite the point) and then bake the nuts in a preheated oven at 250°F for 10 minutes. The seed coat will dehydrate and shrink, causing the nut to protrude through the opening. A gentle squeeze on the pointed end will pop the nuts free.

Chestnuts may be eaten in many forms. Poultry stuffing is perhaps their most common use. The nuts may be stir fried, boiled and mashed like potatoes, and used raw or cooked in casseroles, salads, soups, and hot breakfast cereals. They may be cooked in syrup to create a glacé dessert. Boiled chestnuts may be frozen for long-term storage.

Cultivars

Except where noted, the following descriptions are adapted from *Nut Tree Culture in North America* (1979) by Richard Jaynes. 'Nanking' is the most widely distributed Chinese chestnut cultivar. It customarily bears heavy annual crops of large nuts, but these are not highly regarded for their flavor or storage qualities. 'Nanking' ripens nuts at the Arboretum in mid-October, about the time of the early autumn frosts.

'Eaton' is the selection with which to compare others in the Northeast. An attractive tree with large, waxy leaves, it averages 40 pounds of large nuts per year, and these mature two weeks earlier than those of

'Nanking' (Jaynes 1970). 'Eaton' probably has Chinese, Japanese, and American parentage, but it bears the closest resemblance to the Chinese species. 'Eaton' nuts compare favorably in taste with most American chestnuts.

'Orrin' grows slowly in a compact upright habit, yet it is a prolific producer of large, dark nuts. The tree is reportedly hardy to -34°F (Campbell 1979). The nuts ripen a few days earlier than those of 'Nanking' and store better than most. The glossy, dark green foliage of 'Orrin' is relatively pest free, making this a productive ornamental tree for small spaces. The only disadvantage of 'Orrin' is that its upright branch crotches may be susceptible to breakage under load. In general, 'Orrin' seedlings are regarded as superior.

'Sleeping Giant', as the name implies, is a large tree. This cultivar is a seedling of a Chinese chestnut that was pollinated by a Japanese and American hybrid. Its leaves are large and very glossy, and the original tree, located in Connecticut, consistently yields large nuts that have a flavor comparable to that of 'Nanking'. 'Sleeping Giant' is reportedly difficult to graft, although I have had success using the chip-bud technique.

'Henry VIII', from New Jersey, is a seedling of 'Crane' \times 'Orrin'. It produces top-quality nuts and has dark, pest-resistant foliage. Its shape is pleasantly round.

Earl Douglass, who lives east of Rochester, New York, has hybrid seeds and seedlings of an oriental chestnut crossed with a native American chestnut. Some of these hybrids reportedly have timber form, are cold-hardy, and ripen nuts in September. They also have a relatively high resistance to blight compared to most American chestnuts, but

Douglass says that they, too, eventually will succumb unless sprayed with fungicides.

'Au Cropper', 'Au Homestead', and 'Au Leader' were all selected and recently released by the Auburn Experiment Station in Auburn, Alabama, but I have no data regarding their suitability for the Northeast.

Chinese chestnuts are a valuable food-producing tree for home landscapes in the Northeast and may someday be a commercial crop. With the natural variability of the *Castanea* genus, great genetic potential exists for producing trees with superior nuts, timber, and pest resistance. The realization of that potential is proceeding through the efforts of both professional geneticists and amateur growers. Fortunately, several superior cultivars and seeds are currently available.

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Sources for Chestnut Seeds and Seedlings

The following is a list of nurseries specializing in tree crops. Many are run as small part-time businesses. Orders should be placed well in advance, because supplies are often limited. Most have catalogues available upon request.

Auburn Nursery, 1930 South College Street, Auburn, AL 36830.

Campberry Farms, c/o Mr R. D. Campbell, R R 1, Niagara-on-the-Lake, Ontario, Canada L0S 1J0. Improved strains of nuts.

Earl Douglass, Red Creek, NY 13143. Seeds and seedlings of Chinese and American chestnut hybrids.

John H. Gordon, Jr., 1385 Campbell Boulevard, North Tonawanda, NY 14120. Seeds, seedlings, and root stocks.

Grimo Nut Nursery, R R 3, Lakeshore Road, Niagara-on-the-Lake, Ontario, Canada L0S 1J0. Good selection of cultivars and seedlings. Custom propagation available.

International Tree Crops Institute, Appalachian Regional Office, Route 1, Gravel Switch, KY 40328. Seedlings and cultivars.

Jersey Chestnut Farm, 58 Van Duyne Avenue, Wayne, NJ 07470. Selected seedlings.

Leslie Wilmoth Nursery, Route 2, Box 469, Elizabethtown, KY 42701. Seedlings and cultivars.

Louis Gerardi Nursery, R R 1, O'Fallon, IL 62269. Seeds, seedlings, and cultivars.

Nebraska Nut and Fruit Tree Seed Program, Nebraska Nut Growers Association, Box 4644, Lincoln, NE 68504. Seed packets of native trees.

Ray Guidi Nursery, 193 Curtis Avenue, Dalton, MA 01226. Seedlings.

St. Lawrence Nursery, R D 2, Route 56A, Potsdam, NY 13676. Exceptionally hardy nuts.

Robert G. Seip, R D 1, Box 683, Alburts, PA 18011. Cultivars and seedlings.

Stark Brothers Nursery, Louisiana, MO 63353. Seedlings and cultivars.

Talbott Nursery, R R 3, Box 212, Linton, IN 47441. Seedlings.

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