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GREAT TRINITY FOREST

Forest Vegetation Species Requirements

Volume 15

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Description of Major Tree Species

Currently there are seven major tree species and a number of minor tree species occupying the Great Trinity Forest. This section will briefly summarize each species and present supporting documentation should there be a deeper interest. Descriptions are summaries of the attached data and borrow heavily from the government publication: The Silvics of North America.

Ailanthus

Ailanthus altissima (Mill.) Swingle

Other Common Names:

Tree-of-heaven, Chinese sumac, paradise-tree, stinking sumac, paradise-tree, and copal-tree.

Brief Description:

A rapid growing, thicket forming, introduced species that has become widely naturalized across its range. Leaves have a unique odor when crushed and are unusually large. It has been used as an ornamental planting in harsh environments. The seeds are eaten by a number of birds and browsing by deer has been noted to occur occassionaly.

Habitat:

Introduced from China to Pennsylvania in 1784, it has now established itself throughout the United States. It is somewhat drought hardy and is flood intolerant. It is primarily found growing in untended lots around urban.

Life History:

The species can produce seed beginning at about 2 to 3 years of age. Flowers appear from mid-April to July. The species is dioecious and male flowers emit a foul odor. The seeds ripen from September to October. Seeds are well adapted to wind dispersal which can occur anytime after ripening, but typically seeds persist over winter. Seedling growth is vigorous and studies have shown that survival is high until the first winter. The species is intolerant of shade, however, and therefore reproduction in forested areas is sparse and erratic. The species sprouts prolifically. Allelopathic effects from the leaves of ailanthus have been noted in the literature.

Ailanthus and the Great Trinity Forest:

This species has been reported as invading the forest. A concerted effort needs to be made to remove all invasive species. Injection, basal bark, and foliar applications of herbicides are the most effective means of control due to its sprouting nature.

Ailanthus altissima (Mill.) Swingle

Ailanthus

Simaroubaceae -- Quassia family

James H. Miller

Ailanthus *(Ailanthus altissima),* also called tree-of-heaven, Chinese sumac, paradise-tree, and copal-tree (fig. 1), is an introduced species that has become widely naturalized across the continent. Ailanthus has found an extremely wide variety of places to establish itself, from urban areas to reclaimed surface-mined lands. Its successful reproduction on impoverished soils and in harsh environments results from its ability to sprout from the roots and to seed prolifically. Ailanthus is found as an upper-canopy component, with varying frequency, in the eastern hardwood forests, apparently spreading by sprouting after harvest disturbance.

Habitat

Native Range

Ailanthus, a native of China, was first introduced into the United States from England to Philadelphia, PA, in 1784. Extensive plantings in cities during the 1800's has resulted in its naturalization across the United States. An eastern range extends from Massachusetts, west to southern Ontario, southwest to Iowa, south to Texas, and east to northern Florida. It is found in less abundance from New Mexico west to California and north to Washington.

Climate

Because of its wide distribution, ailanthus grows under a variety of climatic conditions. Within the naturalized range of the species, the climate can be temperate to subtropical and humid to arid. In arid regions bordering the Great Plains, low precipitation, from 360 to 610 mm (14 to 24 in) annually with 8 dry months, can be tolerated (7), whereas in humid localities in the southern Appalachians rainfall can exceed 2290 mm (90 in) annually *(15).* Annual maximum and minimum temperatures are -9° and 36° C (15° and 97° F). Extreme cold and prolonged snow cover restricts the elevational range to the lower slopes of the Rocky Mountains and prolonged cold temperatures have reportedly caused dieback, but resprouting occurs *(1,7).*

Soils and Topography

Ailanthus grows best in loamy, moist soils but tolerates a wide range of textures, stoniness, and pH. On the dry end of the moisture spectrum it is drought hardy, and on the wet end it cannot tolerate flooding. The species is widely recognized by the urban populace since it frequently

occupies and covers untended areas in cities. The species' tolerance of harsh sites led to testing for strip mine reclamation; a study in eastern Kentucky found ailanthus better adapted to acid spoil than to calcareous spoil and capable of growing on spoils with low to moderate phosphorus *(17).* Soils on which ailanthus is most commonly found are within the orders Ultisols, Inceptisols, and Entisols.

Associated Forest Cover

Because of ailanthus' scattered and disjunct occurrence over a wide geographical range, a listing of associated species would have little significance. Forest stands around cities are common areas of invasion and establishment, but it may be an occasional or minor component of forests following disturbance anywhere within its naturalized range.

Life History

Reproduction and Early Growth

Flowering and Fruiting- The yellowish-green flowers of ailanthus appear from mid-April to July, south to north, depending on latitude. The flowers are arranged in large panicles at the ends of new shoots. A dioecious species, it bears male and female flowers on different trees, with male trees producing three to four times more flowers than are usually found on female trees *(11).* Male flowers are more conspicuous than female ones, emitting a disagreeable odor that attracts numerous insects. The foul odor of the male flowers makes the tree less favored for ornamental plantings in cities.

Seed Production and Dissemination- Pollination occurs in the spring and clusters of seed ripen from September to October. The fruit is a samara with the seed in the center of a thin, oblong wing, well adapted for wind dispersal. The ripe samaras are greenish yellow or reddish brown. The seed usually persists on the female tree through the winter, characterizing their appearance, but can be dispersed any time from October to the following spring. The species is a prolific seeder; the most abundant seed production is from trees that are 12 to 20 years.

After collection, seeds should be spread to air-dry. Number of seeds per kilogram averages from 27,000 to 33,000 (12,235 to 14,970lb) and germination after cold stratification averages 65 to 85 percent *(7,18).* Seeds should be stored dry in sealed containers. The recommended cold stratification is 50 C (410 F) in moist sand for 60 days.

Seedling Development- Seeds, can be sown immediately upon ripening or stratified until spring. In nurseries, seeds are usually sown in the spring and seedlings transplanted early the following spring. Germination is epigeal. Vigorous first-year seedling growth of 1 to 2 m (3.3 to 6.6 ft) has been reported *(1,11).* Average survival on 11 different plantings in Indiana strip mines was 74 percent after the first growing season and then decreased to 58 percent after the first winter (5). This illustrates the winter damage and mortality frequently reported *(1,7).*

Because ailanthus is intolerant of shade, reproduction in natural stands appears sparse and erratic except by sprouting.

Vegetative Reproduction- The dense thickets of ailanthus reproduction on disturbed soils of road cuts and city building sites develop from root sprouts. Prolific root and stump sprouting has discouraged use of ailanthus as an ornamental species. After death or injury of the main stem the wide-spreading shallow root system can give rise to an abundance of sprouts. Sprouts have shown first-year height growth of 3 to 4 m (10 to 13 ft) *(19).* Thus, the species can be easily propagated from either root cuttings or from coppicing.

Sapling and Pole Stages to Maturity

Growth and Yield- Information on the growth and yield of ailanthus in the United States at this time is lacking. Maximum heights are often reported as 17 to 27 m (56 to 90 ft) and a maximum d.b.h. as 100 cm (40 in) *(10,12).* A short-lived species, it lives 30 to 50 years *(20).* On arid sites, 15 m (50 ft) or more of height growth can be reached in 25 years, with a straight bole for 10 to 12 m (33 to 40 ft) (7). At a New England location, trees reached a 10 to 15 m (33 to 49 ft) height and 9 to 11 cm (3.7 to 4.3 in) d.b.h. in 30 years *(11).*

Rooting Habit- Ailanthus roots are shallow spreading, often apparent at the soil surface, and roots near the trunk thicken into enlarged storage structures. These large rounded structures are assumed to be for water storage, contributing to the drought hardiness of the species (4). There is a general absence of a taproot with most roots present in the upper 46 cm (18 in) of soil. Within this zone, the deeper roots send numerous small roots to the surface. Adventitious shoots may arise from any of the surface roots.

Reaction to Competition- Ailanthus is a successional pioneer species, intolerant of shade *(8).* It competes successfully in mixed stands of hardwoods throughout its range, indicating that it was present at the start of stand establishment.

Allelopathic effects on over 35 species of hardwoods and 34 species of conifers have been demonstrated for water extracts of ailanthus leaves *(14).* Only white ash *(Fraxinus americana)* was not adversely affected. Germination and growth of slash and Monterey pines *(Pinus elliottii* and *P radiata)* were inhibited by scattering leaves of ailanthus collected in June and July on the seed bed surface, while leaves collected in October stimulated germination and growth *(22).* Such studies point to a strong allelopathic role for ailanthus in forest succession.

Damaging Agents- The species is relatively resistant to insect predation *(7).* Three insect species are known to feed on ailanthus foliage, however *(2).* Most noted of the foliage feeders in the eastern range, especially in the South, is the ailanthus web-worm *(Atteva punctella).* Larvae from this insect feed on leaves enclosed in a frail, silken web. Another larval feeder, imported from Asia, is the cynthia moth *(Samia cynthia).* Ailanthus is the preferred host for this insect, but wild cherry and plum can also become infested. The Asiatic garden beetle *(Maladera castanea)* feeds on numerous plants during night flights, including ailanthus.

Although many fungi have been reported on the leaves and twigs of ailanthus, the tree suffers little from disease, and its pathology need rarely be a consideration in its culture (9). If ailanthus can be said to be subject to a major disease it would be Verticillium wilt *(Verticillium albo-*

atrum). Many trees were killed by this soil-borne wilt in Philadelphia in 1936. Shoestring root rot *(Armillaria mellea)* has been reported in trees in New York *(16).*

While this tree is rated moderately susceptible to Phymatotrichum root rot *(Phymatotrichum omnivorum)* in Texas, it is considered most satisfactory for planting in the southern parts of Texas root rot belt *(20,23).*

In Texas, seeds are eaten by a number of birds, including the pine grosbeak and the crossbill *(21).* Occasional browsing by deer has also been reported.

Wind, snow, and hard freezes are damaging to tops of seedlings, while mature trees are resistant to ice breakage (3). Resprouting usually occurs, although repeated damage leads to a reduction in seedling survival.

Special Uses

Ailanthus's main importance remains in urban forestry, the original purpose of its importation into the United States. The species, tolerance of noxious emissions of gases and various dusts assures its continued use for plantings in industrial environments. Tolerance of poor soils and low soil moisture dictates its selection for city plantings in arid climates as well as shelterbelt plantings and on strip mine reclamation projects, although its unfavorable traits (odor and root sprouting) have decreased city plantings.

Root sprouting into fields is also a problem in shelterbelt plantings.

Pollinating insects are attracted by the male flowers. Honey from ailanthus has been reported as having an initial foul taste that disappears with aging, resulting in an exceptionally good tasting honey *(13).*

Genetics

In the two centuries since its introduction into North America, ailanthus has probably become differentiated into genetically different subpopulations based on seed traits. Seed characteristics of ailanthus have been identified as traits that differentiate varieties and geographical strains. Ailanthus with bright red samaras compared to the more common greenish yellow has been named *Ailanthus altissima* var. *erythrocarpa* (Carr.) Rehd. A study of 11 seed sources from California and Eastern States found that seed width and weight were correlated with latitude (6). Northern sources have wider, heavier seed than the more southern sources.

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American Basswood

Tilia americana L.

Other Common Names:

American linden.

Brief Description:

A fast growing tree predominantly range is north of the Mason-Dixon Line. It is an important timber tree and its seeds and twigs are eaten by wildlife. It is also planted ornamentally.

Habitat:

American basswood's range is predominantly east of the Great Plains and north of the Mason-Dixon Line. It prefers loamy mesic soils. Basswood is also classified as being a nitrogen-demanding species. Basswood leaves have a high nutrient content and contribute these back to the forest floor.

Life Description:

Flowering occurs in June and the nut-like fruit ripens from September through October. The seeds are dispersed soon afterwards by wind, gravity, and predominantly animals. Seed production typically begins at age 15 but can occur earlier. Basswood seeds have a pronounced dormancy and generally germinate poorly regardless of seedbed conditions. Some amount of shading is desirable for the establishment of basswood seedlings but heavy shade can impede further growth. Basswood does sprout readily and can be a vigorous competitor for resources.

American basswood and the Great Trinity Forest:

This tree has been reported to occur occasionally in the forest.

Tilia americana L.

American Basswood

Tiliaceae -- Basswood family

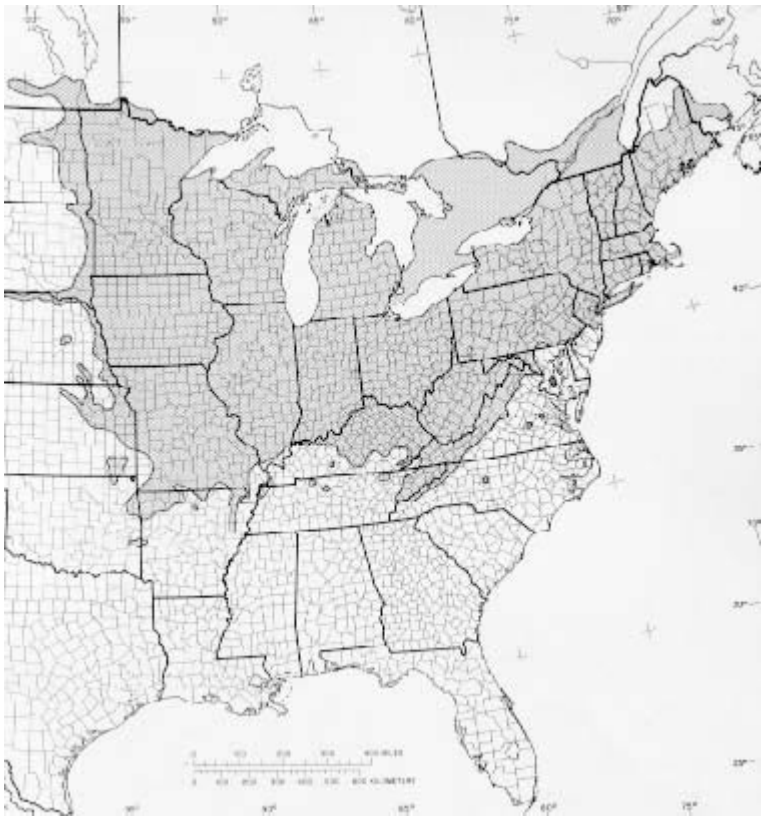
T. R. Crow

American basswood *(Tilia americana)*, northernmost *Tilia* species, is a large, rapid-growing tree of eastern and central hardwood woodlands. Best growth is in the central part of the range on deep, moist soils; development is vigorous from sprouts as well as seed. American basswood is an important timber tree, especially in the Great Lakes States. The soft, light wood has many uses in wood products. The tree is also well known as a honey-tree, and the seeds and twigs are eaten by wildlife. It is commonly planted as a shade tree in urban areas of the eastern states where it is called American linden.

Habitat

Native Range

American basswood ranges from southwestern New Brunswick and New England west in Quebec and Ontario to the southeast corner of Manitoba; south through eastern North Dakota, South Dakota, Nebraska, and Kansas to northeastern Oklahoma; east to northern Arkansas, Tennessee, western North Carolina; and northeast to New Jersey.



-The native range of American basswood.

Climate

Climatic conditions associated with the species range are generally continental-cold winters, warm summers, and a humid to subhumid moisture regime. Mean annual precipitation within the species range is 530 min (21 in) at the western limit and 1140 min (45 in) in the northeast. The northern limit of basswood approximates the -18° to -17° C (0° to 2° F) isotherm for mean daily minimum January temperature. Basswood reaches its maximum development in areas averaging 18° to 27° C (65° to 80° F) in July and receiving 250 to 380 mm (10 to 15 in) of precipitation during the growing season. The frost-free growing period varies from 80 to 180 days within its range.

Soils and Topography

Studies relating to the presence of basswood to soil characteristics in Minnesota, Wisconsin, and Michigan indicate that stands in which basswood shared dominance were generally confined to sandy loams, loams, or silt loams, with basswood obtaining maximum development on the finer textured soils. Most soils were classified as Hapludalfs within the Alfisols order, although some Eutrochrepts (Inceptisols), Cryandepts (Inceptisols), mesic families of entic Fragiorthods (Spodosols), and Haplorthods (Spodosols) were noted.

Basswood grows best on mesic sites, but it is also found on coarse soils such as the sand dunes near Lake Michigan (17) and on dry, exposed rock ridges in Ontario and Quebec (25).

The species grows on soils ranging in pH from 4.5 to 7.5 but occurs more often in the less acidic to slightly basic part of this range. In fact, calcareous soils have been associated with the presence of basswood (9,17).

The importance of aspect and edaphic factors to local distribution is reflected by the restriction of basswood throughout much of its range to moist sites on north- and east-facing slopes. Maple-basswood forests in southern Wisconsin are largely restricted to northerly exposures (19). Basswood is restricted to more mesic sites in southern Illinois and in northern Kentucky (5). At the western limit of its range, basswood frequently grows on the eastern side of lakes and along major drainages. This localized growth is often ascribed to fire protection. Although lack of fire may be a reason for the persistence of a fire-sensitive species such as basswood, presence and distribution are controlled more by soil moisture and the ameliorating effects of water on the local climate.

Basswood is classified as a nitrogen-demanding species because it grows poorly on sites deficient in nitrogen. With increasing nitrogen supplies, basswood growth increases markedly, approaching a maximum radial increment when 560 to 670 kg/ha (500 to 600 lb/acre) of nitrogen are added. Basswood leaves have high contents of nitrogen, calcium, magnesium, and potassium at the time of leaf fall and they contribute most of these nutrients to the forest floor (13,28).

Associated Forest Cover

American basswood grows in mixture with other species and only rarely forms pure stands. It is dominant in a single forest type, Sugar Maple-Basswood (Society of American Foresters Type 26). This cover type is most common in central Minnesota and western Wisconsin but is represented elsewhere from central Illinois, northward to southern Ontario and Quebec, eastward to northwestern Ohio, and westward along valley slopes of the prairie-forest transition (15).

Sugar maple *(Acer saccharum)* dominates both overstory and understory layers, with basswood achieving the position of second dominant in the tree layer. Common associates are white ash *(Fraxinus americana),* northern red oak *(Quercus rubra),* eastern hophornbeam *(Ostrya virginiana),* red maple *(Acer rubrum),* and American elm *(Ulmus americana).*

Although not a dominant species, basswood is also found in the following forest cover types:

21 Eastern White Pine
23 Eastern Hemlock
20 White Pine-Northern Red Oak-Red Maple
24 Hemlock-Yellow Birch
27 Sugar Maple
25 Sugar Maple-Beech-Yellow Birch
28 Black Cherry-Maple
60 Beech-Sugar Maple
39 Black Ash-American Elm-Red Maple
42 Bur Oak

58 Yellow-Poplar-Eastern Hemlock
62 Silver Maple-American Elm

Basswood is one of the major species, with sugar maple, beech *(Fagus),* ash *(Fraxinus),* hickory *(Carya),* and oak *(Quercus),* in the Deciduous Forest Region of southern Ontario. It is a minor component of the sugar maple-yellow birch-hemlock-white pine climax forest type in the southern districts of the Great Lakes-St. Lawrence regions of Ontario (32).

In the Mixed Mesophytic forests of the southern Appalachians, *Tilia americana is* replaced by *T. heterophylla (9).* The genotypic distinction between these species is not always clear, and *T. americana* does appear in the northern part of the Mixed Mesophytic region.

Life History

Reproduction and Early Growth

Flowering and Fruiting- The fragrant, yellow-white, perfect flowers are borne on loose cymes on long stalks attached to leafy bracts. Flowering generally occurs in June but can begin in late May or early July, depending on latitude and annual variations in temperature. Flowering follows initial leaf-out and lasts approximately 2 weeks. During this period, all stages of floral development are present on a single tree or even in a single inflorescence (4 to 40 flowers per inflorescence). The flowers attract a number of insect pollinators. In a study of the pollination biology, 66 species of insects from 29 families were identified as pollinators of *Tilia* flowers. Bees and flies were the most common diurnal pollinators; moths were the primary nocturnal visitors (2).

The fruit, a nutlike drupe 5 to 10 mm (0.2 to 0.4 in) in diameter, usually contains one seed but in collections from both open- and forest-grown trees, 12 percent of the fruit contained two seeds and less than 1 percent contained three seeds. The seeds have a crustaceous seed coat (testa), a fleshy yellowish endosperm, and a well-developed embryo. A variety of forms of fruit and seed have been noted, including egg-shaped, round, onion-shaped, conical, and pentagonal (34). Individual trees tend to consistently produce fruit of a particular form and size.

Seed Production and Dissemination- Fruits ripen in September and October and are soon dispersed by such mechanisms as wind, gravity, and animals. Although the flower bracts are reported to aid in wind dispersal, fruits rarely are carried more than one or two tree lengths from the parent (24). In addition to their limited role in seed dispersal, bracts may act as "flags" to attract pollinators (especially nocturnal ones) to the inflorescences (2). Animals probably increase the seed dispersal significantly.

The seed-bearing age for basswood generally ranges from 15 to 100 years, but seed production at age 8 years (10 years from seed) has been noted (45). The number of ripened fruits averages 9,700 to 13,200/kg (4,400 to 6,000/lb); green fruit averages 5,070 to 5,950 seeds per kilogram (2,300 to 2,700/lb) of fruit (17,33,35). Based on a number of collections, seed weights varied from 12 to 38 mg (0.18 to 0.59 gr) and averaged 31 mg (0.48 gr) (4). In a study for 26 years of 19 species in northern Wisconsin, basswood was one of the most consistent fall-maturing seed

producers (18). It produced good seed crops 62 percent of the time from 1949 to 1974. When crown-released, basswood that were about 50 years old did not increase their fruit production during the 5-year period following release. Moreover, the quality of fruit remained poor throughout this period. In the third year after release, for example, only 5 percent of the fruit collected from the ground contained sound seed (37).

The production of fruit without seed (parthenocarpy) and seed infestation by a lepidopterous larva are two common defects that affect seed viability. A pin hole in the pericarp indicates the presence of the larvae. The percentage of fruits with the pin hole was 3 percent in a September collection and 7 percent for an October collection in southeastern Ontario (35); 30 percent of fruits were insect infested in 45 collections from various parts of the natural range of basswood (4). In the same collections, the percentage of fruits with seed ranged from 0 to nearly 100, but the lack of sound seed on the forest floor seems to be the rule. Only 2 percent were sound out of more than 7,400 identifiable basswood seeds found in the litter in a northern Wisconsin stand. Seeds covered by leaves had rotted and most of the seeds lying on or in the upper litter layers had been destroyed by rodents (18).

Seedling Development- Basswood seeds show a pronounced dormancy and generally germinate poorly regardless of seedbed conditions. The primary cause for the lack of quick germination is an impermeable testa. Using organic acids to digest the pericarps of the fruits and to render the testas permeable improves germination (17). Correctly treated seeds commonly average from 20 to 30 percent germination following stratification at 2° to 5° C (36° to 41° F) for 110 to 130 days. Germination is epigeal. Early harvesting followed by immediate sowing has also been suggested for overcoming dormancy of basswood seeds. Collections should be made when seed coats turn brown but before they become dry and hard, or more specifically, when the moisture content is 20 to 40 percent of the green weight (7,29).

Shading aids the establishment and initial survival of basswood seedlings but heavy shade limits subsequent growth and development, and vigorous growth is unlikely under the forest canopy. Likewise, higher soil temperatures found in forest openings are suitable for greatest growth of basswood seedlings (3).

Basswood seedlings first develop a long taproot, which is soon supplemented by lateral roots. First-year seedlings had a root penetration of 20.3 cm (8 in) with a lateral spread of 7.6 cm (3 in), and second-year seedlings had a root penetration of 21.3 cm (8.4 in) and a lateral spread of 18.3 cm (7.2 in) (30). Stem height was 5.6 cm (2.2 in) the first year and 9.4 cm (3.7 in) the second year.

Cold storage of autumn-lifted basswood seedlings maintains root growth capacity and overall seedling vigor for spring planting. Autumn-lifted stock should be stored at a temperature of 5° C (41° F) and a relative humidity of 70-85 percent (46).

Basswood has been successfully planted in Ontario on cutover land and abandoned farmland. On cutover land, survival was best when a light overhead canopy (8.0 m/ha or 35 ft/acre of residual basal area) controlled competing vegetation (36). Release of the seedlings from the residual overstory and undergrowth was recommended after three growing seasons. Fall plantings failed

to survive. Early failures of hardwoods planted on old-field sites in Ontario have been attributed to the absence of mycorrhizal fungi (30), insufficient site preparation, and insufficient postplanting weed control (42,44). Fertilization at the time of planting had little effect on seedling survival or growth (43).

Vegetative Reproduction- Basswood sprouts prolifically, and this vegetative regeneration can be managed for sawtimber. Sprouts commonly originate on the stump at the ground line, and vigorous sprouts occur over a wide range of diameter classes (31). Almost all trees 10 cm (4 in) in diameter and smaller will produce sprouts and more than half of sawlog-size trees can be expected to produce stump sprouts (23). However, early thinning of stump sprouts (preferably before they reach 5 cm (2 in) d.b.h. or about age 10) is needed to ensure both good quality and rapid growth. Clumps should be thinned to not more than two stems; such thinnings will reduce the incidence of stem degrade due to decay, seams, and sweep (23,38).

Because an extensive root system already exists, a basswood sprout has a higher probability of replacing a parent stem than does a sugar maple seedling. Thus, the ability to produce abundant stump sprouts allows basswood to maintain itself in a stand with the more shade-tolerant maple despite the much larger numbers of sugar maple in the subcanopy (13).

Sapling and Pole Stages to Maturity

Growth and Yield- This species reaches a height of 23 to 40 m (75 to 130 ft) with a d.b.h. of 91 to 122 cm (36 to 48 in). Under favorable conditions, trees sometimes attain a height of 43 m (140 ft) and a d.b.h. of 137 cm (54 in). Estimates of maximum longevity generally exceed 200 years.

Basswood grows faster than most other northern hardwood species. On the same site, basswood often exceeds sugar maple and yellow birch *(Betula alleghaniensis)* in site index by 1.5 rn (5 ft) and beech by 3 rn (10 ft) (11).

Diameter growth for basswood averaged 3 mm. (0.11 in) per year in three unmanaged stands in northeastern Wisconsin (site index at base age 50 years for basswood of 21.3 m or 70 ft). The same site under managed conditions produced substantially higher growth rates. Annual diameter growth average for a crop tree release was 4.6 mm (0.18 in); for a 20.7 m^2 and 17.2 m^2 /ha (90 ft^2 and 75 ft^2 /acre) (residual sawtimber) selection cut, it was 3.8 and 4.8 mm (0.15, 0.19 in); and for a group selection cut, it was 3 mm (0.12 in). Relatively narrow bark ridges and V-shaped fissures, with new light-colored inner bark visible in the fissures, represent a high-vigor basswood. In contrast, low-vigor trees have scaly bark with wide bark ridges and shallow, short fissures, frequently producing a rather smooth surface (12).

Two phases can be noted in the renewal of cambial activity for basswood. The first phase is the reactivity of cambium that occurs independently of the initial meristematic activity within the overwintering buds. The second phase, accelerating cambial activity after bud-break, is presumably under the influence of primary growth (14). Winter stem contraction for basswood often exceeds stem expansion from the previous growing season. The amount of winter shrinkage in basswood stems was greater than that of yellow birch, sugar maple, or hemlock *(Tsuga canadensis) (49).*

The period of shoot elongation for basswood in northern areas is shorter than that for other hardwoods-only red oak and sugar maple had shorter periods of terminal shoot elongation among seven species studied in northern Wisconsin. Based on an average of three growing seasons, shoot elongation for basswood began in May and was completed by the first of June (10). Longer periods of shoot elongation have been noted for open-grown basswood in Illinois and basswood plantations in Ontario (mid-May to mid-August). Chlorophyll is found in xylem rays and primary xylem of basswood twigs *(47).* Although the photosynthetic contribution is not large, it may have seasonal significance when leaves are absent.

Rooting Habit- The initial taproot observed in basswood seedlings gives way in saplings to a system of lateral roots (5). This early root development is gradually obscured by the intensive development of oblique roots in the central mass, and surface lateral roots extend out from this mass (16). Adventitious roots have developed on the lower stem of basswood engulfed by dune sand (4).

Reaction to Competition- Although basswood is less shade tolerant than its common associate, sugar maple, vigorous sprouting and rapid sprout growth allow it to persist under the selection system. Overall, American basswood is most accurately classed as tolerant of shade. This great sprouting vigor also helps it compete with the abundant regrowth following clearcutting. On an excellent site in the central Appalachian hardwoods, basswood was second only to sugar maple in number of stems 7 years after clearcutting. On a good site and a fair site, however, basswood was not among the five most numerous species during the same period (39).

For reproduction from seed, the shelterwood system should provide the partial shade necessary to control competing vegetation, and to create a microclimate suitable for germination. After basswood is established, the overstory should be removed.

Closely spaced, forest-grown trees develop straight, columnar trunks and narrow crowns, but open-grown trees have short stems and many large branches.

Damaging Agents- Basswood plantations established on weed-infested old-field sites are susceptible to girdling by mice and voles, and completely girdled trees die. In a southern Ontario plantation, 44 percent of the basswood stems were completely girdled and 39 percent were partially girdled (41). The species responsible for the girdling, the meadow vole, does most of this damage feeding beneath the snow. Rabbits also feed heavily on seedlings and small saplings in both plantations and natural stands. Basswood seeds are eaten by mice, squirrels, and chipmunks, thus reducing the chances of seedling establishment.

Many different insects attack basswood, but few serious insect problems exist. The linden borer *(Saperda vestita)* makes long, irregular tunnels, particularly at the base of the tree, and may damage weak, very young, or overmature trees. Local infestations of defoliators may occur. The primary ones include the linden looper *(Erannis tiliaria),* basswood leafminer *(Baliosus nervosus),* spring cankerworm *(Paleacrita vernata),* fall cankerworm *(Alsophila pometaria),* whitemarked tussock moth *(Orgyia leucostigma),* gypsy moth *(Lymantria dispar),* and forest tent caterpillar *(Malacosoma disstria) (1,22).* In New England, American basswood is a highly preferred host for gypsy moth (21), while in southern

Quebec, it was classified as intermediate in susceptibility to gypsy moth defoliation (27).

The foliage is host to various diseases-anthracnose *(Gnomonia tiliae),* black mold *(Fumago vagans),* and leaf spot *(Cercospora microsora)*-but none seem to do serious damage. The wood of basswood decays easily and once exposed can be host to many of the common hardwood decay organisms such as the yellow cap fungi (Pholiota *limonella) and* Collybia *velutipes. Phellinus igniarius, Ustulina deusta,* and nectria canker *(Nectria galligena) also* are found on basswood.

Little defect is encountered in basswood when harvested before it reaches 120 years of age. Beyond this age, the chances of losses due to decay are greatly increased. Cull studies in the forests of Ontario indicate that yellow-brown stringy rot was the most common bole defect encountered; brown stain, some incipient yellow rot, and green stain were also found (8).

The thin bark of this species is easily damaged by fire (13). Basswood is one of the hardwoods least susceptible to late spring frosts (40).

Special Uses

Basswood has relatively soft wood that works exceptionally well and is valued for hand carving. The inner bark, or bast, can be used as a source of fiber for making rope or for weaving such items as baskets and mats. Basswood flowers produce an abundance of nectar from which choice honey is made. In fact, in some parts of its range basswood is known as the bee-tree. Throughout the Eastern United States, basswood is frequently planted along city streets.

Genetics

The number of native taxa in the genus *Tilia* has been debated for some time. As many as 15 native species and 13 varieties are named in early taxonomic work. Only three species of *Tilia* are now recognized in the United States, *T. americana* L., *T. caroliniana* Mill., and *T. heterophylla* Vent. (24). Recent studies, however, suggest that the genus *Tilia* in eastern North America should be considered a single, but highly variable, species. In sampling *Tilia* from Quebec, Canada, to Lake County, FL, no apparent morphological discontinuities between populations were found to justify delimitation at the species level (20).

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American Elm

Ulmus americana L.

Other Common Names:

White elm, water elm, soft elm, or Florida elm.

Brief Description:

American elm now comprises a slightly lesser percentage of the larger trees in mixed stands due to its susceptibility to Dutch elm disease. Nevertheless it is still relatively common.

Habitat:

American elm is found throughout Eastern North America. It is most commonly found on flats and bottomlands. It is not found deep within bottoms or in swamps though. They grow best in rich well drained soils, but can be found on a variety of soil types including poorly drained clays. At the extremities of its range it is mostly restricted to bottoms along the edge of watercourses.

Life History:

Flowering, ripening, and seedfall for American elms all occurs in the spring and begins in February. By mid March seeds have already ripened and fallen. Seeds are light and therefore easily disseminated by wind. Water also is a major means of seed dissemination in river bottom stands. Mammals and birds predate on American elm buds, flowers, and seeds and may reduce the seed crop in some years. Germination typically occurs in the fall soon after seedfall. Seeds can become established on a variety of moist medians but do best on mineral soil. Best performance of seedlings in the first year occurs under 1/3 full sunlight and later does best in full sunlight. American elm can withstand flooding in the dormant season but does not fare well if inundation carries into the growing season. It is intermediate in shade tolerance.

American elm and the Great Trinity Forest:

American elm, mixed with cedar elm, is very common in the forest. It is mostly prominent in the central area of the forest near Bart Simpson Lake and in the central mitigation unit. It is less tolerant of flooding than ash and so it probably represents an area of topographical significance that will be considered when developing planting and management schedules.

Ulmus americana L.

American Elm

Ulmaceae -- Elm family

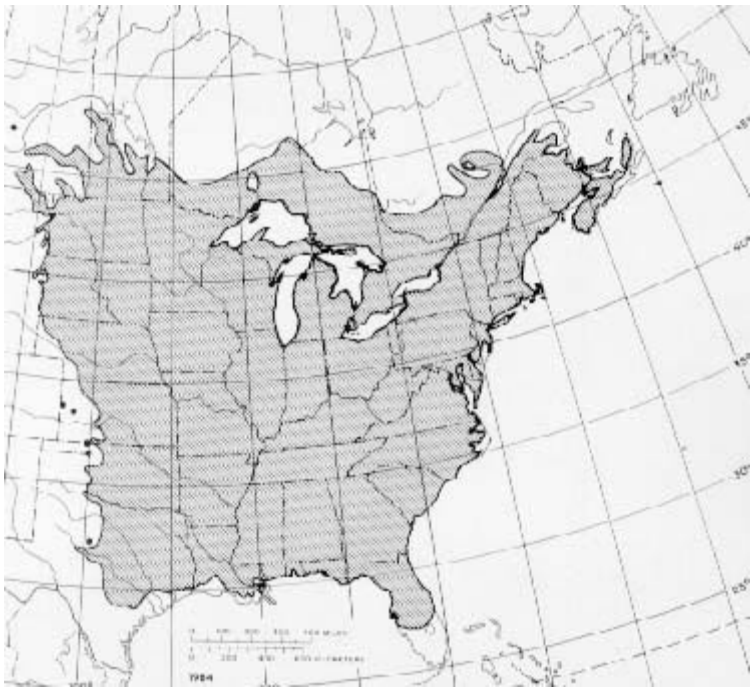
Calvin F. Bey

American elm *(Ulmus americana)*, also known as white elm, water elm, soft elm, or Florida elm, is most notable for its susceptibility to the wilt fungus, *Ceratocystis ulmi*. Commonly called Dutch elm disease, this wilt has had a tragic impact on American elms. Scores of dead elms in the forests, shelterbelts, and urban areas are testimony to the seriousness of the disease. Because of it, American elms now comprise a smaller percentage of the large diameter trees in mixed forest stands than formerly. Nevertheless, the previously developed silvical concepts remain basically sound.

Habitat

Native Range

American elm is found throughout Eastern North America. Its range is from Cape Breton Island, Nova Scotia, west to central Ontario, southern Manitoba, and southeastern Saskatchewan; south to extreme eastern Montana, northeastern Wyoming, western Nebraska, Kansas, and Oklahoma into central Texas; east to central Florida; and north along the entire east coast.



The native range of American elm.

Climate

Within the natural range of American elm, the climate varies from warm and humid in the southeast to cold and dry in the northwest. Average temperatures are as follows: January, from -18° C (0° F) and below in Canada and 16° C (60° F) in central Florida; July, from 16° C (60° F) in Manitoba to 27° C (80° F) in the Southern States; annual maximum, 32° C (90° F) to 35° C (95° F) in the Northeast and 38° C (100° F) to 41° C (105° F) in the South and West; annual minimum, from -40° C (-40° F) to -18° C (0° F) in the North and -18° C (0° F) to -1° C (30° F) in the South.

Average annual precipitation varies from a scarce 380 min (15 in) in the Northwest to a plentiful 1520 mm (60 in) on the gulf coast. Over the central part of the species range there are about 760 to 1270 min (30 to 50 in) per year. Throughout the range most of the precipitation comes during the warm (April-September) season. Average annual snowfall generally varies from none in Florida to about 200 cm (80 in) in the Northeast. A few areas, mainly around the Great Lakes, get 254 to 380 cm (100 to 150 in) of snow per year.

The average frost-free period is about 80 to 160 days for the northern tier of States and Canada to about 200 to 320 days for the gulf coast and Southeastern States.

Soils and Topography

American elm is most common on flats and bottom lands throughout its range but is not restricted to these sites. On the southern bottom-land region, it is found widely in first bottoms and terraces, especially on first bottom flats, but not in deep swamps. At higher elevations in the Appalachians, it is often limited to the vicinity of large streams and rarely appears at elevations

above 610 in (2,000 ft). In West Virginia, however, it does appear in high coves at elevations of 760 in (2,500 ft). In the Lake and Central States, it is found on plains and morainal hills as well as on bottom lands and swamp margins. Along the northwestern edge of the range, it is usually restricted to valley bottoms along watercourses.

Although American elm is common on bottom-land soils, it is found on many of the great soil groups within its range. The soils include well-drained sands, organic bogs, undifferentiated silts, poorly drained clays, prairie loams, and many intermediate combinations.

American elm grows best on rich, well-drained loams. Soil moisture greatly influences its growth. Growth is poor in droughty sands and in soils where the summer water table is high. In Michigan, on loam and clay soils, growth is good when the summer water table drops 2.4 to 3.0 in (8 to 10 ft) below the surface, medium with summer water table at 1.2 to 2.4 in (4 to 8 ft), and poor when topsoil is wet throughout the year. On sandy soils underlain with clay, growth is medium to good where the summer water table is 0.6 m (2 ft) or more below the soil surface. Organic soils are usually poor sites, but those with a summer water table at least 0.6 m (2 ft) below the surface are classed as medium sites for American elm.

In the South, American elm is common on clay and silty-clay loams on first bottoms and terraces; growth is medium on wetter sites and good on well-drained flats in first bottoms (8). In the and western end of the range, it is usually confined to the silt or clay loams in river bottoms and terraces. In shelterbelt plantings on the uplands, however, survival is generally best on sandy soils where the moisture is more evenly distributed to greater depths than in fine-textured soils. American elm most commonly grows on soils of the orders Alfisols, Inceptisols, Mollisols, and Ultisols.

Soil acidity under stands of American elm varies from acid on some of the swamp margin sites in the Lake States to mildly alkaline on the prairie soils. A soil reaction considered suitable for this species ranges from pH 5.5 to 8.0.

Leaf litter of American elm decomposes more rapidly than that of sugar maple *(Acer saccharum)*, shagbark hickory *(Carya ovata)*, white oak *(Quercus alba)*, and northern red oak *(Q. rubra)*. Under Missouri conditions, the leaves crumble readily after 18 months on the ground. They have a relatively high content of potassium and also of calcium (1 to 2 percent). Because its litter decomposes rapidly and contains many desirable nutrients, American elm is considered a "soil-improving" species.

Associated Forest Cover

Throughout its range, American elm seldom grows in pure stands and is usually found in mixture with other species. It is a major component of four forest cover types: Black Ash-American Elm-Red Maple (Society of American Foresters Type 39), Silver Maple-American Elm (Type 62), Sugarberry-American Elm-Green Ash (Type 93), and Sycamore-Sweetgum-American Elm (Type 94). It is a minor component in 20 other forest types.

Black Ash-American Elm-Red Maple (Type 39) appears throughout the Northern Forest and into the Boreal Forest in Canada, and throughout the Lake States and into the northern edge of the Central Forest. In this type the most common associates, other than the type species, are as follows: In the Lake States and Canada, balsam poplar *(Populus balsamifera),* balsam fir *(Abies balsamea),* and yellow birch *(Betula alleghaniensis);* in Ohio and Indiana, silver maple *(Acer saccharinum),* swamp white oak *(Quercus bicolor),* sycamore *(Platanus occidentalis),* pin oak *(Quercus palustris),* black tupelo *(Nyssa sylvatica),* and eastern cottonwood (Populus *deltoides);* in New England and eastern Canada, sweet birch *(Betula lenta),* paper birch *(B. papyrifera),* gray birch *(B. populifolia),* silver maple, and black spruce *(Picea mariana);* and in New York, white ash *(Fraxinus americana),* slippery and rock elms *(Ulmus rubra* and *U. thomasii),* yellow birch, black tupelo, sycamore, eastern hemlock *(Tsuga canadensis),* bur oak *(Quercus macrocarpa),* swamp white oak, and silver maple.

Silver Maple-American Elm (Type 62) is common throughout the Central Forest and extends into Canada. Major associates in this type are sweetgum *(Liquidambar styraciflua),* pin oak, swamp white oak, eastern cottonwood, sycamore, green ash *(Fraxinus pennsylvanica),* and other moist site hardwoods.

Sugarberry-American Elm-Green Ash (Type 93) is found throughout the Southern Forest within the flood plains of the major rivers. Hackberry *(Celtis occidentalis)* replaces sugarberry *(C. laevigata)* in the northern part of the range. Major associates are water hickory *(Carya aquatica),* Nuttall *(Quercus nuttallii),* willow *(Q. phellos),* water *(Q. nigra),* and overcup *(Q. lyrata)* oak, sweetgum, and boxelder *(Acer negundo).*

Sycamore-Sweetgurn-American Elm (Type 94) appears as scattered stands throughout the Southern Forest region and lower Ohio River Valley. Common associates include green ash, sugarberry, hackberry, boxelder, silver maple, cottonwood, black willow *(Salix nigra),* water oak, and pecan *(Carya illinoensis).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- The process of flowering, seed ripening and seed fall in American elm takes place in the spring throughout the range. The glabrous flower buds swell early in February in the South and as late as May in Canada. The flowers appear 2 to 3 weeks before leaf flush. Soon after wind pollination occurs, the fruit ripens, and seed fall is usually complete by mid-March in the South and mid-June in the North.

American elm flowers are typically perfect and occur on long, slender, drooping pedicels, about 2.5 cm (1 in) long, in 3- or 4-flowered short-stalked fascicles. The anthers are bright red, the ovary and styles are light green, and the calyx is green tinged with red above the middle. With controlled pollinations, floral receptivity is greatest when stigma lobes are reflexed above the anthers. The trees are essentially self-sterile. A test in Canada showed only 1.5 percent viable seed from self-pollinated flowers. Pollination may be hampered in a wet spring since the flower anthers will not open in a saturated atmosphere (9).

Seed Production and Dissemination- Seed production in American elm may begin as early as age 15 but is seldom abundant before age 40. When mature, American elm is a prolific seed producers Trees as old as 300 years have been reported to bear seeds. In closed stands, seed production is greatest in the exposed tops of dominant trees. The winged seeds are light and readily disseminated by the wind. Although most seeds fall within 91 in (300 ft) of the parent tree, some may be carried 0.4 kin (0.25 mi) or more. In river-bottom stands, the seeds may be waterborne for miles. Cleaned but not dewinged seeds average 156,000/kg (70,900/lb).

Adverse weather may reduce the seed crop. Spring frosts can injure and kill both flowers and fruit. Observations in Minnesota showed that while nearly ripe seeds were not injured by night temperatures of -3° C (27° F) for several successive nights, most were killed a week later when the temperature dropped to -7° C (19° F) and remained below freezing for 60 hours.

Mammals and birds also may reduce the seed crop. The flower buds, flowers, and fruit are eaten by gray squirrels. The seeds are also eaten by mice, squirrels, opossum, ruffed grouse, Northern bobwhite, and Hungarian partridge.

Seedling Development- Germination in American elm seed is epigeal. It usually germinates soon after it falls, although some seeds may remain dormant until the following spring. While germination may extend over a period of 60 days, most of the seeds germinate in 6 to 12 days. Germination is best with night temperatures at 20° C (68° F) and day temperatures of 30° C (86° F). However, germination is almost as good when daily temperatures range between 10° C (50° F) and 21° C (70° F). Seeds can germinate in darkness, but germination increases in light. Seeds also can lie on flooded ground for as long as 1 month with little adverse effect on germination, except possibly where siltation occurs in flooded bottoms.

American elm seedlings can become established on moist litter, moss, and decayed logs and stumps, but do best on mineral soil. Although they do grow in full sunlight, seedlings perform best with about one-third of full sunlight during the first year. After the first year or two, they grow best in full sunlight. Seedlings that develop in saturated soils are stunted and characterized by early yellowing and loss of the cotyledons, extremely short internodes, and small leaves.

American elm can withstand flooding in the dormant season but dies if the flooding is prolonged into the growing season. Compared with other bottomland species, American elm is intermediately tolerant to complete inundation. Some may be killed by early fall frosts, but those that survive soon are hardened by temperatures alternating between 0° C (32° F) and 10° C (50° F). A constant temperature of 0° C (32° F) for 5 days also hardens the seedlings enough to avoid frost killing (7).

Studies in Iowa and southeastern Michigan on wet lowland and upland mesic sites show that despite high mortality from Dutch elm disease, the next generation will be much like the last. Although American elm has been essentially eliminated from the overstory, it is a significant part of the understory and seedling layers. Some observations suggest that there will be a shift toward more intolerant species under the dead elms. American elm may be perpetuated for generations, even though the average life span of the trees is likely to be reduced. Where seeds are available, American elm is a prominent early invader of abandoned fields. On upland sites in

the Midwest, fire, as a natural component of the environment, has kept American elm from invading the prairies (1,2,12,13).

In determining vegetational patterns and succession, allelopathy is apparently not as important for species coming in under American elm as it is for species coming in under sycamore, hackberry, northern red oak, and white oak. In a test in Missouri, there was lower productivity and higher percent soil moisture under all test species but American elm. This apparently was due to toxic leaf leachate present from the four test species, but not present in leachate from American elm (11).

Vegetative Reproduction- Small American elm trees produce vigorous stump sprouts. Although not documented, some observations suggest that replacement in dense, undisturbed bottom-land stands in Minnesota may be by root suckers of mature trees.

American elm can be propagated by softwood cuttings taken in June and treated with indolebutyric acid or by leaf bud cuttings. In a test, greenhouse-grown stock rooted easier than field-grown stock. Propagation by dormant root cuttings has not been effective.

Sapling and Pole Stages to Maturity

Growth and Yield- American elm seldom grows in pure stands and there is no information on stand yields. On good sites in dense forest stands American elm may reach 30 to 38 m (98 to 125 ft) in height and 122 to 152 cm (48 to 60 in) in d.b.h., with a 15 m (49 ft) clear bole. On medium sites, heights of 24 m (80 ft) are common. On very wet soils or on the very dry soils of the Plains, however, the species is often only 12 to 18 m (40 to 60 ft) tall at maturity. In open-grown or sparse stands, the trees usually fork near the ground and form wide arching crowns. American elm is a long-lived species, often reaching 175 to 200 years, with some older than 300 years.

Rooting Habit- The depth of rooting varies with soil texture and soil moisture. In heavy, wet soils the root system is widespread and within 0.9 to 1.2 m (3 to 4 ft) of the surface. On drier medium-textured soils, the roots usually penetrate 1.5 to 3.0 m (5 to 10 ft). In deep, relatively dry sands in the Dakotas, American elm may develop a taproot reaching 5.5 to 6.1 m (18 to 20 ft) down to the water table.

Reaction to Competition- American elm is classed as intermediate in shade tolerance among the eastern hardwoods. Usually it responds well to release, often growing more rapidly than its associates at advanced ages. Once it becomes dominant in a mixed hardwood stand, it is seldom overtaken by other species. It can persist in the understory of pioneer species such as eastern cottonwood, black willow, and quaking aspen *(Populus tremuloides)* but dies if suppressed by tolerant sugar maple or American beech *(Fagus grandifolia).*

Damaging Agents- Since 1930, when Dutch elm disease reached the United States in a shipment of elm logs from Europe, it has spread to 41 States from coast to coast. The causal fungus, *Ceratocystis ulmi*, is introduced into the sap stream of twigs or small branches during feeding by the smaller European elm bark beetle, *Scolytus multistriatus*, and the native elm bark beetle,

Hylurgopinus rufipes. Dutch elm disease is characterized by a gradual wilting and yellowing of the foliage, usually followed by death of the branches and eventually the whole tree (5,14).

In addition to Dutch elm disease, several other diseases also are responsible for losses in shade and forest elms. Phloem necrosis, caused by a *virus (Morsus ulmi)* is detected by flagging or browned leaves and butterscotch-colored phloem with a wintergreen odor. It is transmitted by the whitebanded elm leafhopper *(Scaphoideus luteolus)* and through root grafts. Trees usually die within a year after symptoms appear. Verticillium wilt *(Verticillium albo-atrum)* is soil borne and usually enters host plants through the roots. Trees show dieback symptoms similar to Dutch elm disease (10). Other diseases include diebacks caused by *Cephalosporium* spp. and *Dothiorella ulmi;* a leaf black spot *(Gnomonia ulmea);* twig blight *(Cytosporina ludibunda);* cankers *(Nectria* spp.*, Sphaeropsis ulmicola,* and *Phytophthora inflata);* elm wetwood *(Erwinia nimipressuralis);* and elm mosaic *virus* (3,4). Some of the common wood rot fungi are *Pleurotus ulmarius, P. ostreatus, Armillaria mellea, Ganoderma applanatum, Phellinus igniarius,* and numerous species of *Polyporus.*

American elm is attacked by hundreds of insect species including defoliators, bark beetles, borers, leaf rollers, leaf miners, twig girdlers, and sucking insects. The carpenterworm *(Prionoxystus robinae)* bores into the sapwood and degrades the wood. Among the insects that defoliate elm are the spring cankerworm *(Paleacrita vernata),* the forest tent caterpillar *(Malacosoma disstria),* the elm leaf beetle *(Pyrrhalta luteola),* the whitemarked tussock moth *(Orgyia leucostigma),* the elm spanworm *(Ennomos subsignaria),* and many other leaf-eating insects that attack elm and other hardwoods. The elm cockscombgall aphid *(Colopha ulmicola)* forms galls on the leaves but does little damage to the tree. Several scale insects attack elm and may cause damage. Both the elm scurfy scale *(Chionaspis americana)* and the European elm scale *(Gossyparia spuria)* are widely distributed. Among the leafhoppers, the whitebanded elm leafhopper is classed as a serious pest since it is the vector for phloem necrosis (15).

Besides insect and disease losses, animal damage, and fire, climatic factors also can have an impact on survival and growth of American elm. Young forest trees may sunscald when exposed by harvesting or thinning operations. Open-grown American elm forks and develops a widespread crown that is susceptible to injury by heavy, wet snows and glaze storms. Of 37 tree species examined after an ice storm in Illinois, American elm ranked fourth in susceptibility to ice damage. In dense stands, such injuries are less severe and are not generally a management problem. Although American elm is shallow rooted in wet soils, it is fairly windfirm because the roots are widespread.

The species is reasonably drought resistant, but prolonged drought reduces growth and may cause death. During the drought of 1934, in the Midwest prairie region, losses of American elm and associated species ran as high as 80 to 90 percent. The 1951-54 drought also caused severe losses in the bottom lands of the South where American elm was more susceptible to drought than the lowland red oaks. Prolonged spring floods may cause death or growth loss. Despite suitable temperatures, in Minnesota bottom lands root elongation does not begin until the spring floods recede and soil aeration increases. On these sites and where trees are planted between street and sidewalk, buttress roots often are a result of inadequate soil aeration.

Fire damage is not a major management problem in the North; however, in southern bottom lands, fall and sometimes early spring fires are extremely damaging. Fires can kill seedling- and sapling-size trees and wound larger trees, thus admitting heartrot fungi.

Animal damage to American elm, from the sapling stage to maturity, is not a serious problem except for sapsucker injury that degrades the wood.

Special Uses

Before the advent of Dutch elm disease, American elm was prized for its use as a street tree. It was fast growing, hardy, tolerant to stress, and appreciated for its characteristic vaselike crown. Beautiful shaded streets in many cities attested to its popularity.

The wood of American elm is moderately heavy, hard, and stiff. It has interlocked grain and is difficult to split, which is an advantage for its use as hockey sticks and where bending is needed. It is used principally for furniture, hardwood dimension, flooring, construction and mining timbers, and sheet metal work. Some elm wood goes into veneer for making boxes, crates, and baskets, and a small quantity is used for pulp and paper manufacture.

Genetics

The study of genetics in American elm has been primarily directed toward combining resistance to Dutch elm disease with desirable growth Characteristics. Only a few selections from American elm look promising at this time. Noteworthy is the "American Liberty" elm, a multiclonal variety selected from second-generation crosses of the most resistant parents. Despite high selection intensity, their resistance is still inferior to resistant cultivars derived from Asian or European sources.

A few horticultural forms have been recognized. These are *Ulmus americana columnaris,* a form with a narrow columnar head, *U. americana ascendens,* with upright branches, and *U. americana pendula,* with long pendulous branches.

Hybridization within the genus *Ulmus* has been aimed primarily at breeding for Dutch elm disease and phloem necrosis resistance. Because of the difficulty of hybridizing American elm, which has a chromosome number twice that of all the other elms (56 versus 28), most of the breeding and selection work does not include American elm. Thousands of attempts to cross the American with the Siberian elm have failed. Reports of successful artificial hybridization and verification of hybridizing American elm with other elms are rare.

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Black Walnut

Juglans nigra L.

Other Common Names:

Eastern black walnut and American walnut.

Brief Description:

Although widely distributed, black walnut overall is one of the most scarce and coveted hardwood trees. Often considered the most valuable tree in terms of wood products, its supply is slowly diminishing. The nuts are also highly prized by both people and animals. Black walnut is also notable for its allelopathic affects to understory vegetation.

Habitat:

Black walnut typically grows as scattered individual trees or in small groups. It ranges primarily throughout the central and eastern parts of the United States, but also extends to the Great Lakes. In some areas such as Kansas black walnut can make up significant portions of large forested areas. It grows best on well drained rich cove sites in bottoms of the Appalachians and the Midwest. Primarily it is sensitive to deep, well-drained soils that have a neutral pH and are generally moist. It grows much more slowly on deep sandy ridges and wet bottomland.

Life History:

Flowers appear about mid-April typically at the same time leaves develop. The large nut mature in September or October o f the same year and drop shortly after the leaves fall. Good seed crops are irregular and once about every three years. Good seed production begins at about 20 to 30 years of age. Seed is disseminated short distances by both gravity and animals. Black walnut is intolerant of shade. Seedlings develop primarily from seed that squirrels bury and fail to recover. Normally germination occurs the following spring, usually April or May, after seedfall. Height growth peaks in late April or early May and is complete by the end of July. It typically loses its leaves before other species. It grows a deep taproot along with an extensive lateral root system. The species is moderately tolerant of flooding. Mature trees are noted to die after 90 days of continuous inundation during the growing season.

Black walnut and the Great Trinity Forest:

Black walnut has been reported to occur in the forest. It helps to fill the valuable niche of a heavy mast producer in the forest. Its planting would be limited to sandy upland sites.

Juglans nigra L.

Black Walnut

Juglandaceae -- Walnut family

Robert D. Williams

Black walnut *(Juglans nigra),* also called eastern black walnut and American walnut, is one of the scarcest and most coveted native hardwoods. Small natural groves frequently found in mixed forests on moist alluvial soils have been heavily logged. The fine straight-grained wood made prize pieces of solid furniture and gunstocks. As the supply diminishes, the remaining quality black walnut is used primarily for veneer. The distinctive tasting nuts are in demand for baked goods and ice cream, but people must be quick to harvest them before the squirrels. The shells are ground for use in many products.

Habitat

Native Range

Black walnut typically grows as scattered individual trees or in small groups throughout the central and eastern parts of the United States. Although it is found on a variety of sites, black walnut grows best on good sites in coves and well-drained bottoms in the Appalachians and the Midwest. Its natural range extends from western Vermont and Massachusetts west through New York to southern Ontario, central Michigan, southern Minnesota, eastern South Dakota and northeastern Nebraska; south to western Oklahoma and central Texas; excluding the Mississippi River Valley and Delta, it ranges east to northwestern Florida and Georgia (28,29). On the western fringe of its range in Kansas, walnut is fairly abundant and frequently makes up 50 percent or more of the basal area in stands of several hectares (21).

-The native range of black walnut.

Climate

The growing season within the range of black walnut ranges from 140 days in the north to 280 days in western Florida (10,43). Annual precipitation is less than 640 mm (25 in) in northern Nebraska and 1780 mm. (70 in) or more in the Appalachians of Tennessee and North Carolina. Mean annual temperatures range from about 7° C (45° F) in the north to 19° C (67° F) in the south. Temperatures as low as -43° C (-45° F) have occurred where walnut grows, but few races of black walnut can tolerate such low temperature. Within black walnut's optimum range, the average annual temperature is about 13° C (55° F), the frost-free season is at least 170 days, and the average annual precipitation is at least 890 min (35 in).

Soils and Topography

Black walnut is sensitive to soil conditions and develops best on deep, well-drained, nearly neutral soils that are generally moist and fertile (10). These soils are in the orders Alfisols and Entisols. Although an Ohio study indicated that site index for black walnut was not significantly related to pH values between 4.6 and 8.2, site index was highest on limestone derived soils even though some of the soils were acid. Walnut grows best on sandy loam, loam, or silt loam textured soils but also grows well on silty clay loam soils (31). Soils with these textures hold a large amount of water that is available to the tree during dry periods of the growing season. Internal drainage and depth to gravel are especially important site characteristics for black walnut. On well-drained soils, 76 cm (30 in) or more to mottling, 25-year-old trees were 6.6 cm

(2.6 in) larger in d.b.h. than trees growing on imperfectly drained soils, 15 to 76 cm (6 to 30 in) to mottling. Twenty-five-year-old trees on deep soils, more than 102 cm (40 in) from surface to gravel, were 5.2 m (17 ft) taller and 6.4 cm (2.5 in) larger in d.b.h. than trees on shallow soils less than 102 cm (40 in) from surface to gravel (30).

Walnut is common on limestone soils and grows especially well on deep loams, loess soils, and fertile alluvial deposits. It also grows well on good agricultural soils that do not have fragipans. Walnut grows slowly on wet bottom land and on sandy or dry ridges and slopes. Throughout its range, walnut generally reaches its greatest size and value along streams and on the lower portion of north- or east-facing slopes. This is particularly true near the limits of its natural range. In northeastern Kansas, site index on alluvial soils was 2.4 rn (8 ft) greater than on residual soils and 2.7 in (9 ft) greater on northeast than on southwest aspects (20).

Associated Forest Cover

Black walnut grows in many of the mixed mesophytic forests but is seldom abundant (43). Usually it is found scattered among other trees; pure stands are rare, small, and usually located on the forest edge. Black walnut is a common associate in five forest cover types (16): Sugar Maple (Society of

American Foresters Type 27) in the central hardwood zone and the Appalachian highlands, Yellow-Poplar (Type 57) at lower elevations of the Appalachians, Yellow-Poplar-White Oak-Northern Red Oak (Type 59) at lower elevations, Beech-Sugar Maple (Type 60) in the Midwest, and Silver Maple-American Elm (Type 62) in southern Ontario washboard swamps where high and low ground intermingle.

It is also found as an occasional associated species in four cover types: Chestnut Oak (Type 44), White Oak-Black Oak-Northern Red Oak (Type 52), Northern Red Oak (Type 55) on moist sites, and Sassafras-Persimmon (Type 64) in older stands.

Chief associated species include yellow-poplar *(Liriodendron tulipifera),* white ash *(Fraxinus americana),* black cherry *(Prunus serotina),* basswood *(Tilia americana),* beech *(Fagus grandifolia),* sugar Maple *(Acer saccharum),* oaks *Quercus* spp.), and hickories *(Carya* spp.). Near the western edge of its range, black walnut may be confined to floodplains, where it grows either with American elm *(Ulmus americana),* hackberry *(Celtis occidentalis),* green ash *(Fraxinus pennsylvanica),* and boxelder *(Acer negundo),* or with basswood and red oak *Quercus rubra)* on lower slopes and other favorable sites (10).

No universal vegetative indicator of a good walnut site is known, but the presence of Kentucky coffeetree *(Gymnocladus dioicus)* seems to indicate such a site (10,43). In general, where yellow-poplar, white ash, red oak, basswood, sugar maple, or slippery elm *(Ulmus rubra)* grow well, black walnut thrives also.

An antagonism between black walnut and many other plants growing within its root zone has been recognized and is attributed to juglone, a toxic substance found in the leaves, bark, nut husks, and roots of walnut trees (32,42). Some tree species apparently are immune, but others,

such as paper birch *(Betula Papyrifera)*, red pine *(Pinus resinosa)*, white pine *(P. strobus)*, Scotch pine *(P. sylvestris)*, and apple *(Malus* spp.), reportedly are sensitive. Tomatoes are especially susceptible. In a laboratory study, juglone at high concentrations was lethal to four coniferous species, but seedling growth was actually promoted when exposed to minute concentrations (19). Although tomatoes are especially susceptible to juglone, black walnut trees may be compatible with some agricultural crops and might even improve the growth of bluegrass *(Poa spp.)*.

Life History

Reproduction and Early Growth

Flowering and Fruiting- Depending on latitude, black walnut flowers generally begin to appear about mid-April in the South and progressively later until early June in the northern part of the natural range. Flowering and leafing out occur at approximately the same time and always early enough for possible damage by late spring frosts (18,27).

Walnut is monoecious; male flowers, which are slender catkins, develop from axillary buds on the previous year's outer nodes, while female flowers occur in short terminal spikes, ranging from a few to many, home on the current year's shoots. Flowering is dichogamous, and protogyny (the female flowers appearing first) is more common than protandry (male flowers appearing first) (33,34). Because of its dichogamous flowering habit, self-pollination is unlikely. However, individual trees usually are not self-sterile; if they are not pollinated by neighboring trees, they may set self-fertilized seeds (3). Fertilization follows 2 to 5 days after pollination, succeeded by development of the husk, the shell, and finally by the seed itself (18).

Seed Production and Dissemination- The large edible nut ripens in September or October of the same year and drops shortly after the leaves fall. Good seed crops are produced irregularly, perhaps twice in 5 years. Open-grown trees may produce some seed when only 4 to 6 years old, but large seed crops do not occur until the trees are 20 to 30 years old (28). For example, at 10 years of age, a midwest plantation produced 28 kg of hulled nuts per hectare (25 lbs/acre), and by age 12 production had increased to 112 kg/ha (100 lb/acre). Best seed production begins when the trees are about 30 years old and continues for another 100 years. Seed is disseminated only short distances by gravity and animals.

In a Missouri study, seed production of trees about 28 years old and 19.3 cm (7.6 in) in d.b.h. was nearly doubled by release and fertilization (40). Trees released but not fertilized produced 13 percent more nuts than nonreleased trees.

Stratification for 90 to 120 days is required for optimum seed germination but the necessity and duration of stratification may vary by seed source (46). In Canada, 69 to 81 percent of nuts stratified 19 months germinated within 3 weeks of seeding, while 10 to 25 percent of nuts stratified 7 months germinated after 12 weeks (48). When nuts that had not germinated after 12 weeks in the seedbed following 7 months stratification were stratified for an additional 9 months, 81 percent germinated within 3 weeks. Many of the nuts stratified for 31 months germinated while in storage.

Seedling Development- Germination is hypogeal (46). Young black walnut seedlings are intolerant of shade and are seldom found under dense tree canopies. Regeneration develops primarily from seed that squirrels bury and fail to recover. Normal winter temperatures usually cause the buried seeds to break dormancy the following spring, but germination is sometimes delayed until the second year.

Seedlings emerge in April or May the first or second spring after the seed is planted (46). On deep, rich, moist soils in coves or well-drained bottom land, seedlings may grow 91 cm (36 in) the first year and even more the second growing season. Although black walnut does not make as rapid height growth as yellow-poplar and white ash on good sites, it generally surpasses the oaks. In eastern Nebraska, near the western edge of its range, walnut made much better height growth than oaks or basswood on a prairie site (10). Walnut developed an excellent root system and was several times taller than the other tree species.

Height growth begins slowly in the spring, reaches a peak rate in late April and May, and is complete by the middle of July or the first of August. Black walnut loses its leaves somewhat earlier than other trees and has a growing period of from 115 to 135 days (10).

Because of its large taproot, planted walnut seedlings typically survive well. However, they require weed control during the first 2 or 3 years to grow well (26).

Vegetative Reproduction- If small black walnut trees are cut or killed back by fire, the stumps usually sprout. Sprouts originating near the root collar generally are free from defect but sprouts originating high on older stumps often develop heart rot or other decay from the parent stump.

Within the last few years the success of grafting and budding of walnut has increased substantially. From 80 to 100 percent success has been achieved by three grafting methods done in the greenhouse and growth chamber (35). In the field the success rate for inlay grafting, the best method tested, ranged from 33 to 83 percent. A consistent field survival of 70 to 90 percent for the outplantings of grafted stock is predicted if tested procedures are followed (4). Black walnut is compatible with several other Juglans species, either as a root stock or scion (22).

Sapling and Pole Stages to Maturity

Growth and Yield- On the best sites, young black walnut trees may grow 91 to 122 cm (36 to 48 in) in height per year (28). The best tree in a southern Indiana plantation at age 7 was 11.9 cm (4.7 in) d.b.h. and 7.6 in (25 ft) in height (9). In a southern Illinois plantation (site index 24.4 m or 80 ft at base age 50 years), the best tree was 21 cm (8.3 in) d.b.h. and 12 m (40 ft) tall at age 14 (1). However, the average size tree in the plantation was 12 cm (4.8 in) d.b.h. and 7 m (24 ft) tall. Even on less favorable sites (site index 21.3 m or 70 ft), trees reach heights of 12 to 15 rn (40 to 50 ft) and diameters of 15 to 25 cm (6 to 10 in) in 20 years (28). In contrast, diameter growth of black walnut planted on Kansas strip mine spoil banks averaged only 6 mm (0.25 in) per year and height growth averaged only 33.5 cm (13.2 in) per year during the first 10 to 12 years (10). On Illinois spoil banks trees grew best on the lower slopes, on areas formed from limestone parent material and containing a high percentage of fine soil, or if underplanted with black locust *(Robinia pseudoacacia).* In two 10-year-old southern Illinois plantations, walnut

trees in mixture with autumn-olive *(Elaeagnus umbellata),* a nitrogen-fixing species, were 89 percent taller and 104 percent larger in diameter than walnut trees in pure walnut plots (41). In an Indiana study, 10 years after autumn-olive was interplanted into 2-year-old black walnut, the walnut in the interplanted plots were 2.6 rn (8.4 ft) taller than those in the pure plots (14).

Mature black walnut trees on good sites may reach 30 to 37 m (100 to 120 ft) in height and 76 to 102 cm (30 to 40 in) in d.b.h. (28). Trees 40 m (130 ft) tall and more than 244 cm (96 in) in d.b.h. have been reported in Wisconsin. In Indiana, black walnut trees were 46 m (150 ft) tall and 183 cm (72 in) in d.b.h. on the most favorable sites (43). Research and experience indicate that with proper care it may be possible to produce 41-cm (16-in) saw logs in 30 to 35 years, and by planting on good sites it may be possible to produce 51 cm (20 in) veneer logs in 40 to 50 years. By applying some basic cultural practices, such as release and pruning, to established trees, growth and quality can be greatly increased in only a few years.

Board-foot volume growth rate was correlated with site quality in midwestern plantations. According to Kellogg's yield tables (23), predicted yield for site index 21.3 rn (70 ft) at age 75 is 10 times that of site index 12.2 m (40 ft), and yields for site index 18.3 m (60 ft) are twice those for site index 15.2 m (50 ft). The yield tables also show that periodic annual growth rate is not constant: maximum growth occurs between ages 40 and 50 years on the better sites.

Rooting Habit- The root system of mature black walnut has been described as combining the deep taproot of more xeric trees, such as the oaks, with the strong laterals characteristic of more mesic ones, such as maple. The rooting configuration of individual trees depends on soil texture and moisture conditions (47).

The root system is deep and wide spreading, with a definite taproot, at least in early life. The taproot of a 9-year-old walnut tree excavated from an Indiana plantation was 2.3 rn (7.5 ft) long and the lateral roots extended more than 2.4 m (8 ft) from the taproot (11). One-year-old walnut seedlings lifted from nursery seedbeds have well-developed taproots (51). The mass of fibrous roots varies with the soil type; the more fibrous-rooted seedlings develop in the more sandy-textured soils.

Early growth of the seedling root system is rapid. Vertical taproot extension during the first growing season is great, especially on drier soils. One researcher reported a taproot penetration of more than 1.2 rn (4 ft) for 1-year-old walnut seedlings on a prairie silt loam soil. Another reported 64 to 69 cm (25 to 27 in) for 1-year-old walnut on a more moist site (47). In the second year of root growth, the taproot continues to extend and many lateral roots develop.

The depth of walnut lateral roots may vary in response to root competition with its associates. In one study, lateral roots of walnut occupied a much shallower position in pure walnut stands than in mixed walnut-ash stands. This was explained by theorizing that the ash, having a strongly developed surface root system, forced the walnut roots into deeper soil layers. Root competition with Norway maple *(Acer platanoides),* on the other hand, was not as intense (47).

Black walnut is moderately tolerant of flooding. Mature trees are generally killed after 90 days of continuous inundation during the growing season, although some individuals may survive for

150 days or more. Black walnut is more flood-tolerant than black cherry, shortleaf pine *(Pinus echinata)*, basswood, and shagbark hickory *(Carya ovata)* (47).

The initial root form of black walnut, with its rapidly growing juvenile taproot and wide spreading laterals, is characteristic of species that grow on deep, fine-textured soils in regions with well-distributed summer rains. Such soils maintain a fairly uniform available water content to considerable depth, and walnut growing on these soils are able to draw their moisture and nutrients largely from the more fertile shallow soil while still being able to rely on the deeper soil layers for survival during times of drought.

Black walnut forms endomycorrhizae of the vesicular-arbuscular type. One study revealed that 100 percent of the walnut seedlings grown in a southern Michigan nursery had endomycorrhizae, but seedlings grown in a southern Indiana nursery had no mycorrhizae. A recent study shows that several Glomus species form a symbiotic relation with black walnut seedlings. Some Glomus, species and combinations of species increased growth of black walnut (36).

Reaction to Competition- Black walnut is classed as intolerant of shade (2). In mixed forest stands it must be dominant or codominant to survive, although it has survived and grown in the light shade of black locust. In a mixed hardwood stand in Indiana, pole-size black walnut responded to crown release by more than doubling diameter growth over a 10-year period (39,40). Trees only partially released grew about 50 percent more than unreleased trees. Controlling understory growth had little effect on growth of the walnut trees. Following release, dominant and codominant trees continue to grow more rapidly than those in intermediate or suppressed crown classes, but strong intermediates often respond most to release (in terms of growth rate increase). A walnut tree should be considered for release if it is healthy, has a bole with potential to make a veneer or high quality saw log, and is small enough that it can reasonably be left for at least 10 more years. To be effective, release must be thorough. A rule of thumb is that at least threefourths of the crown of the released tree should be at least 1.5 m (5 ft) from the crowns of adjacent trees 60 to 100 percent as tall, and at least 3 m (10 ft) from the crowns of taller trees. Subsequent releases will be required at intervals of 6 to 10 years to maintain free growing space.

Some bole sprouting can be expected on forest-grown trees that are released for the first time. Bole sprouts developed on almost half of the unreleased trees and on almost two-thirds of the released trees during an Indiana study (39). Sprouts were more numerous on the unreleased trees (16.1 sprouts per tree) than on the partially (12.2 sprouts per tree) and completely released trees (9.2 sprouts per tree), but the sprouts were much larger on the released trees. The intermediate and suppressed trees had more sprouts than dominant or codominate trees. Most of the bole sprouts were above the butt log, and more were on the south side than on the north side of the trees.

Control of competing vegetation is especially important in new plantations. In an Indiana study, walnut seedlings established on formerly cultivated fields and given 3 years of weed control were 100 cm (39 in) taller at 10 years of age, and 15 mm (0.6 in) larger d.b.h. than trees given 2 years of control (53). Trees with vegetation controlled 2 years were 40 cm (15.7 in) taller and 5

mm (0.2 in) larger in diameter than those where weeds were controlled only 1 year. Broadcast weed control is neither necessary nor desirable because it aggravates erosion problems.

In a southern Illinois experiment, seventh-year survival of black walnut planted on a cleared forest site was 94 to 99 percent regardless of weed control treatment (25). The young trees grew better, however, when all vegetation or only forbs and grasses were controlled than when only woody vegetation was controlled or when no vegetation control was used. Biennial control was no better than triennial, but annual control was superior. When only woody vegetation was controlled, frequency of treatment had no effect.

Pruning lateral branches helps to produce knot-free wood under open growing conditions that would normally permit most of the lower branches to persist. The objective of pruning is to produce a clear bole while minimizing damage to the tree and growth loss. When needed, pruning should be begun early in the life of the tree and continued as needed. To minimize damage and promote rapid healing, branches should be pruned before they are 5 cm (2 in) d.b.h. A neat, clean cut should be made, being careful not to be cut into the branch collar (44). Ring shakes and dark bands of discolored wood were associated with 14 of 17 stubs that were "flush cut" (branch collar removed) 13 years earlier. Pruning young trees eliminates these problems, but if older trees are pruned, care must be taken not to remove the branch collars that form around the bases of dying and dead branches.

When trees are pruned during the dormant season (early spring just before the leaves appear is best), wounds tend to heal more rapidly and completely and sprouts from dormant buds near the wound are less likely to develop. If sprouts do develop, they should be removed promptly. No more than 25 percent of the live crown should be released in a single year, and at least 50 percent of the total tree height should be maintained in live crown (10).

Damaging Agents- Black walnut is damaged by a number of insects. In southern Illinois more than 300 insect species were found on black walnut (49). Even though many insects feed on black walnut, only a few are considered serious pests. Two of the most common defoliating insects are the walnut caterpillar *(Datana integerrima)* and the fall webworm *(Hyphantria cunea).* They are commonly found eating the leaves beginning in midsummer and continuing until September. Important boring insects are the ambrosia beetle *(Xylosandrus germanus),* which may introduce a *Fusarium* fungus into the tree, causing dieback and resprouting from the base of the tree; the flatheaded apple tree borer *(Chrysobothris femorata),* which feeds in the phloem and outer sapwood area as larvae and on the foliage as adults; the walnut curculio *(Conotrachelus retentus),* which damages developing nuts when the larvae bore into them and cause great losses during the so-called "June drop" of walnuts; and the walnut shoot moth *(Acrobasis demotella),* which damages the terminal buds in early spring when the larvae bore into the still unexpanded bud, causing multiple forks and crooks in the main stem. The pecan leaf casebearer *(Acrobasis juglandis) is* closely related to the walnut shoot moth but is a much less damaging pest of black walnut. Important sucking insects are aphids or plant lice *(Monellia spp.* and *Monelliopsis spp.),* which suck the juices from leaves and often deposit a sticky substance called "honey-dew" on the leaf surface that may turn black and prevent photosynthesis; and the walnut lace bug *(Corythucha juglandis),* which causes damage when the adults and nymphs suck the sap from the lower surfaces of walnut leaflets.

Black walnut is susceptible to only a few serious diseases, but their impact is significant. Two serious root rot diseases found in seedling nurseries are caused by the fungi *Phytophthora citricola* and *Cylindrocladium spp.* An important mold of stored seed and seedlings is associated with *Penicillia* and other normally saprophytic fungi (24). Walnut anthracnose, caused by the fungus *Gnomonia leptostyla, is* a leaf spot disease that begins during wet spring weather, although symptoms may not become visible until June or July (49). Another important foliage disease is target leafspot which is caused by the fungus *Cristulariella pryamidalis* and is responsible for premature defoliation (38). A newly discovered, serious leaf spot disease is caused by the fungus *Mycosphaerella juglandis* (24).

Important stem diseases caused by fungi are the *Fusarium* cankers caused by several species of *Fusarium* and the perennial target canker *(Nectria galligena)* commonly known as Nectria canker (49). Cankers usually occur on the main stem where a branch broke off and left an open wound.

Animals damage black walnut in several ways. Deer browse on buds and rub antlers against young trees. Mice and rabbits gnaw on the stems of young trees during the winter, and squirrels dig up and eat direct-seeded nuts and feed on green and mature nuts still on the trees. Perching birds break the terminal or new branches from the tree, and the yellow-bellied sapsucker drills holes through the bark during late winter or early spring (49). Some trees may be nearly girdled with peck holes.

Decay, dieback, and frost also cause damage. At times dieback and frost damage may be extensive. Late spring frosts kill succulent new growth and thus reduce height growth and destroy desirable form. Late winter warming periods sometimes cause walnut trees to break dormancy prematurely, resulting in freezing injury to the stem tissue (13,37).

Special Uses

The best known use of black walnut is for its lumber and veneer. The wood is used for fine furniture of all kinds, interior paneling, specialty products, and gunstocks.

The nuts of black walnut serve many purposes. The kernels provide food for wildlife and humans (45,52). Ground shells provide special products (12). During World War II, airplane pistons were cleaned with a "nut shell" blaster and this idea was carried into the auto industry; manufacturers used shells to deburr precision gears. Ground shell products are also used to clean jet engines, as additives to drilling mud for oil drilling operations, as filler in dynamite, as a nonslip agent in automobile tires, as an air-pressured propellant to strip paints, as a filter agent for scrubbers in smokestacks, and as a flourlike carrying agent in various insecticides.

Genetics

Population Differences

Black walnut contains great genetic variation for growth and survival, and an important part of this variation is related to geographic origin (8). Preliminary seed collection zones have been recommended (15). Geographic variation among stands is three to five times greater than local (within stands) variation for characteristics such as growth rate, dates of foliation and leaf drop, twig maturation, and degree of winter dieback (17). Genetic gains can be made through selection within a designated seed collection zone. Generally, trees from seed collected south of the planting site grow as fast or faster in height and diameter than trees from local or northern sources (7,9). Both duration and rate of growth are responsible for the growth differences. In 1969, trees from Mississippi and Texas seed sources planted in a southern Illinois plantation grew in height for 134 days compared to 93 days for trees from northern Illinois and Iowa sources (5). On the average, height growth continued 1 day longer for every 24 miles south of the planting site that seed was collected (6). Duration of diameter growth was less closely related. However, trees of southern origin grew fastest.

Flowering phenology, seed weight, kernel percent, nut crackability, foliage characteristics, grafting and budding compatibility, rooting capacity of layered trees in stool beds, autumn leaf retention, cold resistance, and growth rates vary widely among black walnut families (17).

More than 400 black walnut cultivars have been named and released during the past century. Twenty of the most popular, including origin and nut evaluations, are listed by Funk (18). Three timber-type walnut clones chosen for outstanding straightness, anthracnose resistance, or late spring foliation have been patented by Purdue University.

Hybrids

Wright (54) has pointed out that species that can cross within a genus usually have distinct (often adjacent) ranges, while species that occupy the same sites in the same regions develop barriers to hybridization. *Juglans* seems to follow this pattern; *J. nigra* and J. *cinerea* often grow together but apparently never cross naturally, while all other walnut species (at least in the western hemisphere) are almost completely isolated. Thus, easy crossing might be expected among the morphologically similar North America Rhysocaryon walnuts. One example is the "Royal" hybrid between *J. nigra* and *J. hindsii* produced by Burbank in about 1888. This hybrid begins to bear viable seed by age 5 and produces exceptionally large nuts (50). The hybrids are vigorous and have been recommended for timber areas. Black walnut has been crossed with other species of *Juglans* in attempts to increase nut production, to produce a thin-shelled nut, or to produce a faster growing tree. *Juglans* can be divided into three sections: the black walnuts, the butternuts, and the Persian/Carpathians. A somatic chromosome number of 32 is consistent for all the species reported to date (18).

Crossing between the black walnut and butternut sections is difficult or impossible. A cross between *J. nigra* and *J. ailantifolia* is the only one recognized between the black walnut and butternut sections. However, J. *regia* can hybridize with species in both the other sections, although the crosses are not always easy.

Artificial hybridization is simple but time consuming. Each pollination may yield two or three nuts and a season's work only a few thousand nuts.

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Black Willow

Salix nigra Marsh.

Other Common Names:

Swamp willow, Goodding willow, southwestern black willow, Dudley willow, and sauz.

Brief Descriptions:

Black willow is the only commercially important willow in North America. It is desirable for bank and soil stabilization. It is limited to wet soils near water courses and is often found growing in pure stands. Extractives from the tree were once used in the treatment of rheumatism.

Habitat:

Black willow ranges east of the Great Plains to the Atlantic Ocean and excludes parts of Florida and Maine. It can be found growing on river margins and batture land. On these sites it often dominates the lower, wetter, and less sandy sites. It is not appreciably damaged by flooding or silting. Good habitat for black willow is anywhere with plenty of direct sunlight and abundant moisture.

Life History:

Seed production begins at about age 10. Flowers appear as the tree leafs out and seeds reach maturity about two months after pollination. Seed germination is dependent on the seeds ability to reach the seed bed within 24 hours of seed fall. Very moist exposed mineral soil is necessary for seedling establishment. Seedlings can exceed four feet of height growth in the first year. The tree sprouts prolifically from cuttings and this is the usual method of artificial regeneration. Black willow is very intolerant of shade. Pure stands can often stagnate due to black willow's inability to express dominance.

Black Willow and the Great Trinity Forest:

Willow is distributed much like cottonwood in the forest, except it can endure wetter areas and is dominated by cottonwood on the better drained locations. Its ability to be propagated from cuttings easily should be considered when attempting to quickly stabilize soils on disturbed sites.

Salix nigra Marsh.

Black Willow

Salicaceae -- Willow family

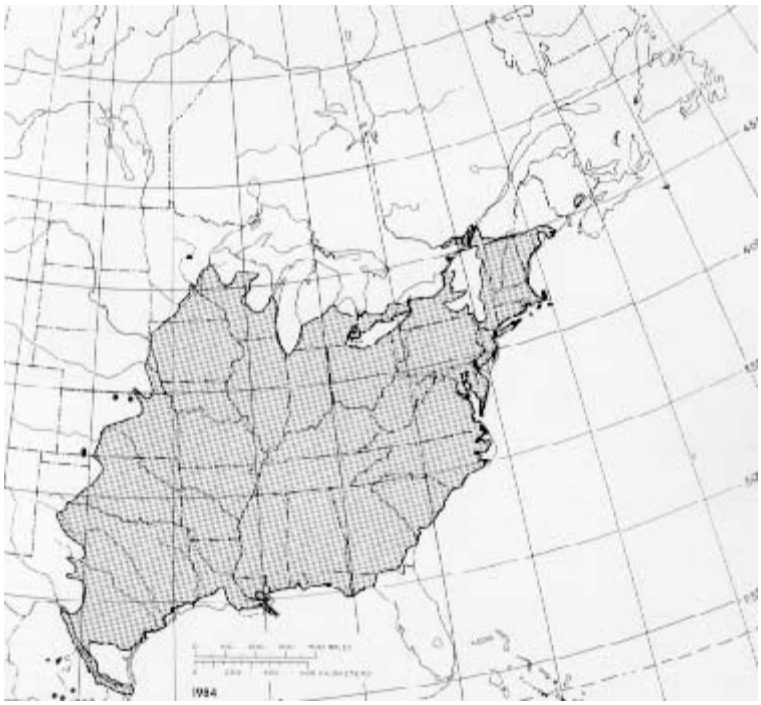
J. A. Pitcher and J. S. McKnight

Black *willow (Salix nigra)* is the largest and the only commercially important willow of about 90 species native to North America. It is more distinctly a tree throughout its range than any other native willow; 27 species attain tree size in only part of their range (3). Other names sometimes used are swamp willow, Goodding willow, southwestern black willow, Dudley willow, and sauz (Spanish). This short-lived, fast-growing tree reaches its maximum size and development in the lower Mississippi River Valley and bottom lands of the Gulf Coastal Plain (4). Stringent requirements of seed germination and seedling establishment limit black willow to wet soils near water courses (5), especially floodplains, where it often grows in pure stands. Black willow is used for a variety of wooden products and the tree, with its dense root system, is excellent for stabilizing eroding lands.

Habitat

Native Range

Black willow is found throughout the Eastern United States and adjacent parts of Canada and Mexico. The range extends from southern New Brunswick and central Maine west in Quebec, southern Ontario, and central Michigan to southeastern Minnesota; south and west to the Rio Grande just below its confluence with the Pecos River; and east along the gulf coast, through the Florida panhandle and southern Georgia. Some authorities consider *Salix gooddingii* as a variety of *S. nigra*, which extends the range to the Western United States (3,9).



-*The native range of black willow.*

Climate

The climate in which black willow grows best is characterized by an average rainfall of 1300 mm (51 in). Approximately 500 mm (20 in) of this occurs during the effective growing season, April through August. The average maximum temperature is 34° C (93° F) in the summer and 15° C (59° F) in the winter. In parts of its range, black willow survives extremes of 46° to -50° C (115° to -58° F). Geographic distribution appears to be independent of temperature (4,7).

Soils and Topography

Black willow is most commonly associated with the soil order Entisols, particularly the Haplaquents and Fluvaquents derived from alluvium. Willow grows on almost any soil, but its extensive, shallow roots need an abundant and continuous supply of moisture during the growing season.

The species is most common on river margins and batture land, where it occupies (and usually dominates) the lower, wetter, and often less sandy sites. It is also common in swamps, sloughs, and swales, and on the banks of bayous, gullies, and drainage ditches, growing anywhere light and moisture conditions are favorable. It flourishes at, or slightly below, water level and is not appreciably damaged by flooding and silting (4).

Although prevalent along most of the Mississippi River, it produces the largest and best formed trees on very low, moist sites in the batture of the lower river.

Associated Forest Cover

Black willow is the predominant species in Black Willow (Society of American Foresters Type 95), a temporary, pioneer forest cover type with excellent growth characteristics (1). It is an associated species in the following cover types: River Birch-Sycamore (Type 61), Cottonwood (Type 63), Sycamore-Sweetgum-American Elm (Type 94), Baldcypress (Type 101), Baldcypress-Tupelo (Type 102), Water Tupelo-Swamp Tupelo (Type 103), and Cottonwood-Willow (Type 235).

Other noteworthy tree associates are red maple *(Acer rubrum),* boxelder *(A. negundo),* red mulberry *(Morus rubra),* and water locust *(Gleditsia aquatica).* In the areas where willow develops best, swamp-privet *(Forestiera acuminata),* buttonbush *(Cephalanthus occidentalis),* and water-elm *(Planera aquatica)* are the major noncommercial tree associates. Black willow often starts with sandbar *willow (Salix exigua),* which dies out before reaching more than small pulpwood size.

Life History

Reproduction and Early Growth

Flowering and Fruiting- Black willow is dioecious. No consistently reliable morphological characteristics are associated with the identification of the sexes. Male and female are indistinguishable except during flowering and seed development. In natural stands the sex ratio is probably 1 to 1, as has been determined for other dioecious tree species, including members of Salicaceae. Flowering begins in February in the southern portion of the range and extends through late June at the northern limits. The many-flowered catkins usually appear at the time of or immediately preceding leafing out. Pollination is mainly by insects; the flowers contain nectar. Pollen is also carried by winds. The seed ripens quickly; 45 to 60 days after pollination the small (3 to 6 mm or 0.12 to 0.24 in) light-brown capsules begin to split open and shed minute green seeds that have a hairy covering.

Seed Production and Dissemination- Seed production usually starts when the trees are about 10 years old, although viable seeds can be obtained at younger ages. Optimum seed-bearing age is from 25 to 75 years. The trees have good seed crops almost every year, with only a few interspersed poor crops and rare failures resulting from late freezes after flower buds have begun to open. Large volumes of seeds are produced; they average 5 million/kg (2.3 million/lb). When the seeds fall, the long silky hairs act as wings to carry the seeds very long distances. The seeds are widely disseminated by wind and water.

Seedling Development- Unless the willow seed is floating on water, it must reach the seedbed within 12 to 24 hours because viability is greatly reduced by only a few days of dry conditions. Germination is epigeal. Germinative capacity is usually high and no dormancy is known. Very moist, almost flooded exposed mineral soil is best for satisfactory germination and early development. Full light promotes vigorous growth once the seedling is well established. In a favorable environment, seedlings grow rapidly-often exceeding 1.2 in (4 ft) in height the first year (4).

Seedlings grow best when there is abundant moisture available throughout the growing season. In the Mississippi Valley, average heights are 9.8 in (32 ft) and average breast-high diameters are 6.6 cm (2.6 in) when the saplings are 5 years old (4).

Vegetative Reproduction- Root stocks of very young willow trees sprout prolifically. Propagation by cuttings is the usual method of artificial regeneration. With adequate moisture, good cuttings, and sufficient cultivation to reduce competition from other vegetation, first-year plantation survival can be close to 100 percent. Post-size willow cuttings have been rooted for use in flood projects to prevent gullies (4).

Sapling and Pole Stages to Maturity

Growth and Yield- In natural stands of the lower Mississippi Valley, 10-year-old trees average 15 in (49 ft) in height and 14 cm (5.6 in) in d.b.h. In 20 years the trees will average 22 in (72 ft) and 19 cm (7.5 in); in 40 years, 31 in (101 ft) and 49 cm (19.4 in). The tallest trees are 43 in (140 ft) high; the largest diameters about 122 cm (48 in) (4). Black willows in the North and those on poor sites in the South generally reach a maximum height of 9 to 18 in (30 to 60 ft) and 15 to 46 cm (6 to 18 in) in d.b.h. These seldom furnish a satisfactory saw log.

In well-stocked stands on the best alluvial soils, particularly along the Mississippi River, the tree prunes itself well and produces an acceptably straight trunk which is clear of limbs for an average of 12 in (40 ft). Open-grown willows and willows among small streams and in swamps are generally limby and of limited usefulness. Being a very weak tree, it is especially prone to breakage; almost all large trees have large broken limbs (4).

Unmanaged stands in the South have been estimated to yield 315 m^3/ha (50 cords/acre) at age 25 and 416 m^3 (66 cords) at age 35. The sawtimber volume (Scribner rule) in similar stands has been estimated at 396 m^3/ha (28,300 fbm/acre) at 35 years and 560 m^3/ha (40,000 fbm/acre) at 50 years. Good sites sustain about 30 m^2 of basal area per hectare (130 ft^2/acre) (4).

Black willow is short lived; the greatest age recorded for a sound tree is 70 years and for an unsound tree, 85 years. The average black willow is mature in 55 years (4).

Thinning increases yields and reduces mortality when carried out in relatively young (18 to 24 yr) stands. Growth is best when basal area is reduced by about one-half. Spacing between trees after thinning should average 21 times the mean stem diameter-25.4-cm (10-in) trees spaced 5.3 in (17.5 ft) apart. If the factor is 18 or less, the spacing is probably too dense; if 24 or greater, the site is probably not fully utilized (2).

Rooting Habit- Willow tends to be shallow rooted, especially on clay-capped alluvial soils. It is seldom found on soil types that undergo seasonal dehydration but is more often present on soils with higher water tables throughout the summer months. Floods may deposit more layers of alluvium in established stands. New roots often develop from adventitious buds formed within the previously exposed trunk. By this means, soil is captured and held to form additional land areas along river courses. Willows also sucker readily. Under certain conditions, an essentially pure willow stand of 1 or more hectares (2.5 acres) may consist of relatively few clones.

Reaction to Competition- Black willow is less tolerant of shade than any of its associates and may most accurately be classed as very intolerant. It usually grows in dense, even-aged stands, in which natural mortality is very heavy from sapling stage to maturity. Trees fail to assert dominance, so willow stands periodically stagnate. Stands not properly thinned may lose up to 50 percent of their volume in 5 to 8 years (4). Because of its intolerance and the absence of exposed mineral soil under existing stands, willow does not succeed itself naturally unless fresh sediment is deposited as the stand begins to open up. Thinning should remove the understory trees and must be light to prevent the heavy windthrow and stem breakage, which is common in very open stands. Light, early, and frequent thinning forestalls stagnation and mortality (2). An apparently satisfactory thinning prescription is to leave a stand of about 14.9 to 17.2 m^2/ha (65 to 75 ft^2/acre) of basal area. Heavy epicormic branching may result if weak trees are released.

Damaging Agents- Several insects attack live willow but few cause serious damage. The forest tent caterpillar *(Malacosoma disstria),* the gypsy moth *(Lymantria dispar),* the cottonwood leaf beetle *(Chrysomela scripta),* the willow sawfly *(Nematus ventralis),* and the imported willow leaf beetle *(Plagiodera versicolora)* sometimes partially, occasionally completely, defoliate willow trees, reducing growth but seldom killing. Stem borers, such as the cottonwood borer *(Plectrodera scalator)* attack willows and may kill by girdling the base. Twig borers, like the willow-branch borer *(Oberea ferruginea),* feed on the branches and cause deformities that may be undesirable in ornamentals.

Insects are frequently the vectors for disease organisms. Willow blight, the scab and black canker caused by *Pollaccia saliciperda,* is transmitted by borers. Members of the genus *Salix* are the only known hosts. *Phytophthora cactorum* causes bleeding canker, lesions on the lower trunk that discharge a dark-colored, often slimy liquid. Confined to the phloem and cambium area, it can result in death if the canker girdles the trunk. *Cytospora chrysosperma* causes canker in poplar and willow. Under forest conditions, cytospora canker is of little consequence but when trees become weakened by drought, competition, or neglect, losses can be heavy. In nursery beds, losses of up to 75 percent of cuttings have been reported. Leaf rust caused by *Melampsora* spp. *is* common on seedlings throughout the range of black willow. Mistletoes *(Phoradendron* spp.*)* damage and deform but seldom kill willows.

The yellow-bellied sapsucker feeds on sap from holes they peck through the bark; this early injury to the tree degrades the lumber sawn later.

Hot fires kill entire stands. Slow, light fires can seriously wound willow, allowing woodrotting fungi to enter. Once dead, willow deteriorates very rapidly. Top and branch rot account for 86 percent of the cull in willow.

Special Uses

The wood is light (specific gravity 0.34 to 0.41), usually straight grained, without characteristic odor or taste, weak in bending, compression, and moderately high in shock resistance. It works well with tools, glues well, and stains and finishes well but is very low in durability.

The wood was once used extensively for artificial limbs, because it is lightweight, doesn't splinter easily, and holds its shape well. It is still used for boxes and crates, furniture core stock, turned pieces, table tops, slack cooperage, wooden novelties, charcoal, and pulp.

Black willow was a favorite for soil stabilization projects in the early efforts at erosion control. The ease with which the species establishes itself from cuttings continues to make it an excellent tree for revetments.

Ancient pharmacopoeia recognized the bark and leaves of willow as useful in the treatment of rheumatism. In 1829, the natural glucoside *salicin* was isolated from willow. Today it is the basic ingredient of aspirin, although salicyclic acid is synthesized rather than extracted from its natural state.

Genetics

Population differences exist but the magnitude and distribution of the variation of specific characters awaits verification through analysis of provenance and progeny tests. Clonal differences in defoliation of black willow by the cottonwood leaf beetle were noted in experimental plots in Mississippi; feeding was also heavier on the male clones (6). In another study, black willows from two natural stands 160 km (100 mi) apart on the lower reaches of the Mississippi River had significantly different fiber lengths (8).

One or more races of black willow are recognized as varieties by some authorities (3,9). Western black *willow (Salix nigra* var. *vallicola* Dudley) of Southwestern United States and adjacent Mexico was renamed as a species, Goodding willow *(S. gooddingii* Ball). Controversy over whether this is a separate species or a varietal species of black willow still goes on. Two other varieties have been named: S. *nigra* var. *altissima* Sarg. of the Texas gulf coast and S. *nigra* var. *lindheimeri* Schneid. of central Texas.

Although the genus *Salix is* widely distributed and many species occupy sympatric ranges, natural hybrids apparently are not common (3). Putative hybrids are difficult to verify since the identity of one parent is often uncertain. The following willows hybridize with *Salix nigra: Salix alba (S. x hankensonii* Dode), *S. amygdaloides (S. x glatfelteri* Schneid.), S. *bonplandiana, S. caroliniana, S. lucida (S. x schneideri* Boivan), and *S. sericea.*

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Boxelder

Acer negundo L.

Other Common Names:

Ashleaf maple, boxelder maple, Manitoba maple, California boxelder, and western boxelder.

Brief Description:

Boxelder is one of the most widespread and best known of the maples. Its greatest value is in windbreak plantings throughout the Great Plains. The plant is easily recognizable by its green twigs that make a unique snapping sound when broken.

Habitat:

This species is distribute across North America, occurring naturally and as an introduced planting. Its dominant range is from Central Texas east to the Atlantic and north into the Northwest Territories of Canada. It also occurs in the mountains of Mexico. This is a highly versatile species. It is frequently used in plantings for windbreaks because of its drought tolerance; yet, it has also been able to survive inundation for as long as 30 days. It grows on a variety of soils and under different moisture regimes.

Life History:

Flowers appear anywhere from March to May starting at an age of 8 to 11 years. Seed ripening takes place from August to October and from then the seeds are dispersed by wind throughout the winter. Boxelder can establish itself under a variety of conditions. It is classified as being shade tolerant.

Boxelder and the Great Trinity Forest:

Boxelder has been noted in the forest inventory data.

Acer negundo L.

Boxelder

Aceraceae -- Maple family

Ronald P. Overton

Boxelder *(Acer negundo)* is one of the most widespread and best known of the maples. Its other common names include ashleaf maple, boxelder maple, Manitoba maple, California boxelder, and western boxelder. Best development of the species is in the bottom-land hardwood stands in the lower Ohio and Mississippi River valleys, although it is of limited commercial importance there. Its greatest value may be in shelterbelt and street plantings in the Great Plains and the West, where it is used because of its drought and cold tolerance.

Habitat

Native Range

Boxelder is the most widely distributed of all the North American maples, ranging from coast to coast and from Canada to Guatemala. In the United States, it is found from New York to central Florida; west to southern Texas; and northwest through the Plains region to eastern Alberta, central Saskatchewan and Manitoba; and east in southern Ontario. Further west, it is found along watercourses in the middle and southern Rocky Mountains and the Colorado Plateau. In California, boxelder grows in the Central Valley along the Sacramento and San Joaquin Rivers, in the interior valleys of the Coast Range, and on the western slopes of the San Bernardino Mountains. In Mexico and Guatemala, a variety is found in the mountains. Boxelder has been naturalized in New England, southern Quebec, New Brunswick, Nova Scotia, and Prince Edward Island; and in the Pacific Northwest in southeastern Washington and eastern Oregon.

- Native range of boxelder

Climate

Boxelder's wide range shows that it grows under a variety of climatic conditions. Its northward limits are in the extremely cold areas of the United States and Canada, and planted specimens have been reported as far north as Fort Simpson in the Canadian Northwest Territories *(2).* Although boxelder is most commonly found on moist soil, it is drought tolerant and is frequently used in windbreaks and around homesteads throughout the Plains *(21).* It has also been known to survive inundation for as long as 30 days *(15).*

Soils and Topography

Boxelder has been found on virtually all types of soils, from heavy clays to pure sands of the orders Entisols, Inceptisols, Alfisols, Ultisols, and Mollisols. It is most common on deep alluvial soils near streams, but it also appears on upland sites and occasionally on poor, dry sites *(11,13).* Through most of its range it grows in areas of little topographic relief, except for those features associated with stream valleys. In southern and central Arizona and New Mexico the species is found up to 2440 m (8,000 ft) *(23)* and in Mexico up to 2680 m (8,800 ft) *(18),* but even at these elevations it is confined to stream bottoms and wet draws.

Associated Forest Cover

Boxelder is most commonly found in association with bottomland hardwoods. It is an associate species in the following cover types (Society of American Foresters) *(8):*

Eastern

42 Bur Oak
61 River Birch-Sycamore
62 Silver Maple-American Elm
63 Cottonwood
87 Sweetgum-Yellow-poplar
93 Sugarberry-American Elm-Green Ash
94 Sycamore-Sweetgum-American Elm
95 Black willow
109 Hawthorn

Western

235 Cottonwood-Willow
236 Bur Oak

Other associates in the eastern United States include red maple *(Acer rubrum),* hackberry *(Celtis occidentalis),* slippery elm *(Ulmus rubra),* black walnut *(Juglans nigra),* basswood *(Tilia americana),* black cherry *(Prunus serotina),* blackgum *(Nyssa sylvatica),* pecan *(Carya illinoensis),* Nuttall, water, willow, and overcup oak *(Quercus nuttallii, Q. nigra, Q. phellos,* and *Q. lyrata),* persimmon *(Diospyros virginiana),* and baldcypress *(Taxodium distichum).* In the Plains region, boxelder appears with green ash *(Fraxinus pennsylvanica),* bur oak *(Quercus macrocarpa),* plains cottonwood *(Populus deltoides* var. *occidentalis),* willow *(Salix* spp.), and hackberry. In the Rocky Mountains and the Colorado Plateau, associates include several species of willow and cottonwood, netleaf hackberry *(Celtis reticulata),* and Arizona sycamore *(Platanus wrightii).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- Boxelder is dioecious with imperfect flowers, although perfect flowers that appeared to be functional have been reported *(12).* The staminate flowers are fascicled, the pistillate flowers are drooping racemes and are wind pollinated *(21,23).* Flowers appear with or before the leaves from March to May, depending on the geographic location *(13,28).*

Seed Production and Dissemination- Seed crops are produced each year on individual boxelder trees beginning at 8 to 11 years of age. The samaras are borne on drooping racemes and average 29 500/kg (13,400/lb) *(26).* Ripening takes place from August to October and seeds are wind distributed continuously until spring. This extended period provides a variety of germination sites, moisture, and temperature combinations and may account for the prolific reproduction from seed that is common for the species *(11).*

Seedling Development- Boxelder is capable of establishing itself on a variety of seedbeds. On southern Illinois bottom lands, it is among the most abundant species seeding in under cottonwood-willow and "soft" hardwood stands and invading old fields. On these sites, overstory density is apparently not a factor in early germination and survival, but seedlings begin to die off after 1 or 2 years unless openings are provided. The 1- and 2-year-old boxelder seedlings are also abundant in areas of ground vegetation ranging from light to heavy and in hardwood litter as much as 5 cm (2 in) deep *(16).*

Methods of collecting, handling, storing, and testing boxelder seeds have been described *(3,4,26).* Germination is epigeal.

Vegetative Reproduction- Reproduction by stump and root sprouts is common in boxelder from young, vigorous trees *(8,18).* Reports on propagation by cuttings indicate that best results are obtained from cuttings taken during the period of transition from softwood to greenwood and treated with an 8,000 ppm IBA-talc mixture (7). European nurserymen propagate some ornamental cultivars of boxelder using side grafts, whip and tongue grafts, or chip budding (7).

Sapling and Pole Stages to Maturity

Growth and Yield- Boxelder is a small to medium-size tree reaching 15 to 23 m (50 to 75 ft) in height and 60 to 120 cm (24 to 48 in) in d.b.h. The species is short-lived, attaining an average age of 60 years but rarely 100 years. Growth during the first 15 to 20 years is very rapid and may be as much as 2.5 cm (1 in) a year in d.b.h. *(11).* Poor sites bring a corresponding reduction in growth. In western Minnesota windbreaks, diameter growth averaged less than 5 mm (0.2 in) per year and height growth averaged less than 0.37 m (1.2 ft) per year during the first 13 years after planting *(25).* Boxelder typically forms a short, tapering bole and bushy, spreading crown.

Because boxelder usually appears in mixed stands and has limited commercial value, no information is available about its potential yield. Equations are available, however, to predict volume of boxelder stems, and green and dry weights of stems, limbs, and leaves *(24).* After trees reach 15 cm (5.9 in) in d.b.h., the proportion of aboveground green components is relatively constant, with bole wood, 63 percent; bole bark, 8 percent; limbs, 22 percent; and leaves, 7 percent.

Rooting Habit- Boxelder usually develops a shallow, fibrous root system. On deep soils it may form a short taproot with strong laterals *(11).*

Reaction to Competition- In the area of its best development, the lower Ohio and Mississippi River valleys, boxelder usually follows the pioneer species of cottonwood and willow in colonizing new ground in alluvial bottoms. In some instances it is a pioneer species in the invasion of old fields *(16).* Boxelder may persist into the oak-hickory type but then begins to be eliminated, probably due to shading *(18).* The species is generally classed as tolerant of shade, although less so than the other soft maples *(13).*

Damaging Agents- The chief rot-causing fungi attacking boxelder are *Fomitopsis fraxinus, Perrenniporia fraxinophilus, Fomes geotropus, Fomitopsis scutellata, Inonotus glomeratus,* and

Ustulina vulgaris. Root rots caused by *Rhizoctonia crocorum* and *Phymatotrichum omnivorum* have been identified on boxelder, but *Armillaria mellea* has not been reported on the species, although it is common on other maples *(14).*

Verticillium wilt *(Verticillium albo-atrum)* is the only notable killing disease of boxelder. The species is also susceptible to a stem canker caused by *Eutypella parasitica.*

A red stain in the wood of living trees caused by *Fusarium reticulatum* var. *negundinis* apparently is specific to boxelder. The stain regularly is associated with Cerambycid beetles and the galleries of other insects, but itself does no damage to the wood *(14).*

Insect damage to boxelder is relatively unimportant, but a number of leaf-feeding and scale insects and borers attack it *(1).* The boxelder bug, *Leptocoris trivittatus* is a common associate of boxelder throughout most of its range. The nymphs feed mainly on pistillate trees in leaves, fruits, and soft seeds. Although the trees are not greatly damaged, the insect's habits of invading houses in large numbers with the onset of cold weather makes it an important pest. The boxelder aphid, *Periphyllus negundinis,* and the boxelder gall midge, *Contarinia negundifolia,* are also common. Other leaf feeders include the Asiatic garden beetle, *Maladera castanea,* the greenstriped mapleworm, *Anisota rubicunda,* a leaf-roller, *Archips negundana,* and the boxelder leafroller, *Caloptilia negundella.* The scale insects include cottony maple scale, *Pulvinaria innumerabilis,* and terrapin scale, *Mesolecanium nigrofasciatum.* Borers include the boxelder twig borer, *Proteoteras willingana,* and the flatheaded apple tree borer, *Chrysobothris femorata.*

Ice and wind damage is common in older trees *(11)* and boxelder is quite susceptible to fire and mechanical damage due to its thin bark.

Boxelder is highly sensitive to 2,4-D. In the northern Great Plains, drift from agricultural spraying operations produced distorted, blighted foliage up to 16 km (10 mi) from the source *(20).*

Special Uses

Because of its drought and cold resistance, boxelder has been widely planted in the Great Plains and at lower elevations in the West as a street tree and in windbreaks. Although the species is not an ideal ornamental, being "trashy," poorly formed, and short-lived, numerous ornamental cultivars of boxelder are propagated in Europe (7). Its fibrous root system and prolific seeding habit have led to its use in erosion control in some parts of the world *(32).*

Seeds and other portions of boxelder are utilized by many species of birds and mammals as food *(19).* Because of the species delayed seeding habit, some seeds are available throughout most of the winter. The sap of boxelder has been used to a limited extent for syrup (9).

Genetics

Population differences in boxelder have been noted in response to photoperiod *(6,28),* in seed germination and stratification requirements *(29),* seed weight *(30),* tracheid length *(31),* frost tolerance (5), and in chlorophyll levels *(10).*

Some 8 to 14 varieties and forms have been described for boxelder, several relating to variegated patterns of the foliage or some other morphological character *(2,17,21,23,28).* At least two varieties appear to be confined to a definite geographic range: var. *arizonicum* Sarg. to central and southern Arizona and New Mexico and var. *californicum* (Torr. and Gray) Sarg. to the Central Valley, Coast Range, and San Bernardino Mountains of California (23).

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Bur Oak

Quercus macrocarpa Michx.

Other Common Names:

Blue oak, mossy-overcup oak, cow oak, and scrub oak.

Brief Description:

One of the more hardy and versatile oaks that is widely distributed geographically occupying a variety of sites and valuable for many uses. It has the largest acorn of all the native oaks and is drought tolerant.

Habitat:

Bur oak is predominantly a bottomland species throughout most of its range, which is east to central Maine, west to the Black Hills of South Dakota, north through mid Canada and south to the Corpus Christi, Texas area. Having adapted to such a wide geographical area, bur oak is a very hardy species. It is found on sites less prone to periods of inundation. Bur oak is more tolerant to urban pollution than most oaks. It is an early successional species on most sites.

Life History:

Bur oak is intermediate in tolerance to shade. A member of the white oak group of oaks, the fruit or acorn of the bur oak matures and drops the same year it is formed making it of special value to wildlife. Germination occurs shortly after seedfall which occurs in late summer to early fall. Seed is primarily disseminated by gravity, squirrels, and to a limited extent by water. Optimum seed bearing age is 75 to 150 years of age, but production can range from 35 to 400 years. When exposed to prolonged flooding of about two weeks during the growing season seedling mortality can be near 50%. Seedlings focus much of their energy on early root growth. Overall bur oak is a slow growing tree that can reach ages of 300 years.

Bur Oak and the Great Trinity Forest:

The Great Trinity Forest's location at the northern reaches of the Trinity River inhabits a unique ecotone for bur oak, where the great bottomland hardwood forests of the coastal plain encountered the arid Great Plains of the Midwest. The result probably is a bur oak of unique hardiness that has allowed it to maintain its foothold in the highly disturbed area of the Great Trinity Forest. Here bur oak will be a highly desirable species due to its resilient nature and value to wildlife. It will most likely be limited to more coarse textured soils on bottomland terraces and upland areas.

Quercus macrocarpa Michx.

Bur Oak

Fagaceae -- Beech family

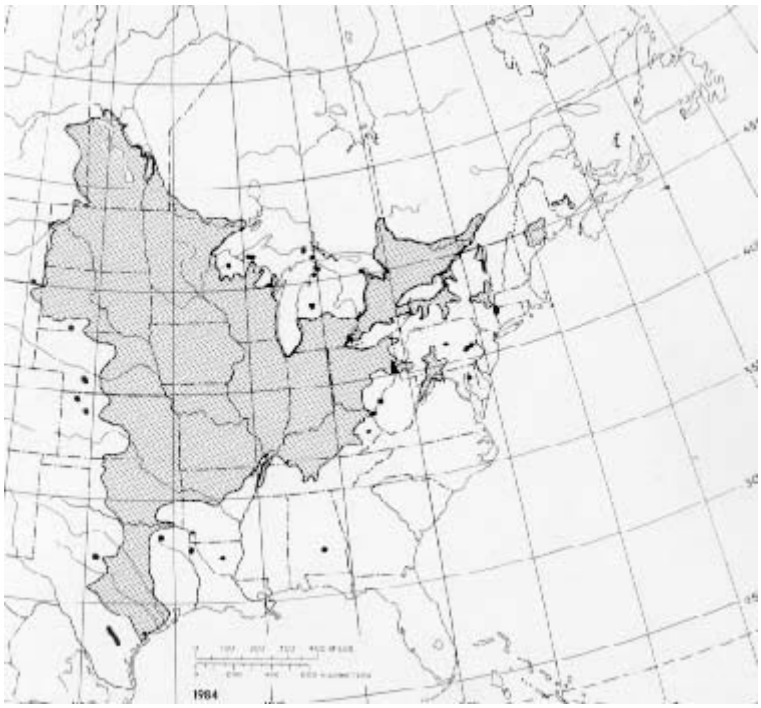
Paul S. Johnson

Bur oak *(Quercus macrocarpa)*, also known as blue oak, mossy-overcup oak, mossy-overcup oak, and scrub oak, has the largest acorns of all native oaks and is very drought resistant. It grows slowly on dry uplands and sandy plains but is also found on fertile limestone soils and moist bottomlands in mixture with other hardwoods. In the west, it is a pioneer tree invading prairie grasslands, and it is planted frequently in shelterbelts. The acorns become an important source of food to wildlife. The wood is commercially valuable and marketed as white oak. The comparative ease with which bur oak can be grown makes it a fine tree for streets or lawns.

Habitat

Native Range

Bur oak is widely distributed throughout the Eastern United States and the Great Plains. It ranges from southern New Brunswick, central Maine, Vermont, and southern Quebec, west through Ontario to southern Manitoba, and extreme southeastern Saskatchewan, south to North Dakota, extreme southeastern Montana, northeastern Wyoming, South Dakota, central Nebraska, western Oklahoma, and southeastern Texas, then northeast to Arkansas, central Tennessee, West Virginia, Maryland, Pennsylvania, and Connecticut. It also grows in Louisiana and Alabama.



-The native range of bur oak.

Climate

Bur oak is one of the most drought resistant of the North American oaks. In the northwestern part of its range, the average annual precipitation is as low as 380 mm (15 in). Here, the average minimum temperature is 4° C (40° F), and the average growing season lasts only 100 days. To the south bur oak grows in areas having an average precipitation exceeding 1270 mm (50 in) per year, minimum temperatures of -7° C (20° F), and a growing season of 260 days. The best development of the bur oak occurs in southern Illinois and Indiana, where the average annual precipitation is about 1140 mm (45 in), minimum temperature is -29° C (-20° F), and the growing season is 190 days (5).

Soils and Topography

Bur oak on uplands is often associated with calcareous soils. In the "driftless" area of southwestern Wisconsin, it is commonly found on limestone ridges; in Kentucky, it is more prevalent on limestone soils than on soils derived from shales and sandstone (5). In western Iowa, it can be found as a dominant on soils of either limestone or sandstone origin. Throughout much of the prairie region of the Midwest, bur oak is found on droughty sandy plains, black prairie loams, and on loamy slopes of south and west exposure. Toward the western edge of its range, such as in eastern Kansas, it is more abundant on the more moist north-facing slopes than on southfacing slopes (2). Bur oak often dominates severe sites with thin soils, heavy claypan soils, gravelly ridges, and coarse-textured loessial hills. The predominant soil orders on which bur oak is found include Alfisols in the central and southern parts of its range, and Mollisols and Spodosols in the western and northern parts of its range, respectively.

Bur oak is also an important bottom-land species throughout much of its range. In the Central States Region and southward, it is found on moist flats and on hummocky bottoms. Northward, in southern Michigan, it has been found in high densities on slightly elevated ridges within wet bottom-land forests occupying old glacial lake beds and drainage ways (20).

Bur oak frequently forms a fringe between the prairie and upland forest in northern Illinois and eastern Iowa, notably at the outer edges of "breaks" and bluffs along streams and around limestone outcrops. It is a valuable timber species on favorable bottom-land sites within this region.

Within the Great Plains Region, it is frequently found in stream bottoms and stream terraces. In North Dakota, bur oak is a major component of the flood-plain forests of the Missouri River (11). Here it may predominate in old stands on high terraces near the edge of the flood plain. It is absent in low terraces near the center of the flood plain. Along adjacent draws and upper slopes, it becomes the first tree established along prairie edges. Bluffs along the Missouri River and its tributaries in eastern Nebraska are frequently covered with bur oaks that range in size from small trees near the base of bluffs to shrublike growth near the top.

In the Black Hills of western South Dakota and the Bear Lodge Mountains of northeastern Wyoming, bur oak grows at low elevations between the ponderosa pine forest and the grasslands (21). Here, it ranges in size from a shrub under a pine canopy at higher elevations to a tree up to 21 m (69 ft) tall along stream bottoms at lower elevations.

Associated Forest Cover

Because of its tolerance to a wide range of soil and moisture conditions, bur oak is an associate of many other trees. In pure or nearly pure stands, it forms the forest cover type Bur Oak (Society of American Foresters Type 42, eastern forests; Type 236, western forests) (6). It is also an important associate in six other types: Northern Pin Oak (Type 14), Aspen (Type 16), Black Ash-American Elm-Red Maple (Type 39), White Oak (Type 53), Pin Oak-Sweetgum (Type 65), and Hawthorn (Type 109).

In southern bottom-land cover types such as Pin Oak-Sweetgum, important associates of bur oak are pin oak *(Quercus palustris),* sweetgum *(Liquidambar styraciflua),* red maple *(Acer rubrum),* American elm *(Ulmus americana),* blackgum *(Nyssa sylvatica),* swamp white oak *(Quercus bicolor), willow* oak *(Q. phellos),* overcup oak *(Q. lyrata),* green ash *(Fraxinus pennsylvanica),* Nuttall oak *(Quercus nuttallii),* swamp chestnut oak *(Q. michauxii),* white oak *(Q. alba),* shellbark hickory *(Carya laciniosa),* and shagbark hickory *(C. ovata).* Associated shrubs and vines on these sites include possumhaw *(Ilex decidua),* poison-ivy *(Toxicodendron radicans),* and trumpetcreeper *(Campsis radicans).*

In more northerly bottom-land types, such as Black Ash-American Elm-Red Maple, important associates of bur oak include black ash *(Fraxinus nigra),* American elm, red maple, American basswood *(Tilia americana),* silver maple *(Acer saccharinum),* swamp white oak, sycamore *(Platanus occidentalis),* and eastern cottonwood *(Populus deltoides).* Common shrub associates

include speckled alder *(Alnus rugosa),* vacciniums *(Vaccinium* spp.), red-osier dogwood *(Cornus stolonifera),* and poison-sumac *(Toxicodendron vernix).*

Important associates of bur oak in the cover type White Oak include northern red oak *(Quercus rubra),* black oak *(Q. uelutina),* chestnut oak *(Q. prinus),* scarlet oak *(Q. coccinea),* and post oak *(Q. stellata),* mockernut hickory *(Carya tomentosa),* pignut hickory *(C. glabra),* and bitternut hickory *(C. cordiformis).* In this type, associated shrubs and vines include vacciniums, sumacs *(Rhus spp.),* witch-hazel *(Hamamelis uirginiana),* wild grape *(Vitis* spp.), Virginia creeper *(Parthenocissus quinquefolia),* and poison-ivy.

On the drier sites in the northwestern part of its range, bur oak grows in mixed stands of American elm, green ash, bitternut hickory, and white oak, and sometimes as nearly pure oak stands. In North Dakota, for example, the cover type Bur Oak accounts for about 19 percent of the forest land. Bur oak is also the major tree of oak savannas ("oak openings") of the prairie-forest transition zone in Wisconsin, Minnesota, Iowa, and Illinois (3,5,8,12).

Shrubs are especially abundant in the bur oak forest of the plains region. Predominant among them are American hazelnut *(Corylus americana),* coralberry *(Symphoricarpos orbiculatus),* and smooth sumac *(Rhus glabra);* common associates on the prairie borders are hawthorn *(Crataegus spp.),* wolfberry *(Symphoricarpos occidentalis),* and prairie crabapple *(Malus ioensis).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- Bur oak is monoecious; male and female flowers in separate catkins are home on the current year's branchlets. It flowers shortly after the leaves appear, from about the first of April in the southern part of its range to about mid-June in the north (5). Pollen from one tree appears to germinate better on the stigmas of another, favoring cross pollination.

Seed Production and Dissemination- The acorns ripen within the year and drop from the tree as early as August or as late as November. Germination usually occurs soon after seedfall, but acorns of some northern trees may remain dormant through winter and germinate the following spring (5).

Bur oaks bear seed up to an age of 400 years, older than reported for any other American oak. The minimum seed-bearing age is about 35 years, and the optimum is 75 to 150 years (5,16). Good seed crops occur every 2 to 3 years, with no crops or light crops in intervening years. The acorns are disseminated by gravity, by squirrels, and to a limited extent by water.

Seedling Development- Various conditions influence seedling development (5). In Iowa uplands, germination of acorns and early development of bur oak were best where litter had been removed. Germination is hypogeal (16). When covered by litter, acorns were most susceptible to pilferage by rodents, and the newly developed seedlings were more liable to fungus and insect attack. In a Nebraska study, about 30 percent of acorns germinated within 1 month after seedfall, and the new seedlings were less susceptible to freezing than those of white oak. Under controlled

environment, bur oak seedlings grew fastest at a daytime temperature of 310 C (880 F) and a nighttime temperature of 19° C (66° F) (23). The relatively high daytime temperature and a high (70 percent) relative humidity were necessary to obtain more than one flush of shoot growth during the first growing season. When grown under continuous light, bur oak also produced a greater number of shoot flushes than under normal light (19).

As a bottom-land species, bur oak is relatively intolerant of flooding, and a mesic, fertile environment is required for seedling establishment (11,14). In open bottom lands, reproduction of bur oak may be prolific, but first-year mortality may be 40 to 50 percent when seedling submersion is 2 weeks or longer during the growing season. For shorter periods of growing-season submersion, seedling mortality is only about 10 to 20 percent. Although bur oak seedlings can endure flooding for up to 30 consecutive days during the growing season, root growth is greatly reduced, thus reducing drought tolerance after flood waters have receded (22).

Bur oak seedlings have also been found to be efficient users of water, based on studies of the ratio of transpiration resistance to C02 uptake resistance (25). In this characteristic, it was slightly exceeded by black oak but was more efficient than northern red oak, white oak, and sugar maple for leaf temperatures up to 35° C (95° F). The large number and area of stomata per unit leaf area in bur oak are associated with potentially high transpiration rates (4).

Root growth of juvenile bur oaks is rapid, and the taproot penetrates deeply into the soil before the leaves unfold. At the end of the first growing season, bur oak roots have been found at depths of 1.37 m (4.5 ft), with a total lateral spread of 76 cm (30 in). This strong early root development, along with high water-use efficiency, may explain why bur oak can pioneer on droughty sites and can successfully establish itself in competition with prairie shrubs and grasses (5).

Vegetative Reproduction- Vigorous sprout growth follows the burning or cutting of pole-size or smaller bur oaks; but except for seedling sprouts, the quality and form of sprout stems are poor. Some sprout growth is also produced by larger trees, but the effect of size and age of parent tree on sprouting vigor and quality has not been determined (5). Five years after prescribed burning in Minnesota, 60 percent of bur oaks 10 to 41 cm (4 to 16 in) d.b.h. had produced sprouts. Sprouts occurred in clumps averaging 21 live stems and the three tallest live stems per clump averaged 2.5 m (8.2 ft) tall (18).

Sapling and Pole Stages to Maturity

Growth and Yield- Bur oak is a slow-growing tree (5). In 12- to 16-year-old plantations on Iowa upland sites, average annual height growth ranged from 0.09 to 0.52 m (0.3 to 1.7 ft) and diameter growth from less than 2.5 to 6.4 mm (0.1 to 0.25 in). In the shelterbelts of the northern Great Plains, an annual height growth of about 0.3 m (1 ft) was reported for trees kept under clean cultivation.

In Iowa, 10-year d.b.h. growth of bur oak averaged 3.0 cm (1.2 in) for 10- to 20-cm (4- to 8-in) trees, 3.6 cm (1.4 in) for 25- to 36-cm (10- to 14-in) trees, 4.6 cm (1.8 in) for 41- to 51-cm (16- to 20-in) trees, and 5.6 cm (2.2 in) for trees 56 cm (22 in) and larger. More rapid growth has been

reported in Kansas where trees 35 to 40 years old averaged 2.5 cm (I in) growth in d.b.h. in 3.8 years. Approximately the same growth rate has been observed in the northern Mississippi Delta region.

Bur oak is said to have reached a height of 52 m (170 ft) and a d.b.h. of 213 cm (84 in) in the lower Ohio Valley. On the better sites, mature trees generally grow 24 to 30 in (80 to 100 ft) tall, 91 to 122 cm (36 to 48 in) in d.b.h., and live 200 to 300 years. Characteristically, they have a massive, clear trunk and a broad, open crown of stout branches.

In the oak openings of southern Wisconsin and in the prairie border areas to the south and west, bur oak often is found in nearly pure stands (3,5). The trees are widely spaced, short-boled, and often uniform in size. Trees in a 50- to 65-year-old stand in eastern Nebraska were 9 to 12 in (30 to 40 ft) tall and spaced at intervals of 3 to 12 in (10 to 40 ft). Bur oak grows 21 in (70 ft) tall on the fertile soils in this region, but on dry, limestone ridges, the trees may be less than 7.6 in (25 ft) tall at 150 years of age. In Minnesota, bur oak is short lived on the poorer sites.

Timber volumes in the bur oak type of Iowa were estimated to be 15.4 m^3/ha (1,100 fbm/acre), three-fourths of which were bur oak.

Rooting Habit- In the sapling stage, taproot development continues to be rapid, with abundant lateral growth as well. The taproots of 8-year-old saplings in upland clay soils of Missouri were more than 4.3 in (14 ft) long, and primary laterals extended up to 3.4 in (11 ft) (5). In prairie areas, roots of bur oak and hackberry have been found at depths of 3 to 6 in (10 to 20 ft); and a 43-year-old bur oak tree had a lateral spread of 12.5 in (41 ft) although the tree was only 6 in (20 ft) tall. A study of a tree 36 cm (14 in) in d.b.h. revealed that the weight of the roots equaled that of the tops, and root volume was only about 10 percent less than top volume.

Reaction to Competition- Bur oak is classed as intermediate in tolerance to shade (5). Some consider it more tolerant than northern red and white oaks; but on the prairie margins, bur oak stands are often invaded by black oak, white oak, and bitternut hickory. Bur oak reproduction in old white pine-bur oak stands in Minnesota reaches only sapling size before dying from suppression, and these stands are being replaced by maple-basswood communities.

In the wet bottom lands of northern Ohio, bur oak is a secondary species in the cover type Black Ash-American Elm-Red Maple, together with shellbark hickory, green ash, white ash *(Fraxinus americana),* pin oak, and swamp white oak. On the better drained bottom lands, bur oak may be successfully replaced by more tolerant species such as sugar maple *(Acer saccharum),* American basswood, and American beech *(Fagus grandifolia).*

On the prairie edges, bur oak is a pioneer tree, commonly succeeded by northern pin oak *(Quercus ellipsoidalis),* black oak, white oak, and bitternut hickory. The climax trees on these sites are sugar maple and basswood or sugar maple and beech. Bur oak may be a climax tree with hickory on extremely dry southern aspects and on thin, stony soils. In general, it is a species well adapted to sites ranging from droughty to moderately wet. But, on any given site, it is largely restricted to plant communities in early successional stages (17).

Damaging Agents- Bur oak is attacked by several insects including the following defoliators: redhumped oakworm *(Symmerista canicosta)* in the Northeast, *S. albifrons* in the South, oak webworm *(Archips fervidana),* oak skeletonizer *(Bucculatrix recognita),* a leaf miner *(Profenusa lucifex),* variable oakleaf caterpillar *(Heterocampa manteo),* June beetles *(Phyllophaga spp.),* and oak lacebug *(Corythucha arcuata)* (1,5). The latter species may heavily defoliate bur oaks in shelterbelt plantings, especially during dry weather. Attacks from bur oak kermes *(Kermes pubescens)* may distort leaves and kill twigs of bur oak.

Oak wilt *(Ceratocystis fagacearum) is* a less serious problem in bur oak than in members of the red oak group (5,10). Although spread of the disease from infected bur oak to adjacent oaks is infrequent, the disease sometimes spreads through root grafts, and entire groves have been killed by the gradual expansion of the disease from one center of infection.

Bur oak is susceptible to attack by the cotton root rot *(Phymatotrichum omnivorum)* and Strumella canker *(Strumella coryneoidea).* Half of the trees in a 20-year-old plantation in Pennsylvania became infected with the latter disease; and nearly a fourth of these died. Other fungi that have been isolated from diseased parts of bur oak include Dothiorella canker and dieback *(Dothiorella quercina),* Phoma canker *(Phoma aposphaerioides),* Coniothyrium dieback *(Coniothyrium truncisedum),* and shoestring root rot *(Armillaria mellea).*

Large bur oak trees are resistant to injury by fire and this, together with resistance to drought and disease, probably account for maintenance of the bur oak "openings" over much of southern Wisconsin at the time of homesteading. The presence of large bur oaks in the sugar maple-basswood community of the Big Woods of Minnesota has been attributed to the tree's thick fire-resistant bark, which enabled it to survive repeated burning and freed it from competition by less fire-resistant species (5).

In the northwest part of its range, bur oak is considered a drought-resistant tree. During severe drought conditions in Iowa, unpastured bur oak stands on dry, exposed slopes were not injured; however, in pastured woods, drought injury occurred, even on protected sites. This was attributed to reduced aeration (caused by trampling) that had limited the growth and efficiency of absorbing roots.

Bur oak is not resistant to flooding, and in two areas where it was permanently flooded it died within 3 years. The species tolerates urban pollution better than most oaks.

Special Uses

Acorns of bur oak make up much of the food of red squirrels and are also eaten by wood ducks, white-tailed deer, New England cottontails, mice, thirteen-lined ground squirrels, and other rodents (5).

On coal-mine spoils with a pH of 5.6 in eastern Kansas, planted bur oak was one of the better performers of several tree species tested (7). After 22 years, it attained a mean height of 8.5 m (28 ft) and a d.b.h. of 12.2 cm (4.8 in). The species is also widely planted in shelterbelts because of its drought tolerance.

Genetics

Population Differences

A northern form of bur oak, *Quercus macrocarpa* var. *olivaeformis*, has been recognized (5). Acorns of this form often germinate in the spring following seedfall rather than soon after falling, and germination is improved by stratification. Acorn size is about half that of the southern form, and the cup is much thinner and smaller. Cleaned seeds average 595/kg (270/lb) compared to only 165/kg (75/lb) for the typical species (16). Where the two forms are found in the same locality, as in eastern Nebraska, the typical bur oak is more common on the moister sites (5,13). Varietal crosses occur in such areas. Photoperiodic ecotypes of bur oak have also been recognized. In one study, shoot growth of a more northerly seed source was about two-thirds of that of a more southerly seed source under short days; under long days, shoot growth of both sources was nearly equal (24).

Hybrids

Bur oak has been known to hybridize with nine species as follows: white oak, *Q. x bebbiana* Schneid.; swamp white oak, *Q. x schuettei* Trel.*;* Gambel oak *(Q. gambellii);* overcup oak, *Q. x megaleia* Laughlin; swamp chestnut oak, *Q. x byarsii* Sudw.; chinkapin oak *(Q. muehlenbergii), Q. x deamii* Trel.; English oak *(Q. robur);* post oak, *Q. x guadalupensis* Sarg.; and live oak *(Q. uirginiana).* The cross with white oak, *Q. x bebbiana,* Bebb oak, is one of the most frequent of the white oak hybrids and is widespread within the overlapping ranges of the two species (9). The hybrid formed with Gambel oak, a western species, is somewhat unusual in that the two species do not now have overlapping ranges (15).

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Cedar Elm

Ulmus crassifolia Nutt.

Other Common Names:

Basket elm, red elm, southern rock elm, or olmo.

Brief Description:

Cedar elm has a much more limited range than its cousin American elm. It is less susceptible to Dutch elm disease. An identifiable trait of cedar elm is its small leaves, the smallest leaves of any native elm, and its place as one of only two that flower in the fall. The national champion at one time was in Limestone County, Texas where it was 94 feet tall and 36 inches in diameter. The current big tree is in Kendall County, Texas where it is 73 feet tall and 41 inches in diameter. It can occasionally be found with small corky wings like its relative, winged elm.

Habitat:

The natural range of cedar elm is predominantly in Texas with parts of its range in southern Arkansas, northern Louisiana, and western Mississippi. The range also extends into Mexico and there is an isolated population in Florida. The tree thrives in deep rich soils of the Mississippi Delta and along streams throughout its range. It can become a large tree along the Colorado and Brazos Rivers, and takes on a small scrubby form on dry limestone hills of Texas and Oklahoma. It also grows on dense, poorly drained clay soils of central Texas.

Life History:

Cedar elm flowers from August to September and fruit ripens from September to October. Seed dissemination occurs the following spring by wind. Germination occurs the same spring. There is a limited amount of research available on cedar elm. It is indicated that cedar elm is intermediate in shade tolerance.

Cedar elm and the Great Trinity Forest:

Cedar elm undoubtedly occurs with American elm within the forest. It is often difficult to distinguish from other elms. Its hardiness makes it difficult to discern what areas it occurs at locally but, it is probably found on drier areas than American elm. It is the least susceptible to Dutch elm disease.

Ulmus crassifolia Nutt.

Cedar Elm

Ulmaceae -- Elm family

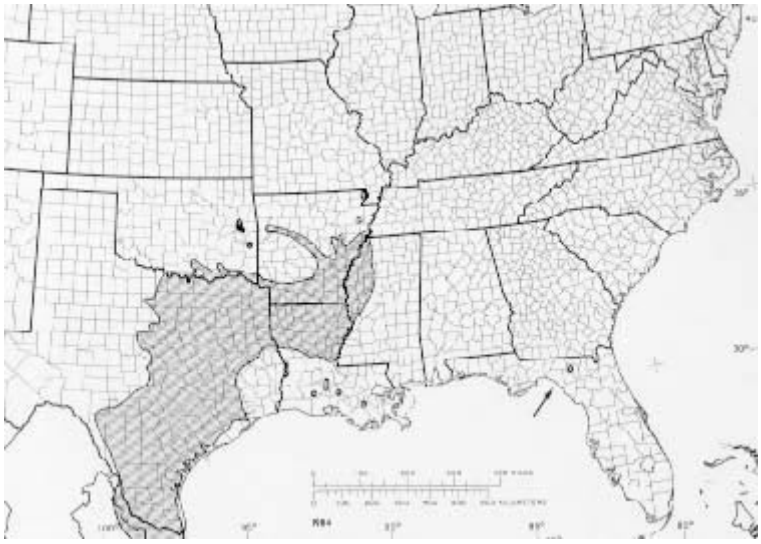
John J. Stransky and Sylvia M. Bierschenk

Cedar elm *(Ulmus crassifolia)* grows rapidly to medium or large size in the Southern United States and northeastern Mexico, where it may sometimes be called basket elm, red elm, southern rock elm, or olmo (Spanish). It usually is found on moist, limestone soils along water courses with other bottomland trees, but it also grows on dry limestone hills. The wood is very strong; the lumber is mixed with other southern elm species and sold as rock elm. Its seeds are eaten by several species of birds. Within its range, cedar elm is often planted as an ornamental shade tree. It has the smallest leaves of any native elm and is one of two that flower in the fall.

Habitat

Native Range

Cedar elm can be found from extreme southwestern Tennessee, Arkansas, and eastern and southern Oklahoma; south to central and southern Texas into the adjacent northeastern Mexican states of Nuevo Leon and Tamaulipas (15); and east to Louisiana and western Mississippi. There is an isolated population in northern Florida (5,10).



-The native range of Cedar elm.

Climate

Cedar elm grows mainly in the Gulf Coastal Plain, which has relatively mild temperatures throughout the year. The average January temperature in the region is 8° C (46° F). Oklahoma and Arkansas average 5° C (41° F), while temperatures sometimes reach 17° C (63° F) in southernmost Texas. The average July temperature is 28° C (82° F) (17).

The five main States in which cedar elm is found have an average annual rainfall of 1140 mm (45 in). South Texas averages 460 mm (18 in), while eastern and central Louisiana receive an average annual rainfall of 1470 mm (58 in). The average number of days without a killing frost is 236. All of the States have a minimum growing season of 220 days.

Solis and Topography

Cedar elm thrives in deep rich soils (Inceptisols) in the Mississippi Delta and along streams in Arkansas, Louisiana, Oklahoma, and Texas, where it becomes a large tree along the Colorado and Brazos Rivers (2,15). Cedar elm grows on dense, poorly drained clay soils (Vertisols) in central Texas. It also can be found on dry limestone hills in Texas and Oklahoma, but the tree is small and scrubby in this environment.

Associated Forest Cover

On dry limestone hills of the central Texas "cedar brakes," cedar elm can be found with Ashe juniper *(Juniperus ashei),* live oak *(Quercus virginiana),* hackberry *(Celtis occidentalis),* Shumard oak *(Quercus shumardii),* Mohr oak *(Q. mohriana),* and Durand oak *(Q. durandii).* On the floodplains of major rivers, cedar elm is a minor component of the following forest cover types (6): Sweetgum-Willow Oak (Society of American Foresters Type 92), Sugarberry-American Elm-Green Ash (Type 93) and Overcup Oak-Water Hickory (Type 96).

In addition, a variant of Cedar Elm-Water Oak-Willow Oak (Type 92) is found on low, indistinct or flattened first bottom ridges with poorly drained soils. The variant is also of minor importance on some impervious terrace sites, amounting to high shallow flats.

Other common associates are pecan *(Carya illinoensis),* eastern cottonwood *(Populus deltoides),* red maple *(Acer rubrum),* waterlocust *(Gleditsia aquatica),* honeylocust *(G. triacanthos),* persimmon *(Diospyros uirginiana),* laurel oak *(Quercus laurifolia),* water oak *(Q. nigra),* winged elm *(Ulmus alata),* blackgum *(Nyssa sylvatica),* boxelder *(Acer negundo),* and (rarely) baldcypress *(Taxodium distichum).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- Cedar elm flowers from August to September and fruit ripens from September to October (19). However, flowering dates have been reported as early as July and fruiting as late as November (20). When flowers appear in August, fruit ripens in September, and then a second flowering and fruiting may occur in October and November, respectively (15).

Flowers are in fascicles of three to five on slender, pubescent pedicels 8 to 13 mm (0.31 to 0.51 in) long, located in the axils of the leaves. The hairy, red-to-green calyx is divided beyond the middle into four to eight equal and acute lobes, and the stamen is composed of five or six slender filaments and reddish purple anthers. Flowers are perfect (19).

Seed Production and Dissemination- The green fruit, or samara, is oblong and flattened, deeply notched at the apex, 6 to 13 mm (0.25 to 0.5 in) long, and pubescent, especially along the margins. The seed within is unsymmetrical, acute, and covered with a dark chestnut-brown coat. Cleaned seeds average 147,700/kg (67,000/lb). Dissemination is by wind and germination occurs the following spring.

Seedling Development- Air-dried seeds may be stored at 4° C (39° F) for at least I year. Stratification at 5° C (41° F) for 60 to 90 days before sowing can improve germination. The seeds should be covered with soil about 5 mm (0.2 in) deep. Germination is epigeal. Approximately 5 to 12 percent of the viable seed produce plantable stock (19). The seedlings can usually be outplanted after one growing season in the nursery.

Vegetative Reproduction- Cedar elm is commonly grown from seed. Though no reference is made to species in the literature, cedar elm can probably be propagated vegetatively like other elms by layering, air-layering, and from greenwood cuttings.

Sapling and Pole Stages to Maturity

Growth and Yield- Cedar elm is classified as a medium to large tree. Reports of height at maturity range from 6 m (20 ft) in the Edwards Plateau of Texas to near 30 m (98 ft) (2,4). The national champion big tree from Limestone County, TX, is 28.7 m (94 ft) tall. Mature trees average approximate 90 cm (36 in) in d.b.h.

Cedar elm has an unusual cross-section that may be triangular, almost square, or deeply irregularly scalloped. The annual growth rings are very indistinct. Thus there may be considerable error in estimating the average growth rate (3). In the early 1950's the Southern Forest Experiment Station estimated a volume of about 5.7 million m^3 (1 billion fbm) in the total United States area (4).

Rooting Habit- The tree is relatively shallow rooted in early life. It is resistant to root pruning in the nursery. In later life the trees are moderately tolerant of soil compaction or disturbance of the root systems (21).

Reaction to Competition- The literature contains no information on tolerance of cedar elm to vegetative competition or tolerance to shade, drought, or other physiological stresses. Observation of seedlings and of crown class, however, strongly suggests that cedar elm should be classed as intermediate in tolerance to shade.

Damaging Agents- Cedar elm is susceptible to the Dutch elm disease caused by the fungus *Ceratocystis ulmi*, which is carried chiefly by the native elm bark beetle *(Hylurgopinus rufipes)* and also by the smaller European elm bark beetle (Scolytus multistriatus). The disease does not

seem to be as harmful to cedar elm as to the American elm *(Ulmus americana)*. The offspring of *U. crassifolia* x *parvifolia* crosses indicated an apparent increase in disease resistance (14).

A vascular wilt easily confused with Dutch elm disease and harmful to cedar elm is caused by Ceratocystis ulmi. Again, cedar elm is not as susceptible to the disease as is American elm. In Mississippi, only 8.5 percent of 25 large trees 18 cm (7 in) in d.b.h. and larger and 1 percent of 132 small trees 15 cm (6 in) in d.b.h. and smaller were affected by the disease, as opposed to 37 percent of the large and 5.7 percent of the small American elms (8).

Cedar elm also has been found fairly resistant to Texas root rot *(Phymatotrichum omnivorum)* (9), but only slightly resistant or nonresistant to heartwood decay caused by several species of Fomes and Polyporus (18). The symptoms of elm phloem necrosis caused by the mycoplasmalike organism Morsus ulmi have been suppressed in American and cedar elm by injections of tetracycline antibiotic (7).

In Texas, Spanish moss *(Tilliandsia usneoides)* frequently drapes the branches of cedar elm; it weakens the branches and may kill the tree (15).

The elm leaf beetle *(Pyrrhalta luteola)* is hosted by all species of elm throughout the United States, but it causes only occasional, slight damage to cedar elm (1).

Special Uses

The seeds are part of the diet of several bird species. In south Texas, 10 percent of the diet of the plain chachalaca consists of cedar elm seeds (11). Wild turkey in Texas use elm seeds and buds for 5 to 10 percent of their diet (12). In addition, squirrels eat the buds.

Cedar elm is frequently planted as an ornamental shade tree in Oklahoma and Texas (21).

Cedar elm flowers about the same time as the ragweeds and is known to cause or to complicate later summer hayfever (5).

The wood is known for its great strength and exceptionally good shock resistance. Its specific gravity and shrinkage are quite similar to those of rock elm *(Ulmus thomasii)* (4). Because their wood is anatomically similar, cedar elm, rock elm, winged elm, and September elm *(U. serotina)* are all classified as "rock elm." They are most easily distinguished by differences in the ultraviolet fluorescence of the aqueous extracts of the heartwood (16).

Because of its similarity to rock elm, cedar elm can be used as a substitute for rock elm (4). It is most suitable for the manufacturing of furniture and fence posts. The wood also is excellent for steam bending and therefore is used to make containers such as boxes, baskets, crates, and barrels. Other products made from the wood include caskets and dairy, poultry, and apiary supplies.

Cedar elm leaves can be used as indicators of the severity of air pollution. The sulfate content of leaf samples shows the long-term exposure to sulfur dioxide, which is related to overall pollution levels (13).

Genetics

Open pollinated hybrids between Chinese elm *(Ulmus parvifolia)* and cedar elm *(U. crassifolia)* have been recorded (14).

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Cedar Elm – Ulmus crassifolia

Family: Ulmaceae

General Information: Also called Scrub Elm, Lime Elm, Texas Elm, Basket Elm, Red Elm, and Southern Rock Elm, is often found in limestone soils in Texas, Oklahoma, Arkansas, and northern Louisiana. U. crassifolia in nature is a tree up to 90 feet tall, with slender, somewhat drooping branches and rounded crown. Twigs or branches often have lateral corky wings (but not so pronounced as the related species the Winged Elm Ulmus alata); crassifolia refers to the rough, sandpaper-like leaves. It is long-lived (over 50 yrs.); and has hard, dense wood, light in color with darker heart.

Leaves: Simple, alternate, 1 – 2 in. long, _ - 1 in. wide, elliptic to ovate, acute or obtuse at apex, rounded or cuneate to oblique at base, doubly serrate on margin; dark green, stiff, and very rough to the touch above, lighter in color beneath. The leaves appear in early spring and turn yellow in fall.

Flowers: Borne usually in July in small, 3 - 5 flowered fascicles; pedicels slender, 1/3 – _ in.; calyx campanulate, hairy, red to green, 6 – 9 lobed, lobes hairy and acute; no petals; stamens 5 – 6, with slender filaments and reddish purple anthers; pistil green, flattened, pubescent, composed of a 2-celled ovary and 2 exserted spreading styles.
Fruit: Samara borne in late summer, small, _ - _ in. long, oval-elliptic or oblong, green, flattened, pubescent; composed of a central seed surrounded by a wing which is deeply notched at apex and ciliate on margin.

Twigs: Reddish brown, pubescent, often with brown, thin, lateral corky wings.
Bark: Brown to reddish, but more often gray, ridges flattened and broken into thin, loose scales. The bark only forms on mature trunks, limbs and branches after a minimum of 5 yrs.
Rootage: Normally found with pronounced taproot leading to fine hair-like root tips, but radial, lateral surface rootage is quite common where surface moisture is abundant. When taproot cut, prolifically grows new roots from edge of cut.

Lighting: Prefers full sun.

Temperature: Hardy to zone 6.

Bonsai: The best specimens of U. crassifolia are usually collected from nature, especially if found growing in an environment where they have been kept low by browsing cattle, horses or native wildlife. However, they may be grown from seed, cutting or air layer, and will adapt to virtually any traditional bonsai style. U. crassifolia easily accepts thread grafts, but generally grafting is not necessary due to the abundance of new budding from the trunk of even mature trees. Pinching of new buds during the growing season will result in considerable leaf reduction.

Collecting: One of the many advantages of U. crassifolia is its ease of collection in the field. It produces new fibrous roots easily, and can be bare-rooted at time of collection with little ill effect (providing that the roots are kept moist until replanted).

Wiring: Since bark does not form on new growth for several years, wiring of new limbs and branches poses no special problems. Limbs can be wired in the traditional wrap-around method, simply pulled with guy wires or moved with branch bending clamps. As with any deciduous tree, if wire is left in place too long it will make scars, however, unlike Maples it is very forgiving and small wiring scars will eventually be obscured by bark.

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Pruning: Pruning is the primary means of shaping U. crassifolia. Pruning and leaf trimming can be used to increase the ramification of twigs, to induce branches to grow where none grow now, and to create valuable open spaces. Major pruning is not a problem; a branch, once removed, is relatively easy to replace as U. crassifolia tends to sprout new buds prolifically at the site of pruned limbs. In the case of major branch removal, U. crassifolia will repair pruning scars quite well if the cut is made flush with the trunk.
U. crassifolia will endure leaf stripping (complete removal of leaves), but only if the plant is healthy in all respects. The new leaves will generally be smaller than those removed.

Repotting: Potting and root pruning should be done in spring, as leaf buds swell. When mature, it is quite hardy and will suffer severe root pruning without ill effect. (However, do not strip leaves in the same year as the severe root pruning). Root pruning probably should be done every other year on a mature tree, but the amount of annual root growth will vary, depending on conditions, pot size, fertilization schedule, watering regime, and the individual tree. Younger trees and seedlings-in-training may be root pruned annually.
U. crassifolia grows naturally in a wide assortment of soils with a preference for alkaline clay soils and will survive in (and may even prefer) a heavier, more water-retaining soil than many trees. They will do quite well in a "normal" bonsai soil -- although in hot climates they may as a result require more frequent watering.
Dark, unglazed earth-tone pots are preferred. Shape--oval or rectangle, depending on the styling of the tree. Here, though, your own tastes are paramount.

Pests & Diseases: Cedar elm will occasionally have insect pests, such as aphids, spider mites, cotton (aka “cushiony”) scale, and some minor elm leaf beetle damage. Small reddish-purple leaf galls can appear on some of the leaves in late spring to early summer caused by a species of wasp. Mildew in the late summer can occur when the leaves are exposed to too much moisture, but can be controlled to some degree with fungicides. Mistletoe will occasionally occur in trees that are under stress and in poor health.

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Compiled by Michael E. Smoller

Return to: Index by Botanical Name or Index by Common Name

Chinaberry

Melia azedarach L.

Other Common Names:

Persian lilac, white cedar, cape lilac, bead tree

Brief Description:

Chinaberry was introduced in the mid-1800s from Asia. It has been widely used as an ornamental planting in the United States since then. Its fruit, leaves, and other parts can be poisonous to humans and livestock. To a limited extent birds feed and disseminate the fruit. It is studied for its medicinal properties.

Habitat:

This species is common on roadsides, urban areas, homesites, and forest margins. It is rare at high elevations. It is cold hardy and drought tolerant. Chinaberry can be found growing on a variety of soils.

Life History:

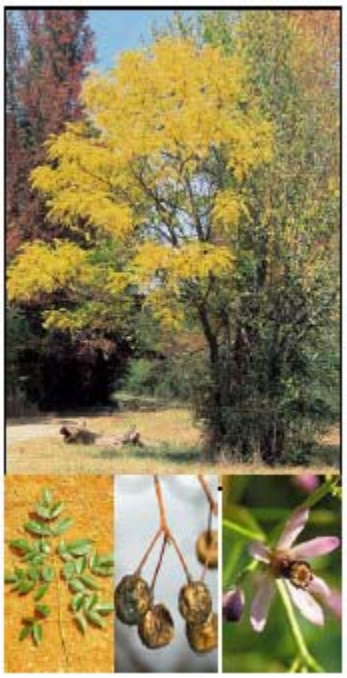
Purple flowers appear from March to May. The yellow poisonous berries mature in July and persist into January. It sprouts readily.

Chinaberry and the Great Trinity Forest:

This species has been reported as invading the forest. A concerted effort needs to be made to remove all invasive species. Injection, basal bark, and foliar applications of herbicides are the most effective means of control due to its sprouting nature. It is probably less aggressive than other invasive trees in the area.

Weed of the Week

Chinaberry Tree Melia azedarach L.



Common Names: chinaberry, Indian lilac, lelah, paraiso, pride of India, white cedar, China tree, bead tree, Persian lilac

Native Origin: Southeast Asia and Northern Australia; introduced in mid-1800s as an ornamental.

Description: A deciduous small to medium-sized tree in the mahogany family (Meliaceae), growing to a height of 50 feet and diameter of 2 feet with spreading crown and branched trunk with multiple boles. Stems are stout, glossy olive green to brown with numerous lighter dots (lenticels) and three-lobed leaf scar. Buds are small, round and fuzzy light brown. Bark is dark chocolate brown becoming increasingly fissured with age. Wood is soft and white. Lacy, dark-green leaves are alternately whorled, bi-pinnately compound, 1 to 2 feet long and 9 to 16 inches wide with a musky odor.
Each leaflet is lanceolate with tapering tips, 1 to 3 inches long and 0.5 to 1.2 inches wide. Glossy dark green with light-green mid-vein above and pale green with lighter-green mid-vein beneath, becoming golden yellow in fall. Long loose clusters of pinkish-lavender to whitish flowers are produced in spring, March to May. Fragrant clusters of flowers yield yellow-brown berries July to January. Berrylike spherical drupes contain a stone with one to six seeds. This fruit is poisonous to humans and livestock.

Habitat: This species is commonly found on roadsides, forest margins, open areas, clearings, and near dwellings, in low elevations (below 1000'). It is tolerant dry soils and semi-shade. Chinaberry forms colonies from root sprouts or sprouts from root collars, and spreads by abundant seeds that are dispersed by birds.

Distribution: This species is reported from states shaded on Plants Database map. It is reported invasive in AL, AR, FL, GA, HI, LA, MS, NC, OK, SC, TX, UT, and VA**.**

Ecological Impacts: It invades disturbed areas and is commonly found along roads and forest edges. It has the potential to grow in dense thickets, restricting the growth of native vegetation. Seeds are dispersed by birds, although they are toxic to humans and livestock.

Control and Management:

- **Manual-.** Manual and mechanical methods of control may therefore be ineffective in controlling the spread and extent of chinaberry because of its ability to send root and stem suckers from underground storage organs.
- **Chemical**- It can be effectively controlled using any of several readily available general use herbicides such as glyphosate or tricloyr. Apply herbicides at the base of the trunk or use the cut-stump treatment. Foliar treatment can be used but high volumes of the solution are required. Follow label and state requirements.

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MELIA AZEDERACH L.

Meliacae/Mahogany Family

Common Names: Chinaberry, pride-of-India
Synonymy: *M. australis* Sweet; *M. japonica* G. Don; *M. sempervirens* Sw.
Origin: Asia

Botanical Description: Deciduous tree to 15 m (50 ft) tall. Twigs stout with purplish bark, dotted with buff-colored lenticels. Leaves alternate, large, long-petioled, 2 or 3 times compound (odd-pinnate), up to 0.5 m (1.5 ft) long; leaflets pungent when crushed, dark green above, often with sparse pubescence along veins; lighter green below, generally glabrous; margins serrate; blade bases often oblique. Inflorescences showy, loose, stalked panicles from leaf axils. Flowers small, fragrant, with 5 lilac petals; stalks of stamens united into dark purple tube. Fruit a stalked, thinly fleshy, subglobose, single-seeded drupe, yellow or yellowish green at maturity.

Ecological Significance: Introduced around 1830 as an ornamental in South Carolina and Georgia (Gordon and Thomas 1997) and widely planted in southern states. Occurs primarily in disturbed areas such as road right-of-ways and fencerows, but has also invaded floodplain hammocks and marshes and upland woods, particularly in north Florida (Clewell 1985, Godfrey 1988). Reported by land managers as infesting parks in 23 counties (EPPC 1996).

Distribution: Most abundantly naturalized in north and west Florida, but often escaping cultivation in peninsular counties, south to the Keys (Nelson 1994, Wunderlin 1982). Naturalized also in tropical America and planted in temperate and subtemperate areas around the world (Bailey and Bailey 1976). Reported as a prominent roadside and shoreline weed in Cape Province, South Africa (Henderson 1991). In the U.S., naturalized from eastern Virginia, southward to south Florida, and westward to eastern half of Texas and Oklahoma (Godfrey 1988).

LCA

Flowers

Life History: Often shrubby and root-suckering, forming thickets. Frequently flowers and fruits at shrub size. Produces flowers in spring, usually March and April; its fruits long-maturing, prolific, and commonly persistent after leaf fall. Fruits poisonous to humans and some other mammals, but seeds dispersed by a variety of songbirds, who relish the drupes and sometimes gorge themselves to the point of temporary intoxication (Nelson 1994).

KAL

Compound leaf

KAL

Fruits

Chinese Tallow Tree

Sapium sebiferum L.

Other Common Names:

Popcorntree and Florida aspen

Brief Description:

Chinese tallow tree is a fast growing and popular ornamental that has escaped cultivation. From 1920 to 1940 it was recommended for seed oil planting by the U.S. Department of Agriculture. The waxy seeds were traditionally used to make candles.

Habitat:

First introduced from China into South Carolina in the 1700s it has now moved across the South and the Gulf Coast. It invades wet areas such as stream and river banks as well as drainage ditches. It can also thrive on upland sites. Chinese tallow tree is shade tolerant, flood tolerant, and allelopathic to other plants.

Life History:

The tree flowers from April to June and the seeds mature in August to persist on the tree over winter or be dispersed by birds. It also sprouts prolifically. It is shade and flood tolerant.

Chinese tallow tree and the Great Trinity Forest:

This species has been observed invading the forest. A concerted effort needs to be made to remove all invasive species. Injection, basal bark, and foliar applications of herbicides are the most effective means of control due to its sprouting nature. Control of this species should be a high priority item.

Weed of the Week

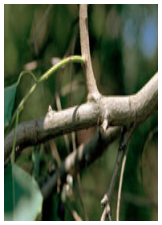
Chinese Tallow Tree *Sapium sebiferum* (L.) Roxb.

Synonym: *Triadica sebifera*(L.) Small

Common Names: Chinese tallow-tree, chicken tree, Florida aspen, popcorn tree, vegetable tallow, white wax berry, candleberry

Native Origin: Native to Japan and to several provinces of central China; Introduced to America for making candles, soap, cloth dressing, and fuel from the seed tallow.

Description: A deciduous tree in the spurge family (Euphorbiaceae) that reaches approximately 50 feet in height and 3 feet in diameter at maturity. Its bark is reddish-brown with wide fissures and narrow ridges, and it often peels off vertically in narrow strips. The branches, which begin relatively low on the trunk, are typically long and drooping. The twigs are slender and waxy. Semicircular leaf scars become raised with age. The simple heart-shaped leaves are alternately whorled and dark-green with light-green mid- and lateral veins and turning yellow to red in fall. When freshly injured, the leaves exude a milky sap. The flowers are dangling yellowish-green 8-inch spikes which yield small clusters of three-lobed fruit that split to reveal popcorn-like seeds in fall and winter. It spreads by bird- and water-dispersed seeds and prolific surface root sprouts.



Habitat: It is adapted to a variety of disturbed sites and a wide range of soil conditions (alkaline, saline, or acidic soils). It invades low, swampy or sub-marshy places, shores of streams, ponds, lakes and impoundments, sometimes on floating islands; also in upland well-drained places, especially near human habitations stream banks. It does best in alluvial forests, on low alluvial plains, and on rich leaf-molds, preferring well-drained clay-peat soils.

Distribution: It has been reported in the following states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Texas and Virginia. It is reported invasive in AL, FL, GA, LA, MS, NC, SC, TX, and VA.

Ecological Impacts: It can invade wild-land areas and swiftly replace natural communities with nearly mono-specific stands. It alters natural soil conditions, creating an inhospitable environment for many native species. In Texas, invasion by *S. sebiferum* marked a dramatic transformation of community structure from graminoids (grasses) and forbs to trees and shrubs as *S. sebiferum* shaded out herbaceous species. The milky, white sap may also be a skin irritant or diarrheic in humans.

Control and Management:

- **Manual**- Mechanical control is not recommended because plants re-sprout vigorously from roots. Controlled burns can be effective during the growth season.
- **Chemical**- It can be effectively controlled using any of several readily available general use herbicides such as triclopyr, imazapyr, hexazinone. There are many possible ways to apply such herbicides, e.g., on foliage, on cut stems, as an injection, or as a basal spray directed to the bark of uncut stems. Repeat applications may be necessary to reduce densities. Follow label and state requirements. Managers should evaluate the specific circumstances of each infestation, seek professional advice and guidance if necessary, and use the herbicide in a manner that is consistent with the product label and other state requirements.

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Invasive Plants website: http://www.na.fs.fed.us/fhp/invasive_plants

SS-AGR-45

NATURAL AREA WEEDS: Chinese Tallow (*Sapium sebiferum* L.)[1]

K. A. Langeland[2]

Introduction

Florida's natural areas--a great source of pride and enjoyment to its citizens--provide recreation, protect biodiversity and fresh water supplies, buffer the harmful effects of storms, and significantly contribute to the economic well-being of the state (Jue et al. 2001). Natural areas are protected in almost nine million acres (nonsubmerged) of state, federal, local and private managed conservation lands in Florida (Jue et al. 2001). Unfortunately, many of these natural areas can be adversely affected when they are invaded by nonnative invasive plant species. An estimated 25,000 plant species have been brought into Florida for use as agricultural crops or landscape plants. While only a small number of these have become invasive, those that do can adversely affect native plant communities by competing for space and resources, disrupting hydrologic and fire regimes, or hybridizing with native species. They must be managed for the protection of native communities in natural areas. Chinese tallow (*Sapium sebiferum* L.) is one of these invasive plant species.

Figure 1. Chinese tallow tree (*Sapium sebiferum* L.) can be identified by its simple, alternate leaves with broadly rounded bases that taper to a slender point and dull white seeds that remain attached after leaves have fallen.

How to Recognize Chinese Tallow

Chinese tallow is a deciduous tree with a milky sap that commonly grows to 30 ft tall. Leaves are simple, alternate, 1-2.5 inches wide, with broadly rounded bases and tapering to a slender point (Figure 1). Leaf stalks are 1-2 inches long. Small yellow flowers that are borne on spikes to 8 inches long occur in spring (Figure 2). The fruit is a 0.5 inch

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2. K. A. Langeland, professor, Agronomy Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

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wide, 3-lobed capsule that turns brown at maturity to reveal 3 dull white seeds (Figure 1). The seeds, which often remain attached to the tree through the winter, resemble popcorn, suggesting the other common name of popcorn tree.

Figure 2. In Spring, Chinese tallow tree displays spikes to 8 inches of small yellow flowers.

Distribution

The first record of Chinese tallow introduction into the United States is found in a letter from Benjamin Franklin written in 1772 to Dr. Noble Wimberly Jones of the Georgia colony. Franklin wrote: "I send also a few seeds of the Chinese Tallow Tree, which will I believe grow & thrive with you. 'Tis a most useful plant" (Bell 1966). As early as 1803, Chinese tallow was spreading into coastal forests according to the noted French botanist Andre Michaux. Since Franklin's time, Chinese tallow has been introduced repeatedly to the United States as an ornamental and potential oil crop species. It is now naturalized from Richmond County North Carolina south through Central Florida, extending west into Texas and northwest Arkansas (McCormick 2005). Within Florida, Chinese tallow was naturalized in 57% of the counties in 1993 (Jubinsky and Anderson 1996) and found as far south as Dade County (Wunderlin et al. 2003).

Invasiveness

Chinese tallow has been recognized as a pest plant in the Carolinas since the 1970s (Langeland and Burks 1998). Within Florida, it has been reported from 46 natural areas (Florida Exotic Pest Plant Council Occurrence Database (http://www.fleppc.org)), and it is a target for removal from 12 natural areas in the Florida Department of Environmental Protection's Upland Invasive Exotic Plant Management Program (DEP Uplands Plant Control Summary, unpublished). Payne's Prairie State Preserve, south of Gainesville, Florida, once contained over 10,000 Chinese tallow trees (Jubinsky and Anderson 1996). Chinese tallow has been extensively used for ornamental planting and is a common plant on landscaped property. These trees present a constant source of seed for infestation of natural areas because the seeds are transported by birds such as pileated woodpeckers, cardinals, yellow-rumped warblers, American robins, and grackles, as well as by water (Jubinsky and Anderson 1996). While the length of time needed to deplete the seedbank is unknown, indications are that seeds remain viable for many years (Jubinsky and Anderson 1966). Zhang and Lin (1994) speculate that seeds may remain dormant for up to 100 years with little or no loss in viability.

The Florida Exotic Pest Plant Council included Chinese tallow on its 1993 List of Florida's Most Invasive Species. **Chinese tallow was added to the Florida Department of Agriculture and Consumer Services Noxious Weed List (5b-57.007 FAC) in 1998. Plants on the Florida Noxious Weed List may not be introduced, possessed, moved, or released without a permit.**

Remove and Replace

Homeowners can help mitigate the problem of Chinese tallow trees in Florida's natural areas by removing them from their property. Mature trees should be felled with a chain saw by the property owner or a professional tree service. The final cut should be made as close to the ground as possible and as level as possible to facilitate application of a herbicide to prevent sprouting. Stumps that are not treated with a herbicide will sprout to form multiple-trunked trees (Figure 3).

Homeowners with only one or a few trees should use Brush-B-Gon or Brush Killer herbicide. These diluted herbicide products (8.0% and 8.8% triclopyr amine, respectively) are available in quart-size containers from retail nursery supply stores. Property owners with large numbers of trees can use the more

Figure 3. Stumps of felled Chinese tallow trees that are not treated with a herbicide will sprout to form multiple-trunked trees.

concentrated Garlon 3A or Garlon 4 (44.4% triclopyr amine and 61.6% triclopyr ester, respectively), which are available only in 2.5-gallon or larger containers from farm supply stores. Renovate 3 is available in 1-quart containers and can be applied to trees that are standing in water. These products must be diluted before use. If it is not objectionable for dead trees to be left standing, Garlon 4 can be diluted at a rate of 1 part herbicide to 5 parts oil and applied to the bark at the base of trees with stems less than 6 inches in diameter. Oil manufactured for this purpose is available from farm supply stores. Pathfinder II (13.6% triclopyr ester) is a pre-diluted, ready to use product that can be used for basal bark application. The herbicide container will have a label with instructions for applying the herbicide. See Table 1.

If trees are cut at a time when seeds are attached, make sure that the material is disposed of in such a way the seeds will not be dispersed to new areas where they can germinate and produce new trees. Seedlings should be continually pulled by hand before they reach seed-bearing maturity.

Space in a landscape left after removal of Chinese tallow can be used to plant a new native or noninvasive non-native tree for shade, or some other landscape purpose. Tree species recommended in Table 2 are similar in size to Chinese tallow. Blackgum, maples, dogwood, and crepe myrtles provide fall color similar to Chinese tallow. Fact sheets that provide additional information on landscape plants can be viewed at http://hort.ifas.ufl.edu/trees/index.htm. For information on the availability of native landscape plant species contact the Association of Florida Native Nurseries (877/352-2366 or http://www.afnn.org). The Cooperative Extension Service Office in your county can help you identify plants appropriate to your property conditions, the ecosystems on and near your site, and your aesthetic preferences.

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Table 1. Herbicides for cut stump or basal bark application to control Chinese tallow trees.

Herbicide	Application method	Dilution	Availability
Brush-B-Gon	Cut stump	Undiluted	Retail garden suppliers
Brush Killer	Cut stump	Undiluted	Retail garden suppliers
Garlon 3A	Cut stump	1 herbicide:5-10 water	Agriculture suppliers
Renovate	Cut stump	1 herbicide:5-10 water	SeaPro Corporation
Garlon 4	Cut stump	1 herbicide:5-10 oil	Agriculture suppliers
Garlon 4	Basal bark	1 herbicide:5 oil	Agriculture suppliers
Pathfinder II	Basal bark	Undiluted	Agriculture suppliers

Table 2. Some suggested tree species for replacing Chinese tallow.

Native	Florida Hardiness Zones
American Hornbeam *(Carpinus caroliniana)*	North, Central
Blackgum *(Nyssa sylvatica var. sylvatica)*	North, Central
Cedar Elm *(Ulmus crassifolia)*	North, Central
Eastern Hophornbeam *(Ostrya virginiana)*	North, Central
Eastern Redbud *(Cercis canadensis)*	North, Central
Flatwoods Plum *(Prunus umbellata)*	North, Central
Florida Maple *(Acer saccharum ssp. floridanum)*	North, Central
Flowering Dogwood *(Cornus floridana)*	North, Central
Fringe Tree *(Chionanthus virginicus)*	North, Central
Geiger Tree *(Cordia sebestena)*	South
Paradise Tree *(Simarouba glauca)*	South
Red Bay *(Persea barbonia)*	Throughout
Red Maple *(Acer rubrum)*	Throughout
Red Stopper *(Eugenia confusa)*	South
River Birch *(Betula nigra)*	North, Central
Satin Leaf *(Chrysophyllum oliviforme)*	South
Silverbell *(Halesia diptera)*	North, Central
Swamp Bay *(Persea palustris)*	Throughout
Turkey Oak *(Quercus laevis)*	North, Central
White Ash *(Fraxinus americana)*	North
Winged Elm *(Ulmus alata)*	North, Central
Non-native	
Crepe Myrtle *(Lagerstroemia indica)*	Throughout
Queens Crepe Myrtle *(Lagerstroemia speciosa)*	South
Trumpet Tree *(Tabebuia argentea)*	South

Chinese Privet

Ligustrum sinense L.

Other Common Names:

Pivet

Brief Description:

Chinese privet is an invasive shrub that forms dense thickets in bottomlands and along fencerows. It is still used as an ornamental planting in the south. The seeds are spread by birds and other animals. Deer occasionally browse young shoots. The fruit is toxic to humans.

Habitat:

Privet occupies a variety of sites across the site, but may not tolerate dry and droughty sites. By invading bottomlands and fencerows, it can further can access to other sites such as fields and right-of-ways. Once established it is difficult to eradicate and can modify whole ecosystems over time.

Life History:

Privet flowers from April to June. It develops drupes of many berries that are then disseminated by birds and other animals. It sprouts profusely and is also considered shade tolerant.

Chinese privet and the Great Trinity Forest:

This species has been reported in the understory of the forest and occurring in thickets. A concerted effort needs to be made to remove all invasive species. Injection, basal bark, and foliar applications of herbicides are the most effective means of control due to its sprouting nature. Control of this species should be a high priority item. Basal bark would be the most effective means of control on plants with individual stems. Foliar sprays should be used when leaves are accessible for total coverage. An application rate that would ensure a thorough coating of the leaves should be favored in this case due to the dense foliar nature of the plant.

exotic weed species

CHINESE PRIVET

Ligustrum sinense Lour.

plant symbol = LISI

Contributed By: USDA, NRCS, National Plant Data Center & Louisiana State University-Plant Science; partial funding from the US Geological Survey and the US National Biological Information Infrastructure

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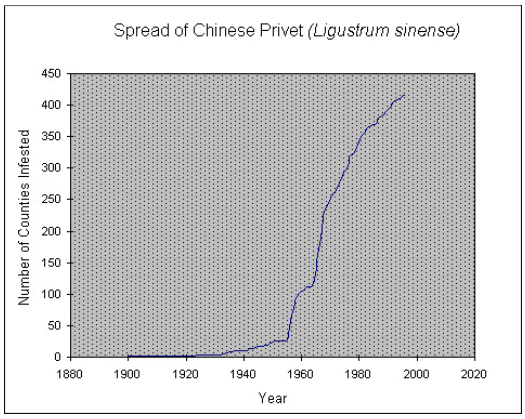
Uses

Weed (very invasive in the southern US), ornamental

Noxiousness

Chinese privet was introduced into the United States from China for ornamental planting. Having escaped from cultivation, it is now naturalized throughout the southeastern United States. The greatest threat posed by this species is large-scale ecosystem modification due to its ability to successfully compete with and displace native vegetation. Chinese privet plants mature rapidly and are prolific seed producers. They also reproduce vegetatively by means of root suckers. Once established, Chinese privet is difficult to eradicate because of its reproductive capacity.

Impact/Vectors: *Ligustrum sinense* is native to China and was introduced into the United States in 1852 for use as an ornamental shrub. It is used for hedge and mass plantings, and sometimes as single specimens for its foliage and its profusion of small white flowers (Dirr 1990; Wyman 1973). It continues to be widely sold in the nursery and gardening industry. The foliage of Chinese privet is also used, presumably, for cut-flower arrangements. This horticultural introduction has been cultivated for a relatively long time in the United States. Wyman (1973) reports that this species is still growing as a hedge on the old Berkman's Nursery grounds in Augusta, Georgia, where it was planted in the early 1860's. It was planted on the Chickamauga and Chattanooga National Military Park after it came under the control of the Secretary of War in 1890. Present day plants are descendants of those early plantings (Faulkner et al. 1989). According to Small (1933), the species was escaping from cultivation in southern Louisiana by the 1930's. A survey of appropriate herbaria reveals collection records from Georgia as early as 1900. Based on herbarium records the species has become naturalized and widespread in the southeast and eastern U.S. during the 1950's, 60's, and 70's. Taylor et al. (1996) notes the rapid, recent spread of *Ligustrum sinense* in Oklahoma.



The species is a major threat to natural landscapes. An example of Chinese privet's ability to push a native species closer to extinction is noted in the recovery plan for Schweintz's sunflower (*Helianthus schweinitzii*). This endangered species is known from about 16 populations on the piedmont of the

Carolinas. Residential and commercial development and the invasion of aggressive exotics, such as *Ligustrum sinense*, represent the greatest threats for this species (U.S. Fish and Wildlife Service 1992). Similar observations about the competitive characteristics of Chinese privet have been noted in various Nature Conservancy reports in the Southeast. Removal of Chinese privet from natural areas is problematic and essential for their restoration (News from Volunteers of the Nature Conservancy, North Carolina Chapter and the Louisiana Chapter, pers. comm. 1997).

In addition to the privet's impact on natural landscapes, it can be directly harmful to humans. All introduced species of *Ligustrum* produce fruit toxic to humans that cause such symptoms as nausea, headache, abdominal pain, vomiting, diarrhea, weakness, and low blood pressure and body temperature. Where Chinese privet occurs in abundance, floral odors may cause respiratory irritation (Westbrooks & Preacher 1986). Chinese privet is sold in nurseries and is often included on recommended planting lists or other literature produced by cooperative extension services without mention of its invasive nature. Named cultivar selections have been developed (Bailey and Bailey 1976).

Chinese privet grows in a wide variety of habitats and can tolerate a wide range of soil and light conditions, but it grows best in mesic soils and abundant sunlight but can tolerate lower light conditions (Thomas 1980; Bailey & Bailey 1976). Few woody plants offer an easier test of gardeners' skills.

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Leaves with developing fruit.

The species persists on abandoned home sites and can readily invade abandoned lots and farmlands where it forms impenetrable thickets. It becomes especially abundant along fencerows, stream, bayou, and forest margins, and it has the ability to invade forests (Godfrey 1988).

Chinese privet reproduces by sexual and vegetative means. Seeds, produced in great abundance, are spread by birds (McRae 1980). Landscape plantings provide seed sources for establishment in disturbed habitats. Soil disturbances of all sorts such as forest clearing, abandoned agricultural lands, and fence construction provide opportunities for colonization by Chinese privet. Natural disturbances for example tree falls, erosion, animal excavations, etc. provide similar colonization opportunities. The plants also have the ability to reproduce vegetatively from root suckers. Once established, Chinese privet is difficult to control because of the huge seedbank and the need to remove underground parts as well. Because of these characteristics, the major impact of Chinese privet is its ability to displace native species and disrupt various terrestrial ecosystems.

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status, such as, state noxious status and wetland indicator values.

Description

General: Olive Family (Oleaceae). Chinese privet is a shrub or small tree that may grow to as much as 30 feet tall although its typical height ranges from 5 to 12 feet. If flowering, its blossoms are very aromatic. Its root system is shallow but extensive. Suckers are readily produced and the plants can spread vegetatively in this fashion. The plants branch abundantly and the branches typically arch gently downward. Its twigs are usually densely hairy (pubescent) when young, and the plant hairs (trichomes) spread at right angles from the twig surface. Raised, tan-colored lenticels are also evident on the twig's surface. Chinese privet leaves are evergreen to semi-deciduous and are oppositely arranged (two leaves per node) along the stem on nodes that are usually less than one inch apart. The leaf stalk (or petiole, shown below) is about one-eighth inch long and covered with hairs. Leaf blades are elliptical in shape and are up to one inch wide and about two inches long. Leaf margins lack teeth (entire). The upper leaf blade surfaces are glabrous (without hairs) at maturity. Hairs occur along the midvein (see photo below) and sometimes on branch veins of the lower surfaces.

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Petiole, axillary bud, stem with spreading hairs

The flowers occur in numerous, cone-shaped, branching clusters (panicles) two to four inches long that profusely cover the shrub when flowering. A short, slender stalk (pedicel) supports each flower. The green calyx consists of four sepals fused to form a small, cup-like structure. Four white to off-white petals that are basally fused to one another make-up the corolla. Each flower has two stamens attached to the corolla, and they project beyond the corolla throat (exserted stamens). The flowers produce a somewhat disagreeable aroma. The single pistil in each flower matures into a blue-black, berry-like fruit. The fruit are ellipsoidal to nearly globose and are produced abundantly in persistent, pyramidal clusters.

© L. Urbatsch
Developing fruit & cuplike calyx of fused petals.

© L. Urbatsch
Midvein of lower leaf surface showing hairs.

Chinese privet is similar to Common Privet (*Ligustrum vulgare*), a European species that is naturalized in more temperate areas of the eastern United States. Chinese privet has evergreen to semi-evergreen leaves, densely hairy twigs and petioles, pubescent midveins on its lower leaf surfaces, and exserted stamens. In contrast, common privet is deciduous to somewhat evergreen with sparsely pubescent twigs, glabrous midveins, and included stamens (the tips of the anthers are shorter than the extended corolla lobes) (Gleason 1952).

© L. Urbatsch
Petiole, leaf base & margin.

Distribution: A survey of herbarium records shows that its present distribution includes an area extending from Florida to southern New England and westward to the eastern parts of Kansas, Oklahoma, and Texas. Chinese privet thrives in wet to dry habitats. It persists around old home sites and flourishes along fencerows, and stream and forest margins where it forms impenetrable, monocultural thickets. For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Control

It is recommended that you contact your local agricultural extension specialist and/or county weed specialist for control measures pertinent to your area.

Various control measures have been reported for Chinese privet. For small areas and for relatively small plants, hand removal is effective. Digging tools such as a mattock are useful for removing underground parts. Broken root fragments need to be removed because of their ability to re-sprout. Repeated mowing and cutting will control the spread of privet, but will not eradicate it. For such treatment, stems should be cut as close to the ground as possible (Bartlow et al. 1997). Mechanical removal is especially effective in the early stages of an invasion when the numbers of plants are relatively small.

For larger natural areas where the use of chemical herbicides is inadvisable, enlisting numerous helpers to mechanically remove Chinese privet may be required. Using heavy equipment for large-scale removal may be appropriate in some locations, but the negative effects of soil disturbance and the potential for erosion need to be considered.

Herbicide treatments properly applied can selectively remove invasive species with minimal soil disturbance. Even slight soil disturbance may offer opportunities for re-invasion. When considering chemical control, local laws affecting herbicide use must be observed. Appropriate precautions in various habitats may be needed. Kline & Duquesnel (1996) point out that not all herbicides are appropriate for all areas. Some may damage non-target species. Herbicides will behave differently in different environments and under different conditions (Neal et al. 1986). For example, they may degrade more slowly in wetter, more anaerobic soils or move downward in sandier soils. A careful monitoring program is essential for evaluating herbicide use.

Randall & Marinelli (1996) report effective control of Chinese privet with glyphosate herbicides stating that foliage treatment is best for actively growing plants. Foliar spray methods should be used only where risk to non-target species is minimal. A 2% solution of glyphosate or 2% triclopyr with a one-half percent of non-ionic surfactant is reportedly effective for treating Chinese privet (Bartlow et al. 1997).

Kline & Duquesnel (1996) discuss various treatments for woody species including Brazilian pepper, Australian pine, Chinese tallow, and other tree-like species. They note that within mixed stands single

stem treatments consisting of basal-bark treatments, cut-surface treatments (injection, cut-stump, or girdle), or direct foliar applications may be effective. A typical basal or cut-surface treatment consists of a 10-50% mixture of one of the following types of herbicides (glyphosate, hexazinone, imazapyr, or triclopyr) with an oil dilutant. They provide a table for use as a guide for selecting application methods and herbicides for various invasive plant species.

Brian Bowen, President of the Tennessee Exotic Pest Plant Council, reports success in controlling privet using 25% glyphosate/75% horticulture oil applied as a cut-surface treatment (personal communication, 1997). He advises against using this application as the plants break dormancy because upward movement of the sap reduces the treatment's effectiveness. The same herbicide preparation is effective when applied to cut stumps as long as the ground isn't frozen (Bartlow et al. 1997). For the basal bark method, applying a mixture of 25% triclopyr/75% horticultural oil to the basal parts of the shrub is reported (Bartlow et al. 1997). W. N. Kline, Senior Scientist, Dow Elanco, Duluth, Georgia, also favors basal-bark or cut-surface treatment over foliar application (pers. comm. 1997). The latter causes such rapid leaf drop that translocation of the herbicide in the plants is reduced, thereby lowering its effectiveness. Furthermore, he reports that disturbance (e.g., fire or mechanical) should be avoided for about one year following basal-bark or cut-surface treatments to allow translocation of herbicides. Disturbance of the plants or root system too soon after treatment may disrupt translocation and result in resprouting.

Fire is a naturally occurring phenomenon that is essential for certain native plant communities to exist. Its use in exotic pest plant control is being investigated. Faulkner et al. (1989) reported its effectiveness as a management tool in the Chickamauga and Chattanooga National Military Park for controlling *Ligustrum sinense* and other pest plants. Fire had the benefit of killing large privet stems, but the vigorous resprouting that followed burning offset this gain. Fall and winter burns had desirable aesthetic effects by considerably reducing the biomass of privet, but no long-term benefits were achieved since the species still remained.

Fire was also used as a herbicide pretreatment (Faulkner et al. 1989). In the spring following the fall and winter burns, foliar application of glyphosate damaged or killed a majority of the Chinese privet shoots. Burning facilitated foliar application of herbicide by reducing biomass. However, it did not increase the effectiveness of the herbicide compared to the unburned controls.

Privet has no known biological controls. A foliage-feeding insect native to Europe, *Macrophya punctumalbum*, is a known pest. Privet is also susceptible to a fungal leaf spot, *Pseudocercospora ligustri*, and a common root crown bacteria, *Agrobacterium tume-faciens* (Bartlow et al. 1997).

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Prepared By
Lowell Urbatsch
Department of Plant Biology, Louisiana State University, Baton Rouge, Louisiana

Species Coordinator
Mark Skinner
USDA, NRCS, National Plant Data Center, Baton Rouge, Louisiana

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For more information about this and other plants, please contact your local NRCS field office or Conservation District, and visit the PLANTS <http://plants.usda.gov> and Plant Materials Program Web sites <http://Plant-Materials.nrcs.usda.gov>.

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Common Persimmon

Diospyros virginiana L.

Other Common Names:

Simmon, possumwood, and Florida persimmon.

Brief Description:

Common persimmon is a moderately sized slow growing tree that can be found on a range of sites and soils. The fruit is desirable to both wildlife and people. It is a common early successional or fence row and old field species.

Habitat:

Common persimmon's predominate range is south of the Mason-Dixon line and west to the Colorado River Valley in Texas. It grows on a variety of dry locations mainly on more coarse textured soils. It can thrive in the Mississippi River Valley on rich bottomland soils.

Life History:

Common persimmon is dioecious and plants flower from April to May. Fruit ripens from September to November and seedfall occurs from September to late winter. Each fruit typically contains one to eight seeds. Trees as young as ten can bear fruit. Seed dissemination is by birds, other animals, and to some extent floodwaters when the tree occurs in such areas. The seeds remain dormant over winter until April to May, or when soil temperatures are above 60° Fahrenheit for about a month. The seedlings are very hardy, but will die under prolonged flooding conditions during the growing seasons. The tree is characterized as being very tolerant and therefore it is able to persist many years under the canopy of other trees.

Common persimmon and the Great Trinity Forest:

Common persimmon occurs occasionally within the boundaries of the forest. It is one of trees that will be used to a limited extent in planting. It will never dominate a site and probably will not occur of any significant size, but its fruit will be valuable to wildlife and it will promote species diversity. Planting will be limited to well drained coarse textured soils.

Diospyros virginiana L.

Common Persimmon

Ebenaceae -- Ebony family

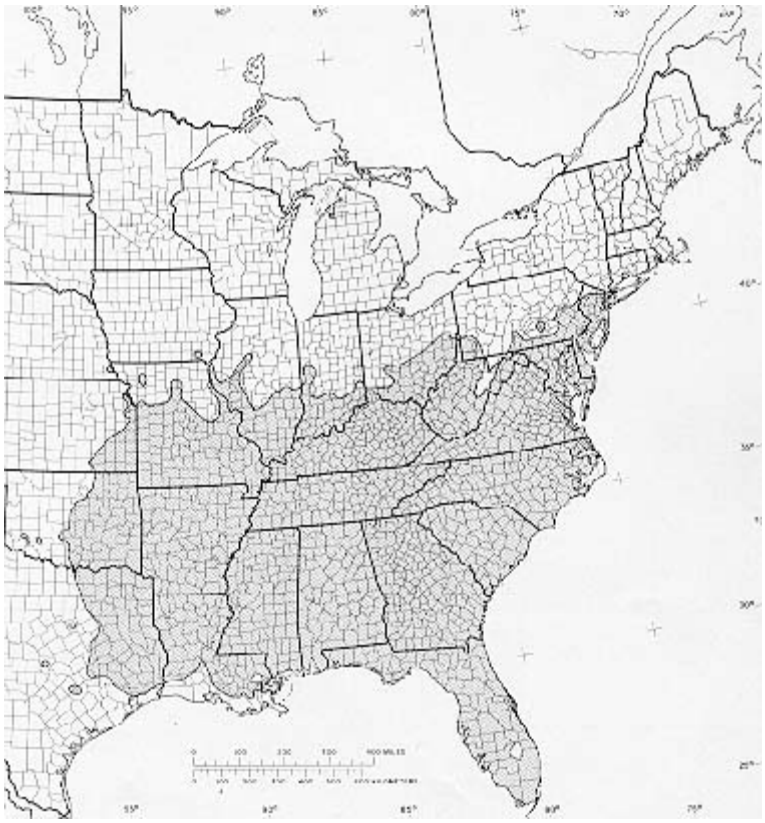
Lowell K. Halls

Common persimmon *(Diospyros virginiana),* also called simmon, possumwood, and Florida persimmon, is a slow-growing tree of moderate size found on a wide variety of soils and sites. Best growth is in the bottom lands of the Mississippi River Valley. The wood is close grained and sometimes used for special products requiring hardness and strength. Persimmon is much better known for its fruits, however. They are enjoyed by people as well as many species of wildlife for food. The glossy leathery leaves make the persimmon tree a nice one for landscaping, but it is not easily transplanted because of the taproot.

Habitat

Native Range

Common persimmon is found from southern Connecticut and Long Island to southern Florida; westward through central Pennsylvania, southern Ohio, southern Indiana, and central Illinois to southeast Iowa; and south through eastern Kansas and Oklahoma to the Valley of the Colorado River in Texas. It does not grow, however, in the main range of the Appalachian Mountains, nor in much of the oak-hickory forest type on the Allegheny Plateau. Its best development is in the rich bottom lands of the Mississippi River and its tributaries and in coastal river valleys (9). It is exceedingly common in the South Atlantic and Gulf States, often covering abandoned fields with a shrubby growth, and springing up by the sides of roads and fences. It is often the first tree species to start growth on abandoned and denuded cropland. It is well adapted to an environment of high insolation and low water supply.



-*The native range of common perssimon.*

Climate

Common persimmon grows in a humid climate throughout its range. Its best commercial development is in areas that receive an average of 1220 mm (48 in) of precipitation annually, about 460 mm (18 in) of which normally occurs duping the growing season. Over the range of persimmon, the average maximum temperatures are 35° C (95° F) in the summer and -12° C (10° F) in the winter.

Soils and Topography

Common persimmon grows in a tremendous range of conditions from very dry, sterile, sandy woodlands to river bottoms to rocky hillsides and moist or very dry locations. It thrives on almost any type of soil but is most frequently found growing on soils of the orders Alfisols, Ultisols, Entisols, and Inceptisols.

Associated Forest Cover

Common persimmon is a key species in the forest cover type Sassafras-Persimmon (Society of American Foresters Type 64) (3) and is an associated species in the following cover types: Southern Scrub Oak (Type 72), Loblolly Pine-Shortleaf Pine (Type 80), Loblolly Pine-Hardwood (Type 82), Sweetgum-Willow Oak (Type 92), Sugarberry-American Elm-Green Ash

(Type 93), Overcup Oak-Water Hickory (Type 96), Baldcypress (Type 101), and Baldcypress-Tupelo (Type 102).

Common associates are elms *(Ulmus spp.),* eastern redcedar *(Juniperus virginiana),* hickories *(Carya* spp.), sugar maple *(Acer saccharum),* yellow-poplar *(Liriodendron tulipifera),* oaks *Quercus spp.),* boxelder *(Acer negundo),* red maple *(A. rubrum),* sycamore *(Platanus occidentalis),* and cedar elm *(Ulmus crassifolia).*

Common shrub and noncommercial tree associates include swamp-privet *(Forestiera acuminata),* roughleaf dogwood *(Cornus drummondii),* hawthorns *(Crataegus spp.),* water-elm *(Planera aquatica),* shining sumac *(Rhus copallina),* and smooth sumac *(R. glabra).*

In the alluvial bottoms of the Lower Wabash Valley, waterlocust *(Gleditsia aquatica)* and common buttonbush *(Cephalanthus occidentalis)* are close associates.

The Sassafras-Persimmon type is temporary and usually replaced with mixed hardwood types.

Life History

Reproduction and Early Growth

Flowering, Seed Production, and Dissemination- The inconspicuous flowers bloom from March to June within its botanical range and from April through May in areas where it grows best. Staminate flowers are in two- or three-flowered cymes, tubular, 8 to 13 mm (0.3 to 0.5 in) long, and greenish yellow.

Pistillate flowers are solitary, sessile or shortpeduncled, about 1.9 cm (0.75 in) long. The corolla is fragrant with 4 or 5 greenish yellow, thick recurved lobes.

Common persimmon is dioecious; the staminate and pistillate flowers are borne on separate trees on shoots of the current year, when the leaves are more than half grown.

The fruit is a persistent spherical berry 1.9 to 5.1 cm (0.8 to 2.0 in) in diameter. It ripens from September to November or occasionally a little earlier. When mature it is yellow to orange or dark red in color, often with a glaucous bloom. Each berry usually contains one to eight flat, brown seeds about 13 mm (0.5 in) long but is sometimes seedless. Fruits fall from September to late winter.

The optimum fruit-bearing age is 25 to 50 years, but 10-year-old trees sometimes bear fruit. Good crops are borne about every 2 years under normal conditions. About 45 kg (100 lb) of fruit yields 4.5 to 13.6 kg (10 to 30 lb) of clean seed, with an average of 2,640 seeds per kg (1,200 seeds per lb). The seed is disseminated by birds and animals that feed on the fruits, and, to some extent, by overflow water in low bottom lands (9). The seeds remain dormant during winter and germinate in April or May, after about a month of soil temperatures above 15° C (60° F).

Persimmon is easily raised from seed, and if planting is to be done with seeds, they should be cleaned and spread out for drying for a day or two and then stratified under moist conditions for 2 to 3 months at 1° to 4° C (33° to 40° F). They should be soaked 2 to 3 days before planting. Seeds lose their viability through extremes of heat, cold, or drying. They should be planted in spring or fall in shallow drills in light soils with plenty of humus and covered to a depth of about 13 min (0.5 in).

No insects or animals are known to damage flowers or fruit seriously. Late freeze can damage the flowers and cause premature fruit drop.

Seedling Development- Persimmon is very tolerant, and natural reproduction can normally be expected in the forest understory. It is often prolific in openings. Germination is epigeal. The seedlings develop a strong taproot and after their first year are about 20 cm (8 in) tall or even taller on good sites. Prolonged flooding or submergence during the growing season will kill young trees; however, seedlings usually survive under very adverse conditions.

Vegetative Reproduction- Persimmon may be propagated by root cuttings and grafting (10). Root cuttings 15 to 20 cm (6 to 8 in) long and 8 mm (0.3 in) in diameter can be used provided the ends are sealed with pitch or wax to prevent rot. Older twigs may be used similarly. They can be buried in sand until ready to plant (15).

Trees may be grafted by chip budding, cleft grafting, or whip grafting. Nursery stock should be set about 15 cm (6 in) apart and root pruned each year. Stock 1 to 2 years old may be transplanted, but this should be done in moist deep soil because of the deep root system (15).

Stumps sprout readily and thickets of shrubby persimmon develop from root suckers. Sprouting from the root collar after fires is common. Seedlings or suckers are difficult to transplant.

Sapling and Pole Stages to Maturity

Growth and Yield- The growth rate of persimmon is generally slow (9). On dry, old-field sites it frequently makes only a shrubby growth 4.6 to 6.1 m (15 to 20 ft) tall. On poor sites the larger trees contain a high percentage of heartwood that cannot be used for lumber because it checks excessively during seasoning.

Approximately 50 percent of the total radial growth is complete in 70 to 90 days, and 90 percent complete in 100 to 109 days after growth starts in the spring (6). Persimmon responds well to fertilizer.

The species normally attains a height of 9 to 18 m (30 to 60 ft) at maturity but in optimum habitats may reach a height of 21 to 24 rn (70 to 80 ft) and a diameter of 51 to 61 cm (20 to 24 in). It usually forms an upright or drooping type tree with a rounded or conical crown. Stems may be clumped, either because seedlings develop in close proximity to one another or because they arise from suckers after a tree has been cut down. The leaves are deciduous, simple, alternate, and entire. The bark is brown to black, fissures are deep, and ridges are broken into rectangular checkered sections.

Per acre volume figures for this species are not available because it usually grows as scattered individuals.

Tops of orchard grown trees should be thinned to allow for better fruit production.

Rooting Habit- No information available.

Reaction to Competition- Persimmon is classed as very tolerant of shade. It can persist in the understory for many years (9). Its response to release is not definitely known but is probably not especially good. Persimmon competes with almost any plant under harsh growing conditions.

Damaging Agents- A number of insects attack persimmon but normally do no serious harm (9). A bark and phloem borer *(Agrilus fuscipennis)* infests living persimmon and the persimmon borer *(Sannina uroceriformis)* tunnels in the stems and taproots of young trees and damages nursery stock. Caterpillars may defoliate the trees in early summer and into mid summer. The principal defoliators are a webworm *(Seiarctica echo)* and the hickory horned devil *(Citheronia regalis).* Unless sprayed, they may defoliate and severely damage a young plant. No serious damage to the merchantable part of living trees is recorded. The twig girdler *(Oncideres cingulata)* retards growth by cutting off smaller branches. The wood of dying and dead trees is often riddled by the false powderpost beetle *(Xylobiops basilaris).*

Cephalosporium diospyri causes persimmon wilt, a fungus disease that kills many trees in central Tennessee and the Southeastern States (1). The disease is characterized by a sudden wilting of the leaves, followed by defoliation and death of the branches from the top down. An infected tree often lives 1 or 2 years after this symptom appears. Diseased trees should be burned, and cuts and bruises on other trees should be painted to prevent entry by wind-borne spores. No disease-resistant trees have been found. A wound is necessary for primary infection. The hickory twig girdler and powderpost beetle cause the majority of wounds in healthy trees. As soon as the tree dies, the fungus produces spores in large quantities between the bark and the wood near the base of the tree.

Because common persimmon is often considered noxious in pastures and fields, much effort has been expended in its control and eradication (2). It is easily defoliated with 2,4,5-T at 1.1 kg/ha (1 lb/acre) or less but sprouts readily from both stem and roots after treatment. Treatment is most effective in May when leaves are fully expanded. Additives (Ethephon, MAA, and TIBA) increase both the defoliation and kill of persimmon. Surfactants increase effectiveness of 2,4,5-T. Picloram in combination with 2,4,5-T, and dicamba, alone and in combination with 2,4,5-T, has also given good control. Soil application of picloram and dicamba at 6.7 kg/ha (6 lb/acre) gave kills of 75 and 70 percent, respectively. Complete top kill was possible by injecting undiluted solutions of dicamba or mixtures of 2,4,5-T and dicamba.

Tordon 101 or Esteron 99 at 7.6 liters (2 gal) plus triclopyr at 9.4 liters/ha (1 gal/acre) and Tordon at 37 liters/ha (4 gal/acre) gave 100 percent control of persimmon (4).

Undiluted 2,4-D dimethylamine killed persimmon when applied in 1- or 2-ml (0.03- or 0.07-oz) dosages in injections placed edge-to-edge up to 23 cm (9 in) apart around the stem (11). A 4-to-1 mixture of triisoproponolamine salts of 2,4-D plus picloram was also effective.

Special Uses

The wood is heavy, hard, strong, and very close grained. The average number of rings is 5.5 per cm (14 per in) (12). Specific gravity of light-brown sapwood is 0.79; a 0.028 m^3 (1.0 ft^3) block weighs about 22 kg (49 lb). Because of its hardness, smoothness, and even texture, it is particularly desirable for turnery, plane stocks, shoe lasts, shuttles, and golf club heads.

Persimmon is sometimes planted for its edible fruit. Dried fruit is added to baked goods and occasionally is fermented with hops, cornmeal, or wheat bran into a sort of beer. The dried, roasted, ground seeds have been used as a substitute for coffee.

Several cultivars are available with improved fruit size and quality. In native persimmon areas, top working or grafting on suckers is a good way to get superior cultivars into bearing quickly. One staminate tree seems sufficient to pollinate at least 23 pistillate trees of the same race (8). The pulp is very astringent when not ripe, but after a frost in the fall, when the fruit turns yellow orange, the flesh is pleasing in taste (12). The fruit is eaten by many species of song birds, also by the skunk, raccoon, opossum, gray and fox squirrels, white-tailed deer, wild turkeys, bobwhite, crows, rabbits, hogs, and cattle (5). It may, however, cause sickness in livestock. Deer browse readily on persimmon sprouts, but cattle graze them only lightly.

Seeds and fruits are generally low in crude protein, crude fat, and calcium but high in nitrogen-free extract and tannin (13).

The inner bark and unripe fruit are sometimes used in treatment of fevers, diarrhea, and hemorrhage. Indelible ink is made from fruit.

Persimmon is valued as an ornamental because of its hardiness, adaptability to a wide range of soils and climates, its lustrous leaves, its abundant crop of fruits, and its immunity from disease and insects. It has been introduced into Europe.

The tree is suitable for erosion control on deeper soils because of its deep root system, but this same characteristic makes it difficult to plant.

Persimmon is considered a woody weed in unimproved pastures, and it prevents many areas from being grazed effectively. Inoculation of persimmon stumps with a fungus *(Cephalosporium diospyri)* was found to be an effective means of preventing subsequent sprouting.

Persimmon flowers are useful in the production of honey.

Genetics

Varieties of the common persimmon are the fuzzy common persimmon *(D. virginiana* var. *pubescens* (Pursh) Dipp.); Oklahoma common persimmon *(D. uirginiana* var. *platycarpa* Sarg.); and Florida persimmon *(D. uirginiana* var. *mosieri* (Small) Sarg.) (7).

Hybrids have been reported between *D. uirginiana, D. kaki,* and *D. lotus (14).*

Several cultivars, selected primarily for fruit color, taste, size, and early maturation, have been chosen from wild populations (8).

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Eastern Cottonwood

Populus deltoides Bartr. Ex Marsh.

Other Common Names:

Southern cottonwood, Carolina poplar, eastern poplar, necklace poplar, and 'alamo

Brief Description:

The fastest growing commercial tree species in North America. Named for the "cotton" material attached to the seed that aids in its dissemination.

Habitat:

Cottonwood grows best on well drained sands or silts near streams. It is often found growing in pure stands. Its range is from the Great Plains east to the Appalachian Mountains and then through parts of Georgia and the Carolinas. Its survival is highly dependent on its ability to stay out of saturated soils. Cottonwood is mostly a streamside species.

Life History:

Seed production begins at about 5 to 10 years of age. Flowering occurs from February to April before leaves appear. Cottonwoods produce very large amounts of seed. Seed dispersal occurs about 2 months after flowering. Seeds are disseminated by spring flood waters and by wind. Germination occurs shortly after seedfall. Seedlings are fragile the first few weeks. On good sites cottonwood growth is phenomenal. Cottonwood does not compete well with other plants though and is extremely intolerant of shade. Of its associates, it is surpassed in shade intolerance only by willow. Cottonwood will crowd out willow on the slightly higher and drier sites. It responds poorly to release from crowding.

Eastern cottonwood and the Great Trinity Forest:

Cottonwood is found growing on the natural levee of coarse textured soils that occurs along the banks of the Trinity River and intermixed throughout on sites that are probably higher and better drained. It could be an indicator of areas that will be suitable for planting.

Populus deltoides Bartr. ex Marsh.

Eastern Cottonwood

Salicaceae -- Willow family

P. deltoides Bartr. ex Marsh. var. deltoides

Eastern Cottonwood (typical)

D. T Cooper

P. deltoides var. occidentalis Rydb.

Plains Cottonwood

David F. Van Haverbeke

Eastern cottonwood *(Populus deltoides),* one of the largest eastern hardwoods, is short-lived but the fastest-growing commercial forest species in North America. It grows best on moist well-drained sands or silts near streams, often in pure stands. The lightweight, rather soft wood is used primarily for core stock in manufacturing furniture and for pulpwood. Eastern cottonwood is one of the few hardwood species that is planted and grown specifically for these purposes.

Besides the typical eastern variety (var. *deltoides),* there is a western variety, plains cottonwood (var. *occidentalis).* Its leaves, more broad than long, are slightly smaller and more coarsely toothed than the typical variety.

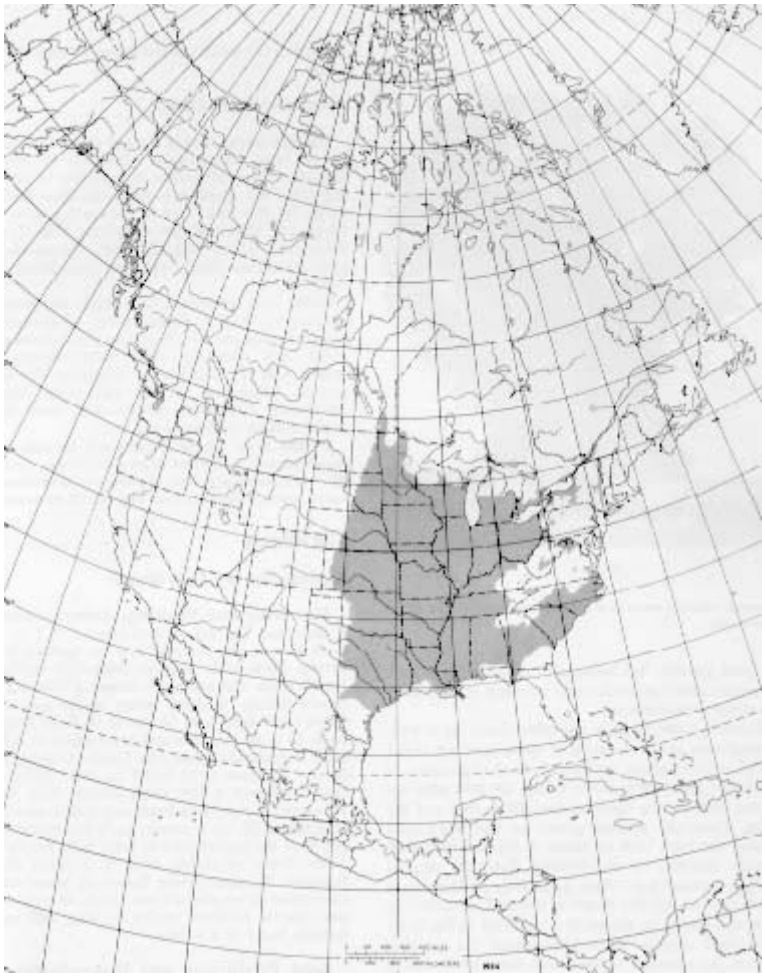
EASTERN COTTONWOOD

Eastern cottonwood (typical) *(Populus deltoides* var. *deltoides)* is also called southern cottonwood, Carolina poplar, eastern poplar, necklace poplar, and álamo.

Habitat

Native Range

Eastern cottonwood grows along streams and on bottom lands from southern Quebec westward into North Dakota and southwestern Manitoba, south to central Texas, and east to northwestern Florida and Georgia. The north-south distribution extends from latitude 28° N. to 46° N. It is absent from the higher Appalachian areas and from much of Florida and the Gulf Coast except along rivers. The western boundary is not well defined because eastern cottonwood intergrades with var. *occidentalis*, plains cottonwood, where the ranges overlap. Altitude is a primary determiner of the western boundary.



-*The native range of eastern cottonwood.*

Climate

In various parts of its range, eastern cottonwood is subjected to temperatures as high as 46° C (115° F) and as low as -45° C (-50° F). Average January temperatures vary from -10° C (14° F) to 8° C (46° F). It occurs in areas with from less than 100 to more than 200 consecutive frost-free days per year. Rainfall ranges from less than 380 mm (15 in) in the northwest corner of the range to more than 1400 mm (55 in) in the southern part of the range. In the dryest parts of its range, eastern cottonwood receives most of its moisture from streams, making rainfall requirements meaningless. In the lower Mississippi Valley, more than one-third of the rain falls during the growing season, following a full subsoil recharge during the winter. Flooding often provides

additional water. Nevertheless, there is usually inadequate moisture for optimum growth during the latter part of the growing season.

Soils and Topography

The species survives on deep, infertile sands and clays but makes its best growth on moist, welldrained, fine sandy or silt loams close to streams. The soils of most cottonwood sites are in the soil orders Entisols and Inceptisols. The best sites are characterized by absence of mottles in the upper 46 cm (18 in), water tables from 60 to 180 cm (24 to 72 in), bulk density of less than 1.4 g/cm³ (0.8 oz/in³), pH of 5.5 to 7.5, and greater than 2 percent organic matter (1). Sites frequently meet the requirements for good growth, but because of competition or lack of proper seeding conditions, planting is necessary for stand establishment.

Eastern cottonwood is not often found as a well-formed tree at an elevation of more than 4.6 to 6.1 m (15 to 20 ft) above the average level of streams. In the lower Mississippi River Valley, the best sites are in the batture, the land between the levees and the river. Here the species grows on the front land ridges, the high land or banks of present or former stream courses, on well-drained flats, the general terrain between low ridges, and rarely on abandoned fields on well-drained ridges in the first bottoms (17). Where it occurs on slopes, it is confined to the lower ones that remain moist throughout the growing season. An example is the brown loam bluff area of loessial soil along the eastern side of the lower Mississippi River flood plain. Fine cottonwood specimens are frequent in the bottoms and on the lowest slopes bordering the small water-courses emerging from the bluffs.

Associated Forest Cover

Eastern cottonwood is the key species in the forest cover type Cottonwood (Society of American Foresters Type 63) and is an associate in the following types (6): Black Ash-American Elm-Red Maple (Type 39), Bur Oak (Type 42), River Birch- Sycamore (Type 61), Silver Maple-American Elm (Type 62), Sweetgum-Willow Oak (Type 92), Sycamore-Sweetgum-American Elm (Type 94), and Black Willow (Type 95).

Other tree associates of eastern cottonwood are hackberry *(Celtis occidentalis),* sugarberry (C. *laevigata),* green ash *(Fraxinus pennsylvanica),* box elder *(Acer negundo),* river birch *(Betula nigra),* white ash (F *americana),* slippery elm *(Ulmus rubra),* blackgum *(Nyssa sylvatica),* American hornbeam *(Carpinus caroliniana),* and eastern hophornbeam. *(Ostrya virginiana).*

In the area where cottonwood attains its best development, roughleaf dogwood *(Cornus drummondii)* and swamp-privet *(Forestiera acuminata)* are major noncommercial tree and shrub associates.

Life History

Reproduction and Early Growth

Flowering and Fruiting- Eastern cotton wood is dioecious. The sex ratio is about 1 to 1 (8). Floral buds form in the summer prior to opening the next spring. Male buds develop somewhat earlier than female buds and are much larger. Flowering occurs from February to April before leaves appear. Male flowers are only 8 to 13 cm (3 to 5 in) long. They have 40 to 60 stamens and are reddish in color and more conspicuous than the female flowers. Female flowers elongate to 15 to 30 cm (6 to 12 in). Males tend to flower a few days earlier than females. Flowering varies by as much as a month among trees in a stand (9). As a result, early-flowering trees do not have the opportunity to cross with late-flowering trees. Trees as young as 4 to 5 years old have flowered. Northern trees flower at lower temperatures than do southern trees. Seeds develop 30 to 60 per capsule on short stalks on long catkins. Each capsule has 3 or 4 valves.

Seed Production and Dissemination- Seed production starts when the trees are 5 to 10 years old, increasing rapidly in amount as the trees become older and larger. Estimates of annual seed production of a single open-grown tree have been as high as 48 million seeds (3). Good seed crops are the rule. About 35 liters (I bushel) of fresh fruit yields 1 kg (2.2 lb) of seeds, or about 770,000 cleaned seeds (19).

Seed dispersal follows flowering by about 2 months in southern populations and a somewhat shorter period in the North. It is characterized by considerable variation among trees as well as a lengthy dispersal period for some individual trees (9). Seed dispersal occurs from May through mid-July in the South and June through mid-July in the North (19). The dispersal pattern results in abundant deposits of seeds along water courses as spring flood waters recede. Seeds may be carried several hundred feet by the wind, aided by the "cotton" attached to the seed. Seeds falling in water may be carried a long distance from the parent tree before being left on silt deposits.

Seedling Development- Unless floating on or immersed in water, cottonwood seeds must reach a favorable seedbed and germinate very soon after falling. Germination of fresh seeds may exceed 90 percent. Seedlings are delicate for the first few weeks. Rains, very hot sunshine, and damping-off fungi kill many of them. Very moist, exposed mineral soils, such as fresh silt deposits, are required. Germination is epigeal. Growth rate of the fragile seedlings is slow for the first 3 weeks but may be very rapid after that. Full sunlight for a substantial part of each day is required after the first few weeks.

Fully mature seeds that are dried promptly to 5 to 8 percent moisture and stored at temperatures just above freezing maintain viability for several months. Storage at -20° C (-4° F) may prolong viability for 5 or more years (20). It is best to increase the moisture content gradually when attempting to germinate very dry seed.

Vegetative Reproduction- Satisfactory sprouting has occurred on low-cut stumps of trees as old as 25 years of age (22). Reproduction by root suckers is not common. Artificial propagation of the species normally involves use of cuttings from 1-year stem growth from nursery trees (23). These may or may not be rooted before outplanting.

The planting season in the North is short, coinciding with the beginning of the growing season. Rooted cuttings commonly are used under these conditions.

In the Southern United States, unrooted cuttings 30 to 50 cm (12 to 20 in) long provide a satisfactory, economical means of planting (15). Survival rates of 70 to 90 percent are normally achieved, depending on the genetics of the clones, quality of cuttings, and field conditions. Root-inducing hormones normally are not used. Rooted or unrooted long cuttings are sometimes used to reach moisture, to reduce damage from deer, to permit less intensive site preparation and to provide greater flood tolerance. Because operational use of asexual propagation of cottonwood permits immediate and complete utilization of superior genotypes, rooting ability is of great importance.

Propagation from 1-year-old wood from older trees is often difficult, but some success is usually achieved. Repropagation from the resulting material is often satisfactory. Clones tracing back to older trees normally have the smooth, somewhat thin, bark characteristics of the tops of older trees.

Sapling and Pole Stages to Maturity

Growth and Yield- Eastern cottonwood is one of the tallest species east of the Rocky Mountains. Heights of 53 to 58 in (175 to 190 ft) and diameters of 120 to 180 cm (48 to 72 in) have been reported (17), as have age 35 stand volumes exceeding 420.0 m^3/ha (30,000 fbm/acre) of sawed lumber (5,10,14,22).

The most phenomenal growth has been from trees planted on favorable sites in the South and receiving adequate weed control. Scientists have recorded heights of 13 in (43 ft) at age 3 and more than 30 in (100 ft) at age 9 on individual trees. In one plantation, unpruned trees at wide spacing averaged 29 cm (11.4 in) d.b.h. at age 5 (11). The best yields with close spacing of unimproved clones without irrigation in the South has been about 138.6 m^3/ha (1,980 ft^3/acre) total volume at age 4 with 2,700 stems per hectare (1,100/acre) (21).

Rooting Habit- Root growth of new seedlings is so slow that the plants are easily dislodged by rain droplets. After the first 3 weeks, root growth accelerates and lateral root growth may exceed height growth for the first year. Most of the roots are in the uppermost, best aerated layer of soil (2). They are nearer the surface in clay soils than in loam soils. Following siltation, roots develop on the covered portion of the stem. Cottonwood trees planted from conventional 20 to 60 cm (8 to 24 in) cuttings have fewer deep roots and are not as well anchored against root lodging as those established naturally or as deep-planted seedlings or rooted cuttings.

Reaction to Competition- Cottonwood is classed as very intolerant of shade. It is more intolerant of shade than any of its associates except willow. Although the two frequently seed in together, pure stands of one or the other are the general rule after the first few years. Willow survives on the wetter sites and cottonwood on the slightly higher, drier sites. Its faster growth allows cottonwood to crowd out the willow except where prolonged deep flooding drowns the cottonwood component of the stand.

Cottonwood responds poorly to release following crowding. Only those trees with the best crowns respond. In natural stands, uneven spacing and size permit some trees to become dominant, and natural thinning allows production of large trees. Under plantation conditions and

particularly when only clones with similar growth rates are used and all trees get off to a good start, stagnation can occur quickly. Spacing and timing of thinning become critical under these conditions. Optimum growth of individual trees requires very wide, seemingly wasteful, spacing. On the best sites in the South, cottonwood planted initially at a spacing of 3.7 by 3.7 m (12 by 12 ft) should be thinned by removing half of the trees at age 3 and again at age 5 if rapid growth rate of individual trees is to be maintained.

Damaging Agents- Although cottonwood grows rapidly under ideal conditions, numerous agents can disrupt its schedule and cause death or loss in tree quality or growth rate. These include insects, disease organisms, flood, fire, and various animals. At least 10 insect species and 12 diseases cause major damage to eastern cottonwood throughout its range (16).

A clearwing borer, *Paranthrene dollii dollii,* attacks the lower stem. Another clearwing borer, *P. tabaniformis,* attacks terminals and small branches causing breakage of terminals. The poplar borer, *Saperda calcarata,* attacks trunks of trees 3 or more years old and may riddle portions of the trunks with tunnels, causing serious degrade or breakage. The cottonwood borer, *Plectrodera scalator,* attacks the root collar and roots of both large and small trees. Small, closely-spaced trees break off easily from this damage. The cottonwood twig borer, *Gypsonoma haimbachiana,* causes stunting, forking, and other malformations in young cottonwood. The cottonwood leaf beetle, *Chrysomela scripta,* defoliates and kills terminals, producing forked stems. The poplar tentmaker, *Ichthyura inclusa,* can cause repeated defoliation, resulting in mortality.

Numerous disease organisms attack cottonwood. *Septoria musiva* causes a small canker that opens a path for other canker organisms. *Cytospora chrysosperma* causes a canker where sites are adverse and tree vigor is low. *Fusarium solani* enters wounds, particularly after major floods, to cause a canker. Two other canker-producing organisms are *Phomopsis macrospora* and *Botryodiplodia theobromae.* On vigorous trees, cankers usually callus over. *Melampsora medusae* causes leaf rust which results in premature defoliation and reduced growth rate. *Marssonina brunnea* causes a leaf spot that also results in early defoliation. *Septoria musiva,* in addition to causing a canker, causes a leaf spot. New leaves may be infected from old leaves or cankers.

Since cottonwood grows primarily in relatively low areas near streams it is subjected to frequent flooding. Floods during the dormant season or floods of short duration during the growing season may benefit cottonwood trees by fully recharging subsoil moisture and providing some degree of vegetation control. Floods that overtop newly sprouting cuttings or established trees for prolonged periods during the growing season or that result in stagnant water pools are harmful.

Cottonwood of all ages is very susceptible to fire. A very light burn kills younger trees, while burns of greater intensity kill or wound larger ones. Butt rot, a common result of fire injury, is uncommon in cottonwood, however (13).

Seedlings and young trees are browsed by rabbits deer, and domestic stock. A substantial portion of the trees can recover from this damage. Beavers cut sapling and pole-size trees for food and for dam construction. The resulting ponds may drown cottonwood trees.

Special Uses

Eastern cottonwood is frequently planted to give quick shade near homes. Male clones, which have none of the objectionable "cotton" associated with seed, are preferred. Windbreaks are occasionally established with cottonwood as a component. Cottonwood is suitable for soil stabilization where soil and moisture conditions are adequate, as along stream or ditch banks. Deep planting permits reforesting of nonproductive fields with sandy soils having available moisture beneath a dry surface layer.

There has been considerable interest in cottonwood for energy biomass, because of its high yield potential and coppicing ability. There has also been interest in growing it for inclusion in cattle feed, since it is a good source of cellulose relatively free of undesirable components, such as tannins. The new growth is high in protein and minerals.

Genetics

Population Differences

Eastern cottonwood tends to be linearly distributed along streams. Differences in climate, soils, day length, and exposure to pests result in genetic differences among these populations. Gene flow to downstream portions of the population may occur as a result of seeds floating in the current. The cottonwood in the lower reaches of the Mississippi River may contain genes from many tributaries.

Races and Hybrids

Some scientists recognize three subspecies of eastern cottonwood (7). These include *angulata,* a southern strain, *missouriensis,* a central or intermediate strain, and *monilifera,* a northern strain. These divisions are based upon minor differences in morphological traits. Plains cottonwood *(Populus deltoides* var. *occidentalis),* discussed in the next paper, appears to be a legitimate race or subspecies, growing at higher altitudes under more adverse conditions.

Eastern cottonwood hybridizes freely with plains cottonwood and crosses with several other species either naturally or artificially. It is most noted for its excellent hybrids with *Populus nigra.* Hybrid swarms with P. *balsamifera, P. tremuloides,* and P *grandidentata* are reported (18), as well as natural hybrids with P *trichocarpa (4).* The following natural interspecific hybrids are recognized (12):

Populus x acuminata Rydb. *(P. angustifolia x deltoides)*
Populus x bernardii Boivin *(P. deltoides x tremuloides)*
Populus x jackii Sarg. *(P. balsamifera x deltoides)*
Populus x polygonifolia Bernard *(P. balsamifera x deltoides x tremuloides)*

In addition, many hybrids between eastern cottonwood and other poplars have been produced artificially.

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PLAINS COTTONWOOD

Plains cottonwood (Populus *deltoides* var. *occidentalis)* also has other common names with geographical and topographical connotations: Texas cottonwood, river cottonwood, western cottonwood, and plains poplar.

Habitat

Native Range

The range of plains cottonwood encompasses a broad, irregular-shaped band approximately 800 km (500 mi) wide and 2400 km (1,500 mi) long, extending south southeasterly from the southern prairie provinces of Canada into the high plains of northern Texas. This range spans approximately 20° in longitude (92° to 115° W.) and 25° in latitude (30° to 55° N.) (14,19).

Specifically, plains cottonwood grows from southern Alberta, central Saskatchewan, and southwestern Manitoba in Canada, south through the Great Plains in North Dakota, South Dakota, Nebraska, Kansas, western Oklahoma into northcentral Texas and extreme northeastern New Mexico; north in Colorado, eastern Wyoming, and eastern Montana. The eastern limit of the range is not well defined because it integrades with the western limit of the range of the typical variety, eastern cottonwood (var. *deltoides)* (13,14).

-The native range of plains cottonwood.

Climate

The climate of the Great -Plains, the region in which plains cottonwood grows, is distinctly continental. The region is characterized as dry subhumid to semiarid, with extremes and rapid fluctuations in temperature, unpredictable and limited precipitation, frequent and cyclic droughts, and strong persistent winds (3).

Average annual precipitation varies from about 250 mm (10 in) in the northern and western Great Plains to about 760 mm (30 in) in the extreme southeastern part of the species range. About 75 percent of the annual precipitation occurs during the growing season. Drought periods of 35 to 60 consecutive days may be expected annually, and periods of 60 to 70 days without rainfall may occur once in 10 years. Infrequent drought periods of 90 to 120 days have been recorded in the northern and southern plains, respectively. Drought hazard is greatest in the autumn and winter in the northern plains, and in the winter in the southern Great Plains where snowfall is less. High-velocity winds occur in all seasons but are strongest and most persistent during winter and early spring (29).

Average January temperatures vary from -15° C (5° F) in the North to 4° C (40° F) in the South. Minimum temperatures range from -46° C (-50° F) in the north to -18° C (0° F) in the South, with maximum temperatures of 38° C (100° F) to 46° C (115° F) throughout the region. The frost-free period varies from 100 d in the North to 220 days in the south (29).

Soils and Topography

Plains cottonwood grows along most of the rivers and streams that flow through the loessial soils of the Great Plains on sites that are 2.4 to 3.7 m (8 to 12 ft) above the water table. The taxon predominates on the level, narrow stringers of the river floodplains and stream bottom lands that cross the region. It is common in pure stands on river sandbars and on overflow land in the bends of large rivers but is also found in the beds of intermittent streams (1).

Plains cottonwood grows on soils of the order Entisols, mainly along alluvial streams, and on soils of the orders Mollisols, Alfisols, and Inceptisols on stream terraces, in drainage ways, and in bottom lands and subirrigated valleys. Best development is on deep, rich, well-drained loams; however, the species also grows on level subirrigated uplands of deep, sandy soils (1). Soil texture and fertility seem to be of lesser importance than moisture, however, in determining its occurrence.

Plains cottonwood grows between elevations of about 300 m (1,000 ft) near its eastern limit to about 1830 m (6,000 ft) in the foothills of the Rocky Mountains. It is seldom found above 2130 m (7,000 ft) (27).

Associated Forest Cover

Plains cottonwood can grow in pure stands, but it is frequently found as an associate in three forest cover types: Bur Oak (Society of American Foresters Type 42), Cottonwood (Type 63), and Cottonwood-Willow (Type 235) (22). Black *willow (Salix nigra)* and peachleaf willow *(S. amygdaloides)* are the most common associates. Other associates on the better sites include American elm *(Ulmus americana),* slippery elm *(U. rubra),* hackberry *(Celtis occidentalis),* boxelder *(Acer negundo),* green ash *(Fraxinus pennsylvanica),* red mulberry *(Morus rubra),* black walnut *(Juglans nigra),* American sycamore *(Platanus occidentalis),* eastern redcedar *(Juniperus virginiana),* and silver maple *(Acer saccharinum)* (1,17,30).

Associated shrubs and vines include sandbar willow *(S. exigua),* red-osier dogwood *(Cornus stolonifera),* indigobush *(Amorpha fruticosa),* coralberry *(Symphoricarpos orbiculatus),* wild grape *(Vitis* spp.), poison-ivy *(Toxicodendron radicans),* smooth sumac *(Rhus glabra),* and American plum *(Prunus americana).* In the western Plains, shrubs are scarce in the cottonwood stands, and several species of grasses and forbs are found in their place. These include sand dropseed *(Sporobolus cryptandrus),* buffalograss *(Buchloe dactyloides),* sunflowers *(Helianthus* spp.), lambs-quarters *(Chenopodium album),* and Russian-thistle *(Salsola pestifer) (1).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- Plains cottonwood's dioecious with only occasional deviations. Staminate and pistillate flowers are borne on twigs of the previous year's growth, appearing in early spring (April and May) before the leaves develop (20,27). Pollination is by wind. Following anthesis, the staminate catkins dry and fall within 2 weeks. Four to 6 weeks, ranging from June through August, are required for seed maturation (9,20).

The flowering period seems to be regular within the limits of geographic zones, but differences can occur in time of anthesis between stands and among trees within stands. Differences in date of flowering from year to year apparently depend upon temperatures. The ratio of staminate to ovulate trees is believed to be about 1 to 1. In the lower Mississippi Valley the ratio was reported to be 54 to 46 percent (10).

Seed Production and Dissemination- Minimum seed-bearing age of plains cottonwood is about 10 years, and fair to large seed crops can be expected annually. The seeds are very small, yet relatively large for the genus; they range from 551,000 to 1,056,000 seeds per kilogram (250,000 to 479,000 lb). Seeds have a tuft of "cottonlike" hairs attached and are dispersed primarily by wind, but also by water, over long distances a few days after ripening. Seedfall among trees within a locality varies greatly and may extend for 6 weeks or longer (9,20).

Seedling Development- The viability of fresh seeds is high; 98 percent germination has been attained during the first 5 days following dispersal (9,20). Longevity of poplar seeds under natural conditions has been reported to be 2 weeks to 1 month. Vitality of fresh, unstored seed drops rapidly, however, if they are not kept moist. There is no evident dormancy.

Poplar seeds can be stored successfully and viability is prolonged if the moisture content is reduced to 4 or 5 percent. Air-dried *P. deltoides* seeds, stored in sealed containers at 1° to 4° C (34° to 39° F), were 100 percent viable after 6 months (9,20). Seeds of some poplar species have been similarly stored in vacuum-packed jars at 0° C (32° F) for as long as 3 years (11). Recently, it was demonstrated that *P. deltoides* seed stored at -20° C (- 4° F), either at normal air pressure or under vacuum, showed significantly higher germination than the same seed stored at 5° C (41° F) under vacuum (in sealed containers), after 6 months of storage. Thereafter, germination at -20° C (-4° F) remained unchanged during a 6-year study period, whereas germination of seed stored at 5° C (41° F) was considered unsatisfactory after 3.5 years. Eastern cottonwood seed should always be stored at below freezing temperature, even for short-term storage (28). Germination is epigeal.

Plains cottonwood seed germinates within 48 hours after dispersal on proven mediums such as moist silt, sand, or fine gravel in full sunlight. The aboveground portion of the seedling develops rapidly and vigorously. Constant moisture is required for at least several weeks to ensure the establishment and survival of the slower developing root systems of the seedlings (5,9).

The best planting sites are moderately welldrained, permeable, and fertile deep loam soils on bottom lands. Very sandy soil is suitable if the water table is within 3.7 to 4.6 rn (12 to 15 ft) of the surface. Even upland sites are satisfactory if they are fertile, not too shallow, and if rainfall is

abundant and well-distributed. Full sunlight, freedom from competition of weeds and grass (particularly sod), and abundant moisture throughout at least the first growing season are essential to seedling survival and establishment (27).

Although initial establishment is usually good and growth is rapid on coarse sands and gravels of river bottom lands, periods of drought and fluctuating water tables make subsequent development uncertain (17). Establishment of plains cottonwood on meander lobes of rivers in southern Canada is positively correlated with flood flows during seed dispersal (June 1-July 10) (2). Floods during the seed-dispersal period recur in southern Alberta and northern Montana about every 5 years.

Vegetative Reproduction- Plains cottonwood is easily reproduced by stem cuttings from 1-year-old "ripened" wood. Since this species, like other members of the genus, sprouts vigorously from both roots and stumps of young trees, clonal "stool" beds are commonly established for the production of these cuttings. Cuttings can also be taken from pollards, 1-year-old plants, or epicormic branches of old plants (11).

Healthy, straight, lignified wands without bark injuries approximately 2 m (6.6 ft) long and 3 to 30 mm (0.1 to 1.2 in) in diameter are cut from stool beds with a sharp knife during the dormant season (October to March), treated with fungicide, and placed in cool 50 C (410 F), moist storage (11). The wands are divided into cuttings approximately 25.4 cm (10 in) long and 10 to 20 mm (0.4 to 0.8 in) in diameter at midpoint and inserted in a mist-sprayed greenhouse rooting bench containing moist sand as a medium.

Recent greenhouse and field tests in Nebraska demonstrated that cuttings taken from the basal end of wands produce significantly more roots than those taken from the upper portion. Also, cuttings from clones of Nebraska and Minnesota-Wisconsin origins produced significantly higher numbers of roots than those of other geographic sources (33). About 4 to 6 weeks are required for rooting and subsequent field establishment. Rooted cuttings of *R deltoides* are not root-pruned when field-planted.

Unrooted cuttings can also be field-planted. In wetter climates and in heavier soils, 25.4 cm (10 in) cuttings are satisfactory. In drier climates and in sandy soils, cuttings 50 to 80 cm (20 to 31 in) long have been more successful. In both situations, dormant cuttings are planted in the early spring and are completely buried except for the top bud and 3 to 5 cm (1 to 2 in) of the wand. Difficult-to-root clones can also be grafted (11).

Experiments in Utah have shown that Populus *deltoides* (of unknown, but presumed eastern origin), *R balsamifera,* and *R angustifolia,* as well as *R tremuloides,* produce abundant shoots (suckers) and roots from root cuttings (segments). New shoots and roots originate from pre-existing suppressed buds embedded in the periderm along the surface of the root cutting and from the region of the exposed cambium at the cut ends. The presence of lateral root increased shoot growth, and the development of shoots and lateral roots responded to the inherent polarity of the root segments (18). The probability that the closely related plains cottonwood will react similarly would seem to be high.

Sapling and Pole Stages to Maturity

Growth and Yield- Young plains cottonwood trees grow 1.8 to 3.7 m (6 to 12 ft) per year in height under favorable conditions, surpassing other native species of the Great Plains region in height and diameter growth. Growth is most rapid in the first 25 to 30 years, by which time the trees can reach 15.2 to 22.9 m (50 to 75 ft) in height and 61.0 to 91.4 cm (24 to 36 in) in diameter. Cottonwood sources from Missouri *(P. deltoides)* and Nebraska (Sioux-land), along with silver maple (Acer saccharinum), ranked highest among seven species tested for the production of biomass during a 2-year study in Kansas (12).

Plains cottonwood usually attains maximum development in about 40 to 50 years. Mature trees can be 24.4 to 27.4 m (80 to 90 ft) tall, with diameters of 1.8 to 2.4 m (6 to 8 ft), and with clear holes for 9.1 m (30 ft) or more. The trees are usually single-stemmed with an open, spreading, symmetrical crown of massive horizontal branches and stout, more or less angled branchlets and twigs. While plains cottonwood is relatively short-lived, it can remain vigorous for 80 to 90 years under favorable conditions (21,27).

Survival and growth of cottonwoods on the Great Plains is directly dependent upon availability of moisture. Mortality during the drought of the mid-1930's was 59 percent along intermittent streams, 55 percent near springs that failed during the drought, and only 6 percent along continuously flowing streams (1).

Fully stocked cottonwood stands along creek and river channels and overflow land in Kansas are estimated to yield 168.0 to 210.0 m^3/ha (12,000 to 15,000 fbm/acre) at 25 to 30 years of age (21). In North Dakota, 30-and 50-year-old plantation yields were 59.5 to 219.8 m^3/ha (4,250 and 17,500 fbm/acre) gross merchantable volume, respectively, Scribner log rule (26).

Plains cottonwood 94 cm (37 in) in diameter outside bark and 19.8 to 22.9 m (65 to 75 ft) tall, growing in the South Platte River bottom, Morgan County in eastern Colorado, attained gross volumes of 8.0 m^3 (283 ft^3) inside bark (8). One could expect trees growing on more fertile and wetter sites along the Platte and Missouri River bottom lands in the eastern part of the range to achieve volumes in the magnitude of 11.3 m^3 (400 ft^3).

Rooting Habit- Early diameter and height growth of plains cottonwood surpasses that of other species native to the Great Plains region (17). Growth and penetration of poplar seedling roots immediately following germination is reported to be relatively slow, however. About 5 days are required after germination for the primary root to begin downward growth, and after 12 days the root may be only 1.5 mm (0.06 in) long (19). Growth continues slowly for 3 weeks to 1 month, at which time taproots of the cultivar Petrowskyana, for example, grown indoors in fairly strong light, averaged only 2.5 cm Q in) in length at the end of I month. This growth pattern explains the critical need for continuous moisture during the seedling stage. Subsequent root growth is much more rapid.

Ninety-eight percent of the roots of a 43-year-old northern cottonwood *(Populus monilifera),* 19.8 m (65 ft) tall, were found to be in the top 1.2 m (4 ft) of a prairie clay soil near Fargo, ND (31). Roots of this and other non-drought-tolerant species formed shallow roots on dry sandy

sites but had a tendency to grow deep vertical roots on very moist (nonsaturated) sandy sites. Similar trends of root development were revealed in excavations of plains cottonwood trees growing in silty loam soils in eastern Nebraska, where (1) a 14-year-old tree, 18.3 m (60 ft) tall, developed only shallow, widespread, and fibrous roots over and down to a water table 0.8 m (2.5 ft) deep; (2) a 16-year-old tree, 11.3 m (37 ft) tall, developed a moderately heavy root system downward to a water table 4.3 m (14 ft) deep and then branched outward; and (3) a 49-year-old tree, 21.3 m (70 ft) tall, developed a distinct and heavy taprooted pattern over an unreachable water table 18.3 m (60 ft) deep (24).

Reaction to Competition- Plains cottonwood requires full sunlight for maximum growth. It is classed as very intolerant of shade and intolerant of root competition (21). It grows either in pure stands, which thin naturally and rapidly, or in open mixed stands, both of which are nearly always even-aged (17). After pioneering on alluvial sites, often with the willows, it is gradually replaced with other broadleaf species that can then become established under the forest conditions so created. Cottonwood does not normally regenerate until the overstory has broken up.

Damaging Agents- Prolonged periods of severe environmental stress, such as drought, weaken trees physiologically and increase their susceptibility to disease and insect pathogens. Plains cottonwood, with its high water requirement is especially vulnerable (1). *P. deltoides* var. *occidentalis* trees, considered water-tolerant, showed 47 percent high stress rate and 18 percent mortality when inundated late in the growing season in the Central Plains (15).

Leaf rusts and stem cankers are the most widespread and damaging diseases. Leaf rusts cause premature defoliation of trees. This defoliation not only causes growth losses; it weakens the trees and increases their susceptibility to infection by other pathogens, which cause cankers and mortality.

Melampsora leaf rust caused by *Melampsora medusae* is one of the most serious leaf diseases of plains cottonwood. Others include Septoria leaf spot, caused by *Septoria musiva, Marssonina brunnea* leaf spot, and Alternaria leaf and stem blight, caused by *Alternaria tenuis* (16).

The most serious of the canker pathogens is Cytospora canker *(Cytospora chrysosperma),* which often results in wind-breakage at the wound area. Other canker pathogens include those caused by *Septoria musiva, Fusarium solani, Phomopsis macrospora, Botryodiplodia theobromae, Cryptosphaeria populina,* and *Pleurotus ostreatus.* Root and butt rots may be due to *Ganoderma lucidum, Armillaria tabescens,* and *Scytinostroma galactinium* (16).

The insects most damaging to plains cottonwood are the defoliators and wood borers; the former cause loss of vigor, the latter reduce the quality of lumber. Some of the more important defoliating insects include the cottonwood leaf beetle *(Chrysomela scripta),* cottonwood dagger moth *(Acronicta lepusculina),* forest tent caterpillar *(Malacosoma disstria),* poplar leaffolding sawfly *(Phyllocolpa bozemani),* fall cankerworm *(Alsophila pometaria),* and the fall webworm *(Hyphantria cunea)* (25).

Important boring insects include the poplar borer *(Saperda calcarata),* cottonwood borer *(Plectrodera scalator),* flatheaded wood borer *(Dicerca divaricata),* carpenterworm *(Prionoxystus robiniae),* poplar-and-willow borer *(Cryptorhynchus lapathi),* and the bronze poplar borer *(Agrilus liragus)* (25).

Several species of mites and aphids infest plains cottonwood, but their effects are not usually fatal.

Special Uses

Plains cottonwood is an important component of windbreak plantings in the Great Plains. It is frequently used as an ornamental to provide quick, if rather temporary, esthetic and protective effects. Plains cottonwood can produce an effective windbarrier 12.2 to 15.2 in (40 to 50 ft) tall in 15 to 20 years on stream lowlands and on deep, sandy, subirrigated lands (17).

The wood of plains cottonwood is coarse, odorless, soft, and lightweight, yet relatively strong. The heartwood is pale yellowish brown, the sapwood nearly white. The wood frequently warps on drying and is not durable in contact with soil and other moist conditions. It nails without splitting, is clean appearing, and takes printing and stenciling well.

The wood is used primarily for pallets, rough construction lumber (farm buildings), interior parts of furniture, excelsior, crating, and wood pulp (21,27). The pulp produces a very high-grade gloss paper.

New and potentially important commercial uses of the wood include roughage food for livestock and the production of fiber and reconstituted wood products derived from short-rotation (2- to 8-year) biomass operations (6,23).

Genetics

Races

Within the large and climatically diverse north-south range of plains cottonwood, subtle but recognizable differences in the population have evolved by natural selection. What is here called Populus *deltoides* var. *occidentalis* has received at least nine names denoting either specific or varietal rank over the past two centuries (14).

Recently, the eastern cottonwood *(Populus deltoides)* complex has been treated as a group of three intergrading subspecies showing random or clinal variation or both within each subspecies (7). Plains cottonwood, on the basis of taxonomic affinities to the poplars of the Great Lakes region, was recognized as *P. deltoides* ssp. *monilifera* (Ait.) Eckenwalder. This treatment, supported by recent provenance evaluations in Nebraska, seems to be a more tenable interpretation. In these provenance evaluations the poplars of Kansas, Nebraska, and South Dakota, with smooth bark, small branches, small leaves with a few or no glands and few

serrations, and prolific rooting habit tended to be similar to poplars of Minnesota. and Wisconsin origin (32).

Hybrids

The eastern members of plains cottonwood *(Populus deltoides* var. *occidentalis)* intergrade with western-most eastern cottonwoods (P. *deltoides* var. *deltoides);* therefore, the literature reveals no named hybrids between these very closely related populations (14).

Interspecific hybrids have been reported, however, between plains cottonwood and named species to the north and west. In southern Alberta, Canada, plains cottonwood is reported to cross and introgress readily with balsam poplar (Populus *balsamifera* L.), narrowleaf cottonwood (P *angustifolia* James), and possibly quaking aspen (P *tremuloides* Michx.) (4). Lanceleaf cottonwood (P. x *acuminata* Rydb.) is regarded as an interspecific hybrid between narrowleaf cottonwood (P. *angustifolia* James), which occurs from northern New Mexico, Nebraska, and North Dakota to southern Alberta, and plains cottonwood (P *deltoides* var. *occidentalis)* (14). Other reported interspecific hybrids involving plains cottonwood include *Populus x jackii* Sarg. (P *balsamifera x deltoides* var. *occidentalis),* and Populus x *polygonifolia* Bernard (P *balsamifera x deltoides* var. *occidentalis x* tremuloides (4).

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Eastern Redbud

Cercis canadensis L.

Other Common Names:

Judas-tree

Brief Description:

Eastern redbud is a small, short-lived deciduous tree found throughout the eastern United States. It is a well known and easily recognizable tree for its striking purple flowers that form before most other trees leaf out.

Habitat:

Eastern redbud can be found from the Great Plains to the East Coast excluding coastal areas and the far Northeast. There is also a disjunct population that extends from South Texas to Mexico. Redbud can grow on a variety of sites and soils, but does not tolerate flooding, poorly drained, or sandy soils. It is tolerant of nutrient deficient sites which can help it become established due to poor competition.

Life History:

Flowers precede leafing and usually occur from March to May. The fruit matures and remains on the tree till after fall. Seeds are usually dispersed by wind or animals. The seeds that fall to the ground usually remain dormant for several years. Once a seedling becomes established it can endure much shade. As the tree ages it becomes less tolerant of shade though. It is classified as being shade tolerant.

Eastern redbud and the Great Trinity Forest:

This shrubby tree has been noted to occur in the forest. Because of its aesthetic nature it could be considered a desirable understory shrub, but could compete with planted hardwoods on some sites and should be controlled in that case with herbicides.

Cercis canadensis L.

Eastern Redbud

Leguminosae -- Legume family

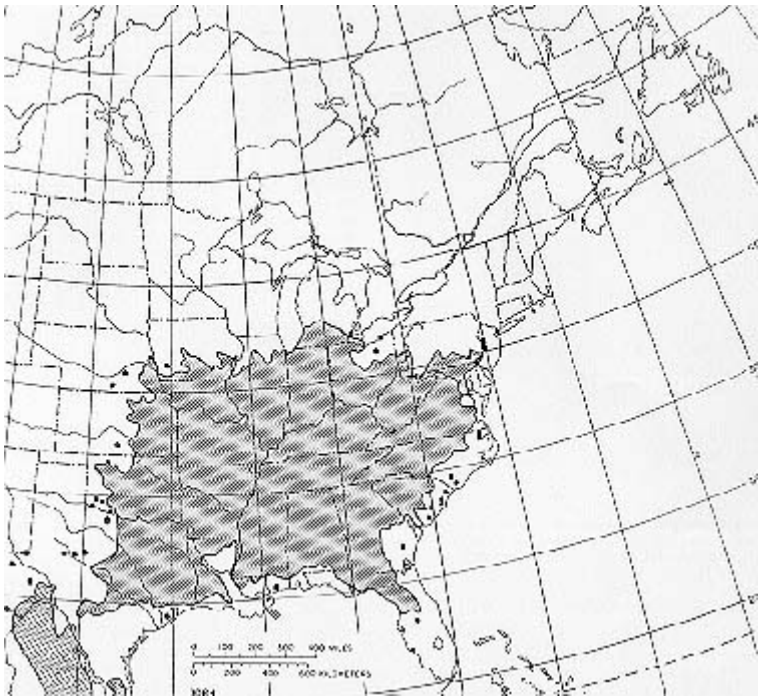
James G. Dickson

Eastern redbud *(Cercis canadensis)* is a small, short-lived deciduous tree found throughout the eastern United States. Redbud is also known as Judas-tree. According to legend, Judas Iscariot hanged himself from a branch of the European species *Cercis siliquastrum* (13). Eastern redbud is a strikingly conspicuous tree in the spring because it flowers before other tree leaves form. The wood is heavy, hard, and close-grained, but because of the small size and irregular shape of the tree it is of no commercial value as a source of lumber. This tree is most valued as an ornamental and is extensively planted.

Habitat

Native Range

The range of eastern redbud is from New Jersey and southern Pennsylvania northwest to southern Michigan, southwest into southeastern Nebraska, south to central Texas, and east to central Florida (8). A disjunct population of redbud extends from the Trans-Pecos and south Texas into Mexico.



-The native rane of eastern redbub.

Climate

A wide range of climatic conditions are present in the large geographical range of redbud. Mean annual precipitation is less than 510 mm (20 in) in dry south Texas and approximately 1270 mm (50 in) in moist central Florida. Mean annual snowfall in the northern perimeter of redbud is about 90 cm (35 in). Mean January temperatures vary from -8° C (18° F) to 16° C (61° F) within the native range of redbud. Mean July temperatures vary from about 21° C (70° F) in southern Pennsylvania to 26° C (79° F) in central Florida. Frost-free days can vary from 160 to 300 days.

Soils and Topography

Redbud is found on a variety of sites ranging from xeric to mesic but grows better on moist, well-drained sites. It is normally more abundant on south-facing slopes where sunlight is more intense and there is less plant competition (11). This species does not usually grow on flooded sites because it cannot endure inundation or survive in poorly aerated soils.

The tree grows well in a variety of soil textures but is not found in coarse sands (11). It requires some fine or colloidal material. Redbud is tolerant of a wide pH range but grows best where the pH is above 7.5. It is prevalent on limestone outcrops and on alkaline soils derived from them (11,12). Redbud is tolerant of nutrient deficiencies. Therefore, less competition can occur from associated trees that are less vigorous on the nutrient deficient sites. In Indiana no relationship was noted between distribution of redbud and soil calcium or magnesium. Redbud is found on soils of most soil orders, but most commonly on those of the orders Alfisols and Mollisols.

Associated Forest Cover

Redbud is a regular but usually not a common understory component of many forest types throughout the Eastern United States. It is not a commercial timber species, and although it grows in many forest cover types, it is not listed in all of them by the Society of American Foresters (4).

Life History

Reproduction and Early Growth

Flowering and Fruiting- Redbud flowers are pink to reddish purple, and rarely white. They are home on pedicels in clusters of two to eight. Flowers are produced from small buds on old twigs, branches, and trunks. Flowers are bisexual and the tree is self-pollinating. Flowering usually occurs sometime from March to May and precedes leafing. In Indiana, the tree requires 30 days of temperatures averaging more than 10° C (50° F) . Previous winter chilling also enhances flowering (11). Pollination is usually accomplished by bees. After 2 or 3 weeks leaves appear and the flowers drop. The ovaries of one to several flowers in most flower clusters enlarge and develop into fruits that reach their full size by midsummer (13). Fruits are flat reddish-brown pods about 1.3 cm (0.5 in) wide and 5 to 10 cm (2 to 4 in) long (16). Each fruit contains 4 to 10 brown, hard, compressed bean-like seeds, each about 6mm (0.25 in) long. The fruits remain on the tree until after leaf fall; some persist throughout winter (15).

Seed Production and Dissemination- Seeds are released by the opening of fruit sutures or decay of the fruit wall. Most seeds are dispersed during fall and winter by wind and animals. Many seeds are injured by insects. Those that fall to the ground usually remain dormant for several years (1).

For artificial propagation, seeds should be collected, cleaned, and dried when ripe to avoid insect damage. Dried seeds can be stored in sealed glass or metal containers at 2' to 5' C (35' to 41° F). Seed treatment is necessary for propagation because redbud shows delayed germination due to impermeability of the seed coat to water and dormancy of the embryo (1). The seed coat can be made permeable to water by mechanical scarification or by immersion in boiling water or in concentrated sulfuric acid for about 30 minutes. After scarifying, seeds should be stratified in moist sand at about 5° C (41' F) for 5 to 8 weeks (14).

Prepared seeds should be sown in well-prepared seedbeds in late April or early May (14). Moist soil should cover seeds at a maximum depth of 0.5 em (0.2 in). Propagation can also be accomplished by layering or cuttings.

Seedling Development- Approximate site characteristics and seedling vigor determine seedling establishment. Germination is epigeal (14). Under optimum conditions seedlings can grow 0.3 m (1 ft) in height the first growing season. Continuous terminal growth is related to light intensity, photoperiod, and temperature (11). Once established, seedlings can endure much shading.

Vegetative Reproduction- No information available.

Sapling and Pole Stages to Maturity

Growth and Yield- Development of young redbud to the flowering stage is rapid. Young redbuds have been observed first flowering when less than 7 years old but do not fruit the first year of blossoming. Annual cambial growth begins just before flowering and shoot growth usually begins during flowering (11). In Indiana terminal growth of saplings started when the weekly mean of the daily mean temperature reached 13° C (55° F). Maximum growth was reached the fourth week and growth ceased after 6 to 10 weeks under low soil moisture conditions. With adequate soil moisture, terminal growth continued until frost. More than 1076 lux (100 lumens/ft^2) of light and more than 13 hours of daylight daily are needed to maintain terminal growth of saplings.

Rooting Habit- Redbud develops a deep taproot that descends rapidly the first few years if the soil permits. Initial growth depends on soil moisture and the absence of a tight clay subsoil. If impenetrable subsoils are present the taproot grows horizontally. Secondary roots appear when the taproot is 5 to 8 cm (2 to 3 in) long and grow rapidly.

Reaction to Competition- As redbuds grow and mature they become less shade tolerant. Old trees usually suffer from heart rot and cannot normally tolerate severe competition and shade. Redbud is most accurately classed as tolerant of shade.

Damaging Agents- Redbud is a host to a variety of insects, but damage is not normally severe. Bark and phloem borers include three species of *Hypothenemus,* and *Pityophthorus lautus (2).* A seed beetle, *Gibbobruchus mimus,* breeds in the seed of redbud.

Numerous wood borers have been found in redbud. *Agrilus otiosus,* three species of *Hypothenemus,* three species of *Micracis,* two species of *Microcisella, Pityophthorus lautus, Ptosima gibbicollis,* and *Thysanoes fimbricornis* all inhabit portions of the wood of redbud.

Other insects feed on the leaves of redbud. The redbud leaffolder, *Fascista cercerisella,* feeds on leaves which the larvae web together. The grape leaffolder, *Desmia funeralis,* an important pest of grape, also feeds on redbud. The Japanese weevil, *Callirhopalus bifasciatus,* and *Norape ovina* both consume redbud leaves.

Other insects feed on redbud by extracting juices from the plant. The twolined spittlebug, *Prosapia bicincta,* has been recorded feeding on redbud. The terrapin scale, *Mesolecanium nigrofasciatum,* and San Jose scale, *Quadraspidiotus perniciosus,* like most of the other redbud parasites, inhabit a variety of hosts including redbud. The periodical cicada, *Magicicada septendecim,* lays its eggs in more than 70 species of trees and other plants, including redbud.

There are three main diseases of redbud: leaf anthracnose, *Mycosphaerella cercidicola,* Botryosphaeria canker, and Verticillium wilt (6). The most serious is the canker *Botryosphaeria ribis* or its variety *chromogena.* The species is mainly a saprobe; the variety is a parasite. This variety produces stem and twig lesions and entire groves of redbuds have been killed by this disease. Verticillium wilt *(Verticillium albo-atrum)* sometimes kills redbuds, especially in the Midwestern United States. Redbud is vulnerable to Texas root rot *(Phymatotrichum omnivorum),* but redbud is not commonly grown in its range. A variety of sap and heart rots also infect eastern redbud.

Special Uses

The eastern redbud is extensively planted as an ornamental throughout the Eastern United States. It is tolerant of a wide range of site conditions, is not especially vulnerable to insects or diseases, is relatively easy to maintain, and makes a beautiful shrub or small tree, especially when flowering.

Bark of redbud has been used as an astringent in the treatment of dysentery. Flowers of the tree can be put into salads or fried and eaten (16). There is some documented wildlife use of redbud fruit. Cardinals have been observed feeding on the seeds, and seeds have been consumed by ring-necked pheasants rose-breasted grosbeaks (5), and bobwhites (7) White-tailed deer and gray squirrels have also been observed feeding on the seeds (5). Flowers of the tree are regarded as important in the production of honey by bees (10).

Genetics

Donselman (3) investigated morphological variation in trees grown from seed collected from 13 diverse locations in the range of redbud. He concluded that trees from more xeric locations in the Southwestern and western portions of the range exhibited adaptations to high solar radiation, drying winds, low humidity, low soil moisture, and other environmental factors associated with high evapotranspiration. Leaves from those plants were thicker and smaller, had increased pubescence, and showed more efficient stomatal geometry than trees from mesic locations.

Two subspecies of redbud have been identified: Texas redbud *(Cercis canadensis* var. *texensis)* found in southern Oklahoma, Trans-Pecos Texas, and southeastern New Mexico; and eastern redbud (C. *canadensis* var. *canadensis)* found in the remainder of the range of redbud (9). Another native *Cercis* species, California redbud *(C. occidentalis),* is found in Utah, Nevada, California and Arizona.

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Eastern Redcedar

Juniperus virginiana L.

Other Common Names:

Red juniper, or savin.

Brief Description:

Although not generally considered a commercial species, eastern redcedar wood is highly valued for its beauty, durability, and workability. It can be found growing on a variety of sites and is useful in soil stabilization applications. Eastern redcedar also provides unique habitat for wildlife.

Habitat:

Eastern redcedar can be found in every state east of the 100th meridian. Its range has been extended westward through plantings. This species is frequently associated with areas of thin rocky soils called glades. In general it can be found growing on ridge tops, slopes, flat land, but is commonly found invading dry abandoned fields and fencerows.

Life History:

Seed production and flowering occurs at about age 10. Flowers appear in late September and cones begin to form. Fertilization occurs the following June and seeds are mature in about two months. Cones do not open and will remain on the tree through the winter unless eaten and dispersed by animals. The remaining cones are dispersed in February and March. Most seed germination occurs the second spring after dispersal. Seedling survival can be low but once established it is a vigorous competitor. Eastern redcedar is intolerant to very intolerant of shade, but can survive beneath the canopies of other trees on better sites. It is a pioneering early successional species.

Eastern redcedar and the Great Trinity Forest:

Redcedar is found on the transitional and rocky upland areas of the forest. It provides unique diversity to the forest both for wildlife and visitors. It could be used as a hedge on upland areas, possibly in conjunction with Osage-orange. Its dense nature both as an individual tree and in its association with others of the same species provides cover for wildlife and a nesting habitat for certain species of birds.

Juniperus virginiana L.

Eastern Redcedar

Cupressaceae -- Cypress family

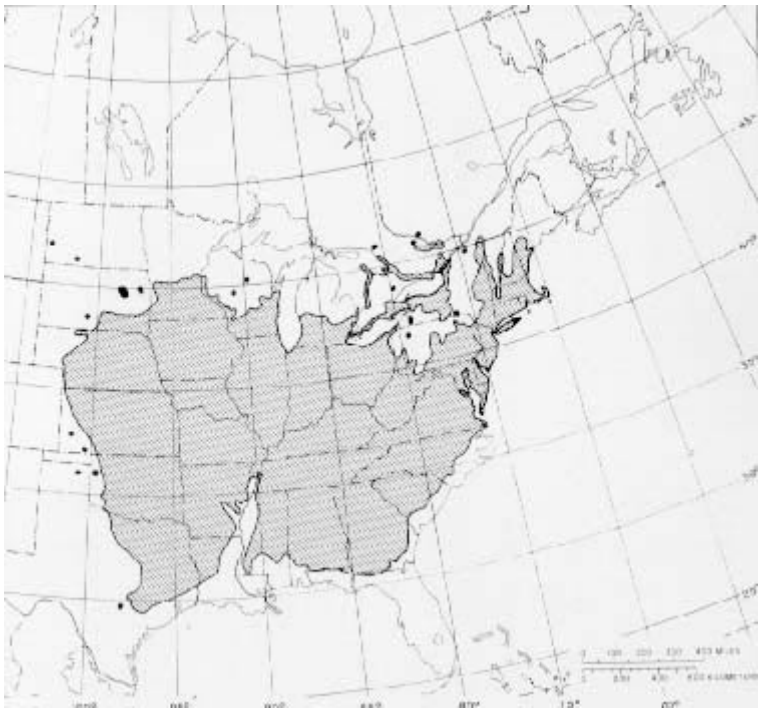
Edwin R. Lawson

Eastern redcedar *(Juniperus virginiana)*, also called red juniper or savin, is a common coniferous species growing on a variety of sites throughout the eastern half of the United States. Although eastern redcedar is generally not considered to be an important commercial species, its wood is highly valued because of its beauty, durability, and workability. The number of trees and volume of eastern redcedar are increasing throughout most of its range. It provides cedarwood oil for fragrance compounds, food and shelter for wildlife, and protective vegetation for fragile soils.

Habitat

Native Range

Eastern redcedar is the most widely distributed conifer of tree size in the Eastern United States and is found in every State east of the 100th meridian. The species extends northward into southern Ontario and the southern tip of Quebec (27). The range of eastern redcedar has been considerably extended, especially in the Great Plains, by natural regeneration from planted trees (47).



- *The native range of eastern redcedar.*

Climate

The wide natural distribution of eastern redcedar clearly indicates its ability to grow under varying and extreme climatic conditions. Average annual precipitation varies from about 380 mm (15 in) in the northwestern section to 1520 mm (60 in) in the southern parts of its range (40). Throughout the eastern redcedar range, average precipitation from April through September measures from 380 mm (15 in) to 760 mm (30 in). This suggests that summer precipitation may be more limiting to the species than average annual precipitation. Average annual snowfall ranges from a trace to more than 254 cm (100 in).

Average annual temperatures vary from about 4° C (40° F) in the north to 20° C (68° F) in the southern part of the botanical range. Average annual maximum temperature ranges only from about 32° C (90° F) to 41° C (105° F), but average minimum temperature ranges from -43° C (-45° F) to -7° C (20° F). The growing season varies from about 120 to 250 days.

Soils and Topography

Eastern redcedar grows on a wide variety of soils, ranging from dry rock outcrops to wet swampy land (15). The most common soils fall within the soil orders Mollisols and Ultisols. No attempt will be made here to describe all of them. Like most species, eastern redcedar grows best on deep, moist, well-drained alluvial sites, where its height may reach 17 to 18 m (55 to 60 ft) in 50 years. On the better sites, however, hardwood competition is so severe that the species rarely becomes dominant. Eastern redcedar also grows well on deep, upland soils, particularly abandoned farmland. A 0.4-hectare (1-acre) plantation established in Arkansas from wildlings,

with spacing of 1.8 by 1.8 m (6 by 6 ft), yielded a basal area of 37.4 m^2/ha (163 ft^2/acre) and an estimated 196 m^3/ha (2,800 ft^3/acre) of merchantable volume in 44 years (11).

The species is frequently associated with areas commonly called glades, characterized by thin rocky soils and intermittent rock outcrops; soil depth is difficult to determine because soil rock content and depth of rock fissures vary (11,16). Soils on the poorest glade sites are less than 30 cm (12 in) deep, medium sites are usually less than 61 cm (24 in) deep and have large crevices, and good sites have deeper soil. Arend and Collins (3) developed the site classification system shown in table 1.

Table 1- Site classes for natural stands of eastern redcedar in northern Arkansas

	Site Class			
Item	**I**	**II**	**III**	**IV**
Soil character	alluvial	upland	upland	upland
Soil depth, cm	61+	61+	30 to 58	less than 30
Soil depth, in	24+	24+	12 to 23	less than 12
Site index[1]				
Open stand, m	16.8	13.7	10.7	7.6
Open stand, ft	55	45	35	25
Closed stand, m	18.3	15.2	12.2	9.1
Closed stand, ft	60	50	40	30

[1]Adjusted to base age 50 years.

Eastern redcedar grows on soils that vary widely in acidity. Soils found in natural stands range in pH value from 4.7 to 7.8. Although the species will grow on sites that are slightly alkaline, it is not particularly tolerant to higher pH levels. Eastern redcedar is, in fact, among the least alkali-tolerant of drought-hardy trees and shrubs. Soils in eastern redcedar stands tend to become neutral or slightly alkaline because the high calcium content of the tree's foliage can change the pH of the surface soil in a relatively short time. This condition also increases earthworm activity, with an increase in incorporation of organic matter, a lower volume weight, and an increase in pore volume and infiltration rate (11,15).

Eastern redcedar grows on ridgetops, varying slopes, and flat land and is frequently found on dry, exposed sites and abandoned fields. This aspect also influences eastern redcedar development. In the western part of its range, the species may be found on north-facing slopes and along streambanks where there is some protection from high temperatures and drought. Although the most desirable elevation is not clearly delineated, eastern redcedar is found most often growing between 30 m (100 ft) and 1070 m (3,500 ft). It is notably absent below the 30 m (100 ft) elevation zone in the southern and eastern parts of the species range (15,27).

Associated Forest Cover

Pure stands of eastern redcedar are scattered throughout the primary range of the species. Most of these stands are on abandoned farm lands or drier upland sites. The forest cover type Eastern Redcedar (Society of American Foresters Type 46) is widespread and therefore has many associates (10).

Variants of the type are eastern redcedar-pine, eastern redcedar-hardwood, and eastern redcedar-pine-hardwood. The eastern redcedar-pine variant is composed of eastern redcedar and either shortleaf pine *(Pinus echinata)* or Virginia pine *(P. virginiana)* and is found throughout the southern half of its range. The eastern redcedar-hardwood variant is found throughout the central part of its range and includes a mixture of red *(Quercus rubra)* and white *(Q. alba)* oaks, hickories *(Carya* spp.), black walnut *(Juglans nigra),* and other hardwoods. The third variant, eastern redcedar-pine-hardwood, includes all of the above species associations (15). Eastern redcedar appears as a minor component of several other forest cover types.

Eastern redcedar is among the first to invade abandoned fields and areas cleared for pasture (25). On deeper soils, persimmon *(Diospyros virginiana)* and sassafras *(Sassafras albidum)* are associated invaders and may crowd it out. In cedar glades, the species is commonly associated with blackjack oak *(Quercus marilandica),* winged elm *(Ulmus alata),* fragrant sumac *(Rhus aromatica),* Carolina buckthorn *(Rhamnus caroliniana),* rusty blackhaw *(Viburnum rufidulum),* and Alabama supplejack *(Berchemia scandens).* Little bluestem *(Andropogon scoparius),* big bluestem *(A. gerardi),* yellow Indiangrass *(Sorghastrum nutans),* switchgrass *(Panicum virgatum),* dropseed *(Sporobolus* spp.), and numerous composites and legumes are common herbaceous plants.

Life History

Reproduction and Early Growth

Flowering and Fruiting- Eastern redcedar is a dioecious species, and trees probably reach sexual maturity at about 10 years. Staminate strobili or conelets begin to develop on male trees at the tips of axillary branches of new scale-leaves. Pollen grains are formed by late September in conelets having 10 to 12 entire-margined sporophylls. Staminate strobili turn a conspicuous yellowish brown when they reach maturity during winter, and thus male trees are readily distinguished from ovulate ones.

Small green conelets begin to develop by early fall or late summer on ovulate trees but grow very little during the winter. They are borne terminally on axillary branches of the new scale-leaves but do not become conspicuous until late February to early spring. At this time the microsporangial walls of the staminate conelets split longitudinally, discharging the mature pollen. Pollen grains lodge at the end of the micropyle of the many ovules in the conelet. Pollination is complete in a few days when the conelet closes.

Growth of the pollen tube is slow at first but becomes active by late May or mid-June. Fertilization occurs in June and the mature embryo is full grown in about 2 months, anytime from late July to mid-November, depending on location. As the ovulate cone develops, greenish fruit-scales form the outer fleshy protective coat of the berrylike cone. Cones change color from green to greenish white to whitish blue and finally to bluish as the season progresses.

Each cone or fruit contains one to four (occasionally more) rounded or angled brownish seeds, 2 to 4 mm (0.08 to 0.16 in) long, often with longitudinal pits. The seed coat has a thick and bony outer layer and a thin, membranous inner layer (23,47).

Seed Production and Dissemination- Mature eastern redcedar trees produce some seeds nearly every year, but good crops occur only every 2 or 3 years. The cones do not open and will remain on the tree through the winter, although many are eaten and dispersed by animals. Most remaining cones are dispersed in February to March. Mature fruits are usually collected in the fall by hand-stripping or shaking onto canvas. Seeds may be stored as dried fruits or cleaned seeds.

After fanning to remove leaves, twigs, and other debris, the seeds can be extracted by running the fruit through a macerator and floating the pulp and empty seeds away. Dried fruits should be soaked in water several hours before macerating. Since eastern redcedar fruits are resinous, they should be soaked in a weak lye solution for 1 or 2 days. The soaking helps separate the oily, resinous pulp from the seeds and aids further washing, flotation, and stratification. This treatment should be followed by thorough washing (45). The cleaned seeds are ready for use, or they can be dried to 10 to 12 percent moisture content for storage at -7° C (20° F) to 4° C (40° F). The number of cleaned seeds per kilogram ranges from 81,570 (37,000/lb) to 121,250 (55,000/lb) and averages 96,120 (43,600/lb) (23). If seeds are to be sown in the spring, they should be soaked in a citric acid solution (10,000 ppm) for 96-hours, placed in moist-warm stratification at 24° C (75° F) for 6 weeks, and finally placed in moist-cool stratification at 5° C (41° F) for 10 weeks. Germination is best if fresh seeds are used. If desired, dry, stored seeds may be sown in mid-July, which accomplishes moist-warm stratification, and the over-winter period accomplishes moist-cool stratification for early spring germination (46).

In nursery practice, eastern redcedar seeds are broadcast or sown in rows spaced 15 to 20 cm (6 to 8 in) apart in well-prepared seedbeds and covered with about 6 mm (0.25 in) of firmed soil or sand. Stratified seeds should be sown in the spring early enough to allow completion of germination before air temperatures exceed 21° C (70° F). Germination of stratified seed usually begins in 6 to 10 days after sowing and is completed in 4 to 5 weeks. Untreated seeds may be sown in the fall and mulched until germination during the second spring after planting (23); but

when fruits are depulped, dried, and stored at -16° C (4° F), seeds germinate the first spring after summer sowing (46). Germination is epigeal.

Fruits are eaten by birds and other animals, which are important vectors for seed dissemination (20). Seeds that pass through animal digestive tracts and those that remain on the ground beneath the trees may germinate the first or second spring. Most of the natural germination of eastern redcedar seed takes place in early spring of the second year after dispersal.

Eastern redcedar may also be established by hand direct-seeding or machine-sowing (29). Both hand and furrow seeding are successful when stratified seeds are used at the rate of 1.35 kg/ha (1.2 lb/acre). Seedling catch is best where the amount of litter has been reduced and hardwood competition has been completely removed. The rate of sowing may be adjusted to allow for variations in germinative capacity of the seeds and degree of competition control.

Seedling Development- Eastern redcedar seedlings grown in nurseries may be transplanted from seedling beds after 1 or 2 years. Spacing in transplant beds ranges from about 15 by 3 cm (6 by 1 in) to 20 by 5 cm (8 by 2 in), depending on locality. The age at which trees are outplanted varies from area to area. Generally, eastern redcedar is field planted as 2-0, 3-0, 1-1, 1-2, 2-1, or 2-2 stock (numbers refer respectively to growing seasons in seedling beds and transplant beds).

Survival and growth of planted stock can be improved by grading the seedlings just after lifting from the nursery beds. Seedlings that are relatively small, topheavy, oversized, damaged, diseased, or insect-infested are discarded (37). Culling after lifting from transplant beds is usually 1 to 3 percent, compared to 5 to 20 percent from seedling beds. Eastern redcedar seedlings should have a stem diameter of at least 4.0 mm (0.16 in), but preferably 5.6 mm (0.22 in), at the ground line. It is also desirable for seedlings to have top green weights that are no more than 3 to 4 times heavier than the roots (26,36). Seedlings having higher top-to-root ratios are more likely to die under environmental stress.

Survival of eastern redcedar plantations has been variable, with low survival being attributed to poor seedling quality, low site quality, and competition. If these factors are considered carefully, however, eastern redcedar plantations can be successfully established. One early plantation established from hand-pulled wildlings had 84 percent survival. In a Nebraska plantation, established with 2-0 seedlings from 204 sources of eastern redcedar and Rocky Mountain juniper, first-year survival averaged 95.1 percent. Four other plantations from these sources averaged more than 85 percent survival, although one in Oklahoma had only 19.7 percent (11,38).

Most natural eastern redcedar regeneration takes place on relatively poor hardwood or pine sites, along fence rows, or in pastures that are not burned or mowed. Seedlings are commonly established in rather open hardwood stands, adjacent to older seed-bearing eastern redcedar trees, as a result of birds eating the fruit and subsequent deposition of seeds (34). On very dry sites, most seedlings are found in crevices, between layers of limestone, and in other protected places where the microclimate is most favorable. Seedling development is relatively slow on these adverse sites, although eastern redcedar seedlings withstand drought rather well (4,22). First-year seedlings do not produce much height growth but develop a long fibrous root system (15).

Plantings from 2-0 stock showed good growth in some areas, however, exceeding 45 cm (17.8 in) in height after one growing season (38). If competition from an overstory is rather severe, eastern redcedar seedlings may not survive. Once established, however, eastern redcedar survives for extended periods under severe competition (15,28). Eastern redcedar also competes very well in shelterbelts, where it is the most common natural reproduction (43).

Vegetative Reproduction- Eastern redcedar does not reproduce naturally by sprouting or suckering, but the species may be propagated by grafting, by air-layering, or from cuttings (6,15,33,44).

Sapling and Pole Stages to Maturity

Growth and Yield- Growth rates of eastern redcedar depend largely on site quality, competition from other species, and stand density. These factors probably reflect competition for available soil moisture on most sites. Trees 20 to 30 years old are generally 5 to 8 m (18 to 26 ft) tall and 6 to 8 cm (2.3 to 3.0 in) in d.b.h. Mature trees are usually 12 to 15 m (40 to 50 ft) tall and 30 to 61 cm (12 to 24 in) in d.b.h. On good sites, trees may reach 37 m (120 ft) in height and 122 cm (48 in) in d.b.h. (25).

Some of the earliest data on diameter growth in natural eastern redcedar stands is presented in table 2 (3). Site classes mentioned are those described in table 1. Analysis of these data provided equations to compute the height-age relationships in table 3. The relation of height of dominant and codominant trees to d.b.h. and stand density was also determined, after pooling of data for age and site classes (11). Height growth, a reflection of soil depth and fertility, increases with stocking density (fig 1).

Table 2- Average annual diameter growth of dominant eastern redcedar by site class and stand density[1]

	Site Class			
Stand character	**I**	**II**	**III**	**IV**
		mm		
Under-stocked	7.6	8.1	4.6	3.6
Well-stocked	-	8.1	4.3	3.0
Over-stocked	-	3.8	2.5	1.8
		in		
Under-stocked	0.30	0.32	0.18	0.14
Well-stocked	-	0.32	0.17	0.12
Over-stocked	-	0.15	0.10	0.07

[1]Based on increment core measurements of 456 trees (3).

Table 3- Total height of eastern recedars by age[1] and site class

	Site Class			
Growth rings	**II**		**III**	
	m	***ft***	***m***	***ft***
10	4.6	15	3.7	12
15	5.5	18	5.2	17
20	7.6	25	6.1	20
25	8.5	28	7.3	24
30	9.8	32	7.9	26
35	10.7	35	8.8	29
40	11.3	37	9.4	31
45	12.2	40	10.1	33
50	12.8	42	10.7	35

[1]Age was computed using the total number of growth rings; false rings make accurate determinations difficult.

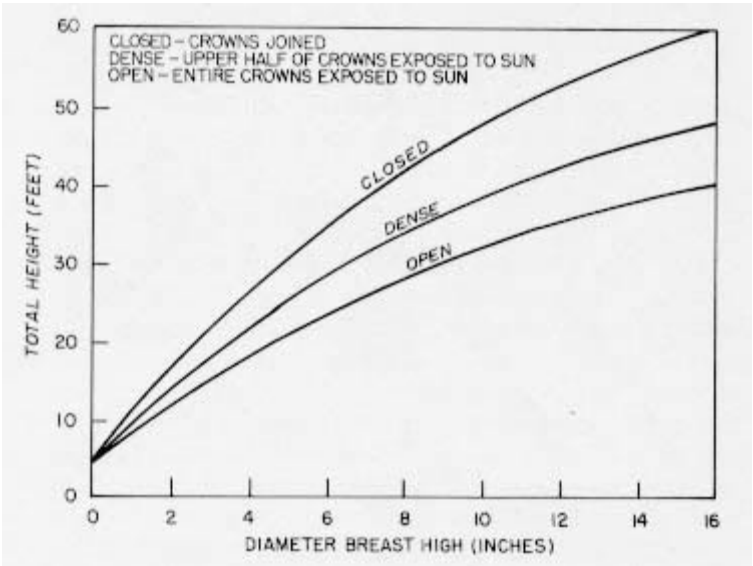


Figure 1- *Relation of height to d.b.h. by stocking class.*

Other studies in Arkansas have shown that growth and yield are affected by stand density and hardwood competition. In a 45-year-old eastern redcedar stand, highest volume growth was obtained in unthinned stands from which hardwoods had been removed. Volumes averaged 1.96

m^3/ha (28 ft^3/acre) per year during a 14-year period. This was double the growth of stands where hardwoods were left. A stand containing 432 crop trees per hectare (175/acre), 7.6 cm (3.0 in) d.b.h. and larger grew nearly the same volume after 14 years when 80 percent of the competition was removed as an unreleased stand of 988 trees per hectare (400/acre) (11).

Over a 10-year period in northern Arkansas, completely released stands averaged higher growth in d.b.h., basal area, and volume than stands where only crown competition was removed. The greatest mean d.b.h. growth, 6.4 cm (2.5 in), occurred with the lightest stocking, 124 crop trees per hectare (50/acre). As stocking increased, mean d.b.h. growth decreased. Basal area increase was greatest in stands having 988 crop trees per hectare (400/acre), and as stocking decreased, basal area and volume growth decreased. An initial stocking of 988 eastern redcedar crop trees per hectare (400/acre), averaging about 7.6 cm (3 in) d.b.h., produced over 28 m^3/ha (2,000 fbm/acre) in 10 years. A stocking of 432 trees per hectare (175/acre), averaging 10.2 cm (4 in) d.b.h., produced slightly more volume during the same period on similar sites (11).

On most sites eastern redcedar grows slowly, and long rotations are required to produce conventional sawlogs. Because the wood is used for small items, however, and there is wide latitude in acceptable defects, shortening of rotations and intermediate harvesting of merchantable wood are possible. About 20 to 30 years are required for posts and 40 to 60 years for sawtimber (11,25).

Maintaining relatively dense stands can maximize post production. Thinning one or more times before harvest cut hastens sawlog production but may not increase total yield. The ideal density for growing sawlogs is not known, but excessive thinning may promote excessive formation of sapwood and growth of lower branches.

Rooting Habit- On shallow and rocky soils, eastern redcedar roots are very fibrous and tend to spread widely. Even first-year seedlings begin developing a long fibrous root system, often at the expense of top growth (15). If soil conditions permit, eastern redcedar trees develop a deep, penetrating taproot.

Root development is greatly influenced by the size of soil-filled fissures. Eastern redcedar roots are known to grow extensively in soils in which limestone rocks make up more than 52 percent of the total soil volume (11).

Reaction to Competition- Eastern redcedar has been classified as intolerant to very intolerant of shade (11,30), but trees that have lived for decades beneath a full canopy of hardwoods or pines on medium- to low-quality sites have been observed. Apparently, eastern redcedar has an inherent low capacity for water loss and the ability to sustain stomatal opening at low water potentials, which help the species adapt to dry environments (4). Eastern redcedar can also conduct photosynthesis when overstory hardwoods are leafless and perhaps even reduces its light requirements for photosynthesis by adjusting to shaded conditions (17,24). Eastern redcedar is a pioneer species on surface-mined areas, old fields, or pastures that are protected from fire; and it is the primary natural reproduction in many shelterbelts. However, stands formed through invasion of old fields may deteriorate at around 60 years of age as hardwoods or other competing species become established. Eastern redcedar grows well and faster than associated species

because it is sun-adapted, drought-resistant, and has a long growing season. On most sites, eastern redcedar is temporary and is eventually replaced by more tolerant hardwoods and pines. However, clusters of eastern redcedar established beneath hardwoods have survived longer than the competing hardwood trees, possibly due to an allelopathic effect, or the species may be a better competitor for water and nutrients (34). The species is more permanent on poor sites having thin, rocky soils, such as the glades of the Ozarks of Missouri and Arkansas and the Nashville Basin in central Tennessee. Eastern redcedar invasion of pastures is a problem on areas converted from poor hardwood sites in the Ozarks and western areas of its range (9,31), and the species is likely to persist for a long time if left to grow (7).

Eastern redcedar should be managed in even-aged stands, judging from studies conducted in northern Arkansas (11). Good growth rates can be maintained by controlling competition and stand densities.

Damaging Agents- Fire is probably the worst enemy of eastern redcedar. The thin bark and roots near the ground surface are easily injured by fires. Some natural protection against fire exists because its foliage does not bum well and litter accumulation is minimal under stands on thin soils (11,15).

Several insects damage eastern redcedar trees but rarely cause serious permanent damage (5). Roots of seedlings are very susceptible to attack by nematodes and grubs. The foliage is eaten by bagworms *(Thyridopteryx ephemeraeformis)* and spruce spider mites *(Oligonychus ununguis),* both of which can completely defoliate trees. The eastern juniper bark beetle *(Phloeosinus dentatus)* attacks the species but usually does not kill trees except when the attack is associated with the root rot fungus, *Heterobasidion annosum.* Another bark beetle *(Phloeosinus canadensis*) may feed on eastern redcedar. Several boring insects, including the black-horned juniper borer *(Callidium texanum),* cedartree borer *(Semanotus ligneus),* cypress and cedar borer *(Oeme rigida),* and pales weevil *(Hylobius pales)* will attack eastern redcedar. The juniper midge *(Contarinia juniperina) is* a gall insect pest of redcedar which bores into the twigs at the base of needles and kills the portion beyond the entrance hole. In addition to pales weevil, two other weevils, the arborvitae weevil *(Phyllobius intrusus)* and the strawberry root weevil *(Otiorhynchus ovatus),* feed on roots of eastern redcedar. The latter two weevils are also leaf feeders, along with the juniper webworm *(Dichomeris marginella);* a wax moth *(Coleotechnites juniperella);* a leaf roller *(Choristoneura houstonana),* a pest of windbreak and ornamental plantings; and a sawfly *(Monoctenus melliceps).* The Fletcher scale *(Lecanium fletcheri)* and juniper scale *(Carulaspis juniperi)* are two other commonly occurring insects that attack junipers.

Eastern redcedar, especially when weakened by stress or insects, is very susceptible to damage by the root rot fungus, *Heterobasidion annosum.* This disease is thought to cause the greatest damage over much of its range. Cubical rot fungi *(Fomes subroseus* and *Daedalea juniperina)* and juniper pocket rot fungus *(Pyrofomes demidoffii)* enter eastern redcedars through dead branch stubs and attack the heartwood. Several other minor heart-rot fungi infect eastern redcedar (21).

The major stem and foliage diseases of eastern redcedar are fungi known as cedar rusts in the genus *Gymnosporangium.* The most commonly known and widely spread species is cedar apple rust *(G. juniperi-virginianae),* which attacks trees in all stages of development. Because it is an alternate host to this disease, the presence of redcedar is a problem to apple growers. Other common species are *G. clavipes, G. globosum, G. effusum,* and *G. nidus-avis.* The latter fungus is widely distributed and produces witches' brooms (21). Important foliage diseases include Phomopsis blight *(Phomopsis juniperovora)* and *Cercospora sequoiae* blight, which also attack seedlings. Phomopsis blight has been difficult to control in nurseries, but newer developments show promise (12,32). Both blights can cause major losses to eastern redcedar in the field, but Phomopsis blight is not a serious problem after seedlings reach age 4.

Newly established seedlings are subject to frost-heaving, and foliage may occasionally be damaged by winter injury (23). Mice and rabbits may damage young eastern redcedar seedlings. Livestock generally avoid biting seedlings or trees but may trample the plants and their roots while grazing. During times of scarce food, deer will heavily browse eastern redcedar and destroy most reproduction (11,20). Redcedar withstands the weight of snow fairly well, but it has only moderate resistance to ice damage (8). Although the species is generally very tolerant to drought and temperature extremes, the author observed considerable mortality in west central Arkansas associated with the extremely hot, dry summer of 1980.

Special Uses

Eastern redcedar is important to wildlife. As an evergreen, it provides good nesting and roosting cover for many birds (18,39). Dense thickets provide good escape cover for deer, and the abundant foliage, although low in quality, provides emergency food for them during times of stress. Fruits are high in crude fat and crude fiber, moderate in calcium, and very high in total carbohydrates. Eastern redcedar fruits are eaten by many wildlife species, including waxwings, bobwhite, quail, ruffed grouse, pheasant, wild turkeys, rabbits, foxes, raccoons, skunks, opossums, and coyotes (20).

Eastern redcedar is among the best trees for protecting soils from wind erosion and reducing the desiccating effects of wind. It ranks high in the Great Plains shelterbelt plantings because of its ability to withstand extremes of drought, heat, and cold (15). In Nebraska, eastern redcedar was the most suitable species among five combinations tested for single-row field windbreaks (42). The fibrous root system also helps to hold soil in place, especially on shallow soils. Many varieties of eastern redcedar are used as ornamental plantings (19,35). The species is also ranked among the top five for Christmas trees (25). Eastern redcedar is also important as a source of cedarwood oil, which is a natural product for direct use in fragrance compounding or as a source of raw material producing additional fragrance compounds (1).

Genetics

Population Differences

Eastern redcedar displays great diversity in phenotypic characteristics such as tree form, foliage color, and crown shape. Van Haverbeke's study (41) included a total of 43 gross morphological, foliage, cone, and seed characteristics and biochemical data derived from cone pulp. He points out that much of the research on morphological characteristics of eastern redcedar has been in the central and western parts of the species' range. More recently, however, information on genetic variation in natural stands in the eastern part of its range has been obtained (13). Natural variation in the species may have been modified by past commercial exploitation of natural stands and by the selection, propagation, and distribution of clones (47).

Races and Hybrids

Two distinct varieties have been recognized in the United States. *Juniperus virginiana* var. *crebra* (Fernald) is a northern form having a narrow crown and slightly pitted seeds. The other variety, *J. virginiana* var. *ambigens, is* an intermediate form between eastern redcedar and creeping juniper, *J. horizontalis* Moench (15).

Although there are no recognized hybrids at this time, evidence is mounting that hybridization does occur. Population studies, especially in the western part of eastern redcedar's range, suggest that considerable introgression and perhaps blending of genetic differences have occurred whenever species' ranges overlap; and that *J. virginiana* readily hybridizes with *J. scopulorum, J. horizontalis,* and *J. ashei,* resulting in juniper populations that contain the germ plasm of two or three species (15). Research in the Ozarks, however, showed no evidence of introgression into *J. ashei* by *J. virginiana* where *J. ashei* was surrounded by *J. virginiana (2).*

The relatively strong influence of *J. scopulorum* germ plasm in the western part of the eastern redcedar population suggests that the entire population in the area studied is of hybrid origin (41). This west-to-east flow of *J. scopulorum* germ plasm was further supported by Flake, Urbatch, and Turner (14), who sampled many of Van Haverbeke's sample trees for terpenoid analysis. He proposed an alternative hypothesis that eastern redcedar of eastern and central North America may have been derived from the western juniper complex.

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Green Ash

Fraxinus pennsylvanica Marsh.

Other Common Names:

Red ash, swamp ash, and water ash.

Brief Description:

The most widely distributed of all American ash trees. It is commonly found in moist bottomlands, but its hardiness and good form has enabled its planting throughout North America. White ash is a close relative with which it is commonly lumped with when selling wood products. It has large seed crops that can be beneficial to wildlife.

Habitat:

Green ash can be found east of the Rocky Mountains to the Atlantic, excluding parts of Florida and the Northeastern states. Green ash grows best on moist well drained soils, but can be found on clay soils subject to frequent flooding. It can remain healthy on sites that remain flooded as long as 40 percent of the growing season. Forested sites support better tree growth than old fields.

Life History:

Green ash is dioecious with flowering occurring with the development of leaves. Flowering begins when trees reach heights of 20 to 25 feet and diameters of 3 to 4 inches. Seed fall occurs in late September to early October or as soon as seed ripening is complete. Ash is a light seeded tree and therefore seed dispersal is most commonly by wind and to a limited extent by water. Smaller green ash trees sprout readily. Deer and rabbits will browse new growth when it is available. This leads to understory seedlings that often are of very poor form. It is tolerant of shade and responsive to release from competition. Green ash seedlings can withstand flooding by regenerating new roots from primary roots, developing adventitious water roots on the submerged stem, and by accelerating anaerobic respiration in the absence of oxygen.

Green ash and the Great Trinity Forest:

Green ash is the most abundant tree growing in the forest. It is probably a climax species on most of the sites and yet its light seeds allow it to invade other areas as an early successional forest species.

Fraxinus pennsylvanica Marsh.

Green Ash

Oleaceae -- Olive family

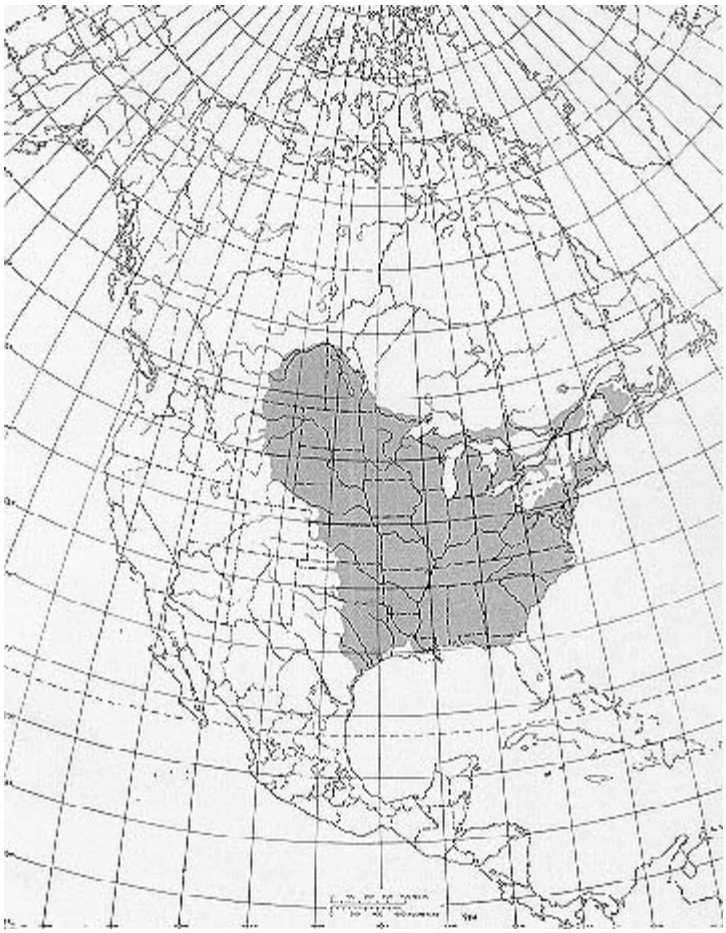
Harvey E. Kennedy, Jr.

Green ash *(Fraxinus pennsylvanica)*, also called red ash, swamp ash, and water ash, is the most widely distributed of all the American ashes. Naturally a moist bottom land or stream bank tree, it is hardy to climatic extremes and has been widely planted in the Plains States and Canada. The commercial supply is mostly in the South. Green ash is similar in property to white ash and they are marketed together as white ash. The large seed crops provide food to many kinds of wildlife. Due to its good form and resistance to insects and disease, it is a very popular ornamental tree.

Habitat

Native Range

Green ash extends from Cape Breton Island and Nova Scotia west to southeastern Alberta; south through central Montana, northeastern Wyoming, to southeastern Texas; and east to northwestern Florida and Georgia.



-The native range of green ash.

Climate

The climate within the range of green ash is subhumid to humid, with the following ranges: Annual precipitation from 380 to 1520 mm (15 to 60 in), warm season precipitation from 250 to 890 mm (10 to 35 in); average January temperature of -18° to 13° C (0° to 55° F); average July temperature of 18° to 27° C (65° to 80° F); snowfall from 0 to 254 cm (0 to 100 in); average length of frost-free season 120 to 280 days.

Solis and Topography

Like most trees, green ash grows best on fertile, moist, well-drained soils. It is probably the most adaptable of all the ashes, growing naturally on a range of sites from clay soils subject to frequent flooding and overflow to sandy or silty soils where the amount of available moisture may be limited (24). Natural stands of green ash are almost completely confined to bottom lands, but the species grows well when planted on moist upland soils. It thrives when planted on medium- to coarse-textured upland sands and loams from North Dakota to Texas where soils had good moisture and neutral to alkaline reactions. Green ash most commonly is found on alluvial soils along rivers and streams and less frequently in swamps (25). It lines the watercourses in the western parts of its range where rainfall is insufficient to support upland growth. It is common on

land subject to flooding and can remain healthy when flooded for as long as 40 percent of the time during a growing season. Green ash grows on soils most common to the orders Inceptisols and Entisols.

In fertilizer experiments, green ash was tolerant of soil alkalinity but showed severe chlorosis when grown on a soil with a pH of 8.1 (25). Culture-species tests on a riverfront site in Mississippi have shown that ash grew well on a silt-loam soil with a pH ranging between 7.5 and 8.0.

Other studies have shown the importance of soil characteristics to tree growth. Growth was much better on soils that had not been cultivated than on ones that had been in cultivation (7). The longer an area had been in cultivation or the more severely eroded the A horizon, the poorer the growth of green ash. Forest sites support better growth than old field sites, probably because of suitable mycorrhizae and organic matter in the forest soils.

Green ash has been planted on spoil banks resulting from strip-mining (25). These soils usually are highly acidic. Survival generally has been high, but annual growth rates of only about 0.3 m (1 ft) have been reported. Studies in Arkansas on sandy loam soils with pH ranging from 5.0 to 5.4 have shown excellent survival and growth rates of 1.5 to 1.8 m (5 to 6 ft) per year.

Associated Forest Cover

Green ash is an integral part of the forest cover type Sugarberry-American Elm-Green Ash (Society of American Foresters Type 93) and is an associated species in the following types (22):

16 Aspen
26 Sugar Maple-Basswood
42 Bur Oak
52 White Oak-Black Oak-Northern Red Oak
62 Silver Maple-American Elm
63 Cottonwood
65 Pin Oak-Sweetgum
87 Sweetgum-Yellow-Poplar
88 Willow Oak-Water Oak-Diamondleaf (Laurel) Oak
89 Live Oak
91 Swamp Chestnut Oak-Cherrybark Oak
92 Sweetgum-Willow Oak
94 Sycamore-Sweetgum-American Elm
95 Black Willow
96 Overcup Oak-Water Hickory
101 Baldcypress
102 Baldcypress-Tupelo
103 Water Tupelo-Swamp Tupelo

Species most commonly associated with green ash are boxelder *(Acer negundo)*, red maple *(A. rubrum)*, pecan *(Carya illinoensis)*, sugarberry *(Celtis laevigata)*, sweetgum *(Liquidambar*

styraciflua), American sycamore *(Platanus occidentalis),* eastern cottonwood (Populus *deltoides),* quaking aspen *(P. tremuloides),* black willow *(Salix nigra), willow* oak *(Quercus phellos),* and American elm *(Ulmus americana).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- Green ash is dioecious. The small, usually inconspicuous flowers appear in the spring, with or just before the leaves, in terminal or axillary clusters (4). Flowers are generally borne over the entire outer part of the live crown. Usually, flowering starts when trees are 8 to 10 cm (3 to 4 in) d.b.h. and 6 to 8 in (20 to 25 ft) tall. A high percentage of the male and female trees bear flowers annually, and many female trees bear fruit each year.

Flowers may appear as early as March or April in Florida and from late April to early May in the northern part of its range (25). Male flowers require 1 to 2 weeks to pass from the enlarged winter condition to completion of pollen shedding. Individual trees shed pollen over an interval of 3 to 4 days. Within a stand, range among individual trees in onset of pollen shedding is only 2 to 3 days. The pollen is disseminated by wind and is dispersed relatively short distances, most of it falling within 61 to 91 in (200 to 300 ft) of the source.

Flower bud enlargement starts a few days later on female trees than on male (25). The stigmas of the female flowers are receptive as soon as they emerge from the bud and remain receptive for about a week. Receptivity appears to end just before the stigmas start to wither. The female flowers and young fruit are very sensitive to late spring frosts.

Within a month after pollination, the samaras developing from fertilized flowers reach mature size. Ash fruits are elongated, winged, single-seeded samaras borne in clusters. Unpollinated flowers or flowers pollinated by an incompatible ash species drop off within the first month. Growth and ripening of embryos lag behind growth of samaras and are not completed until late September or early October.

Physiological maturity of green ash seeds can be related to a fully elongated embryo that fills the entire embryonic cavity. When ripe, the embryo should be about 10 min (0.4 in) long and slightly less than I mm (0.04 in) in diameter. Mature embryos have firm, white tissues that break crisply. Physical characteristics indicating seed maturity can be utilized by workers in the field during seed collections (3). Color change in the samaras, from green to yellow or brown, is not complete until after the embryo is fully grown. Samples picked in mid-October in central Mississippi gave excellent germination though samaras were still slightly green. While samaras are still green, they may contain as much as 50-percent moisture, and care must be taken to prevent seed lots from overheating. A little heat damage at this stage may significantly reduce seed quality, especially if long-term storage is contemplated. In seed collections, especially bulk collections, complete change of samaras to a brown color probably is a safer index to maturity than size of the embryo.

Seed Production and Dissemination- Green ash seeds start to fall as soon as they ripen and continue to fall into the winter (25). Most seeds are dispersed by wind within short distances of the parent tree. Some dispersal by water also may occur, but the importance of water as a long-distance dispersal agent is unknown.

Seed clusters can be collected from trees by hand or with pruners and seed hooks. Fully dried samaras also may be shaken or whipped from limbs of standing trees onto plastic sheets spread under the trees. Fruit should be spread in shallow layers for complete drying, especially when collected early. Dried clusters may be broken apart by hand, by flailing in sacks, or by processing through a macerator. Seeds should be dried to 7- to 10-percent moisture content for storage. No loss in viability for 7 years was found when green ash seeds were stored in sealed containers at 5° C (41° F) with a seed moisture content of 7 to 10 percent.

The epigeal germination may occur in the spring following seedfall, or seeds may lie dormant in the litter for several years before germinating. Dormancy is apparently due to both internal factors and to seedcoat effects (3,4). For the nursery, dormancy may be overcome by cold, moist stratification in a suitable medium, or simply storing in containers of water. Both methods should be used at temperatures of 2° to 4° C (35° to 40° F) for 90 to 120 days. Seeds may be sown in fall and allowed to stratify in the nursery bed.

Seeds should be sown in nursery beds at approximately 80 to 100/m (25 to 30/ft) of row with rows 15 to 30 cm (6 to 12 in) apart (25) and covered with burlap or greenhouse shade cloth until germination starts. Seedbed densities of 110 to 130/m² 10 to 12/ft²) are recommended for green ash to produce high-quality seedlings.

Seedling Development- Under good nursery conditions in the northern part of its range, seedlings grow about 30 cm (12 in) in height the first year and another 46 cm (18 in) the second year. In the southern part of the green ash range, nurseries can produce seedlings 0.8 to 0.9 m (2.5 to 3.0 ft) tall the first growing season.

Uninjured nursery seedlings usually develop no side branches during the first year. On vigorous seedlings, the uppermost one or two pairs of lateral buds develop into branches during the second year.

Apical dominance usually is strong enough in vigorous, uninjured open-grown trees so that they often have a single, straight stem until they are 5 m (15 ft) or more tall. If this dominance is lost by the removal of a terminal bud, the uppermost lateral branch quickly takes over and reasserts dominance over the lower branches (25). In slow-growing shaded specimens, the tendency for quick assertion of apical dominance following deer nipping or other damage to a terminal bud is much less pronounced. As a consequence, understory seedlings frequently have poor form.

Vegetative Reproduction- Stumps of sapling and pole-size green ash sprout readily. Studies in Mississippi have shown ash, as sprouts, to be one of the dominant species in bottom-land clearings (11,13). Dominants among the ash sprouts were 3.8 cm (1.5 in) d.b.h. and 5 m (15 ft) tall after five growing seasons.

Cuttings made from 1-0 seedlings or 1-year-old sprouts root easily under greenhouse and field conditions (25). Cuttings may be planted horizontally under the soil or vertically with good results(14,15). However, no practical way to root cuttings from older trees has yet been found. Green ash can be successfully bench-grafted or field-grafted (2,18). Understocks; can be stored by severely root-pruning young seedlings and heeling them in by groups of 50 to 100. Most of the seedlings remain alive but grow so little that they supply an assortment of small understocks whenever needed.

Sapling and Pole Stages to Maturity

Growth and Yield- In shelterbelts in the Great Plains, green ash averaged 0.4 m (1.3 ft) per year height growth for the first 6.5 years (25). Opengrown trees planted on a fertile soil in Pennsylvania grew 14 to 17 m (45 to 55 ft) tall and 20 to 30 cm (8 to 12 in) in d.b.h in 21 years.

In most areas in the northern part of its range, green ash reaches heights of 15 to 18 m (50 to 60 ft) and breast-high diameters of 46 to 61 cm (18 to 24 in). On good sites in the southern part of its range, trees attain a height up to 37 m (120 ft) and a d.b.h. of 61 to 76 cm (24 to 30 in) (20). Diameter growth of dominant crop trees in well-stocked, managed stands is about 6 to 8 cm (2.5 to 3.0 in) in 10 years (5).

Little data exist on growth rates and volumes of trees grown under natural stand conditions. Probably the best information available is contained in results of research conducted in Georgia (6). Four sites included in the study ranged from well-drained sandy loams on levees or terraces to poorly drained, wet, silty flats. Green ash was the dominant species in these stands, comprising about 80 percent of the total stand basal area. Stand ages ranged from 27 to 65 years. Average stand heights for green ash sawtimber ranged from 24 m (78 ft) in the 27-year-old stand to 35 m (116 ft) in the 65-year-old stand.

Volume growth ranged from 2.7 to 4.6 m^3/ha (39 to 65 ft^3/acre) per year. Growth was related to stand age with better growth rates occurring in the younger stands. Merchantable sawtimber volume ranged from 104.4 m^3/ha (1,491 ft^3/acre) in the 27-year-old stand to 175.8 m^3/ha (2,511 ft^3/acre) in the 65-yearold stand. In addition to sawtimber, pulpwood volumes from tops and small trees ranged from 144.8 m^3/ha (23 cords/acre) in the younger stand to 245.6 m^3/ha (39 cords/acre) in the older stand.

Green ash on most sites in the southern part of its range is characterized by a clear, straight bole for about half the total height (6). Above this point the stem often forks or crooks and has large branches that degrade the lumber. Merchantable height for saw logs averages about two 5-m (16-ft) logs. Merchantable height for pulpwood to a 10-cm (4-in) top may extend to 12 m (40 ft) in younger stands. Its pioneer nature and ability to grow rapidly in relatively pure, even-aged stands indicate green ash is well suited for plantation management. Studies in Mississippi and Arkansas have shown that green ash grows about 1.2 to 1.5 m (4 to 5 ft) in height and 13 mm. (0.5 in) in d.b.h. the first 5 to 10 years under plantation management (fig. 4).

Natural stands appear to support sufficient volume to allow commercial thinnings at 25 to 30 years (6). To ensure reasonable volume production and reduce epicormic branching in the

residual stand, basal area should not be reduced below 23.0 to 27.6 m^2/ha (100 to 120 ft^2/acre). This should be represented by about 250 to 300 trees/ha (100 to 120 trees/acre).

Rooting Habit- Root systems were studied in North Dakota on a Fargo clay soil, with a 0.3-m (1-ft) layer of black surface soil overlaying a light-colored, calcareous, clayey soil with no hardpan (25). The soil was poorly drained and wet in the spring; later in the growing season the water table was at a depth of about 5 in (15 ft) or more. Roots had extended laterally for 15 in (48 ft) and 1.1 in (3.6 ft) downward; they were about equally distributed in the upper 0.9 in (3 ft) of soil. Excavations of other root systems have shown green ash roots to penetrate about 1 in (3.2 ft) deep in sandy and clay soils and 1.4 in (4.5 ft) deep along the edges of sloughs. In the southern part of its range, green ash has a root system that is typically saucer-shaped with no distinct taproot; roots penetrate to depths of 0.9 to 1.2 in (3 to 4 ft). The extensive root system of this species makes it relatively windfirm.

Green ash seedlings, and probably older trees, have certain rooting habits or adaptations that enable them to withstand flooding (1,16,21). Young green ash (8) has been shown to have the ability under flooded conditions to regenerate new secondary roots from the primary root, develop adventitious water roots on the submerged stem, accelerate anaerobic respiration rate in the absence of oxygen, and oxidize its rhizospheres. These root adaptations enable it to withstand flooding regimes of several months during the dormant and early growing season that would kill other species (9,10,25). Specific gravity has been shown to be related to flooding in some hardwoods (19).

Reaction to Competition- Green ash varies from intolerant to moderately tolerant to shade in the northern part of its range. It comes in early in succession on alluvial soils, either as a pioneer species or following cottonwood, quaking aspen, or black willow (25). It is less able to maintain its position in the crown canopy than some of its more rapidly growing associates such as red maple and American elm.

In the southern part of its range, green ash would be considered tolerant when young and moderately tolerant as it grows older. Studies have shown that advanced reproduction of green ash can be maintained in the understory for more than 15 years (12). Green ash may not grow more than 15 cm (6 in) in height yearly, with 12- to 15-year-old trees being 4 to 5 in (12 to 15 ft) tall and 2.5 cm (1 in) in diameter. However, these trees respond well to release and outgrow many of their competitors (13). Other studies of green ash in plantations, where various levels of cultural treatments were applied, showed that green ash could tolerate competition from weeds and vines better than any of the 6 to 10 other species tested (17). Overall, green ash may most accurately be classed as tolerant of shade.

Damaging Agents- Many insects feed at least occasionally on green ash. One of the most serious is the oystershell scale *(Lepidosaphes u1mi),* which is distributed throughout the Northeast and can cause serious damage among seedlings and small trees. The carpenterworm *(Prionoxystus robiniae)* bores into the heartwood of large branches and trunks, permitting the entrance of fungi. The brownheaded ash sawfly *(Tomostethus multicinctus)* and the blackheaded ash sawfly *(Tethida barda)* occasionally cause serious damage to shade trees. The ash borer

(Podosesia syringae) damages the stems of trees of all sizes, causing lumber degrade in timber-sized trees and contributing to decline and mortality in shelterbelt plantings (23,25).

Several diseases are of general importance. The fungus *Mycosphaerella fraxinicola* creates a leaf spot which may cause premature defoliation of young trees. Anthracnose *(Gloeosporium aridum)* also causes premature defoliation. A rust caused by *Puccinia peridermiopora* results in distortion of petioles and small twigs. Several rots cause minor damage in green ash. In Texas and Oklahoma, green ash has shown intermediate susceptibility to a root rot caused by *Phymatotrichum omnivorum* (25).

Young trees are subject to damage from deer browsing, and rabbits may sever the stems.

Special Uses

Green ash wood, because of its strength, hardness, high shock resistance, and excellent bending qualities, is used in specialty items such as tool handles and baseball bats but is not as desirable as white ash. It is also being widely used in revegetation of spoil banks created from strip mining (25). Green ash is very popular as a shade tree in residential areas because of its good form, adaptability to a wide range of sites, and relative freedom from insects and diseases. Seeds are used for food by a number of game and nongame animals and birds.

Genetics

Population Differences

Green ash is composed of three or more geographic ecotypes. The trees belonging to these ecotypes are easily distinguishable when growing under uniform conditions in a nursery but not when growing naturally. For that reason, they have not been given Latin varietal or subspecific names.

Three different ecotypes were evident in the Great Plains (25). The population from the arid, northwestern part of the green ash range was more drought resistant than that from the more moist central Great Plains. As compared with the Coastal Plain ecotype, the Northern States ecotype grew more slowly, had greener petioles, was more winter hardy, and was less subject to leaf damage by fall frosts. These ecotypes may or may not be identical with those from the Eastern United States.

Hybrids

Attempts have been made to artificially cross green ash with other ash species. Only the cross of green ash with velvet ash *(Fraxinus velutina)* was consistently successful, yielded viable seed, and produced identifiable hybrids that grew as fast as the eastern parent. The other crosses yielded no identifiable hybrids.

The pumpkin ash *(Fraxinus profunda) is* a rare hexaploid (2n = 138 chromosomes) species of the Coastal Plain and Mississippi Valley (25). Its leaves, twigs, flowers, and fruit are larger than those of green ash or white ash but qualitatively similar to one or the other of these two species. The patterns of morphological variation and geographic distribution taken together are strong evidence for the view that pumpkin ash is a true-breeding polyploid derivative of a cross between a diploid green ash and tetraploid white ash.

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Honeylocust

Gleditsia triacanthos L.

Other Common Names:

Sweet-locust, thorny-locust, Confederate pin tree

Brief Description:

Honeylocust is a very hardy tree and is easily recognizable by its thorns. Thornless varieties have been used in urban plantings to replace elm trees. It can exhibit moderately fast growth on good sites. Its seed pods are consumed by wildlife. It can be an invader of old fields.

Habitat:

Honeylocust ranges between the Great Plains and the Appalachian Mountains. Its range has expanded due to cultivation. The species is very tolerant of drought and alkaline soils. It generally fails on shallow soils and performs badly on gravelly or heavily clayey soils. Typically it is a bottomland species and is found on moist soils near streams or lakes. Although it does not occur in the Mississippi River Delta, it frequents clay ridges and flats in first bottoms and secondary floodplains of the Missouri River's tributaries in Nebraska.

Life History:

Flowering occurs in late spring around mid May. Seed production begins around age 10. The seeds ripen around mid-September and soon after they begin to fall and disseminate. Germination is thought to be enhanced if the seed has been consumed by an animal first. This also surely aids in dispersal. The seeds if not scarified by some means can remain dormant for up to 7 years. It is classified as shade intolerant and trees that become shaded do not fair well.

Honeylocust and the Great Trinity Forest:

Honeylocust was mentioned in the forest inventory. It is not controlled by some herbicides and therefore care must be taken when treating individuals.

Gleditsia triacanthos L.

Honeylocust

Leguminosae -- Legume family

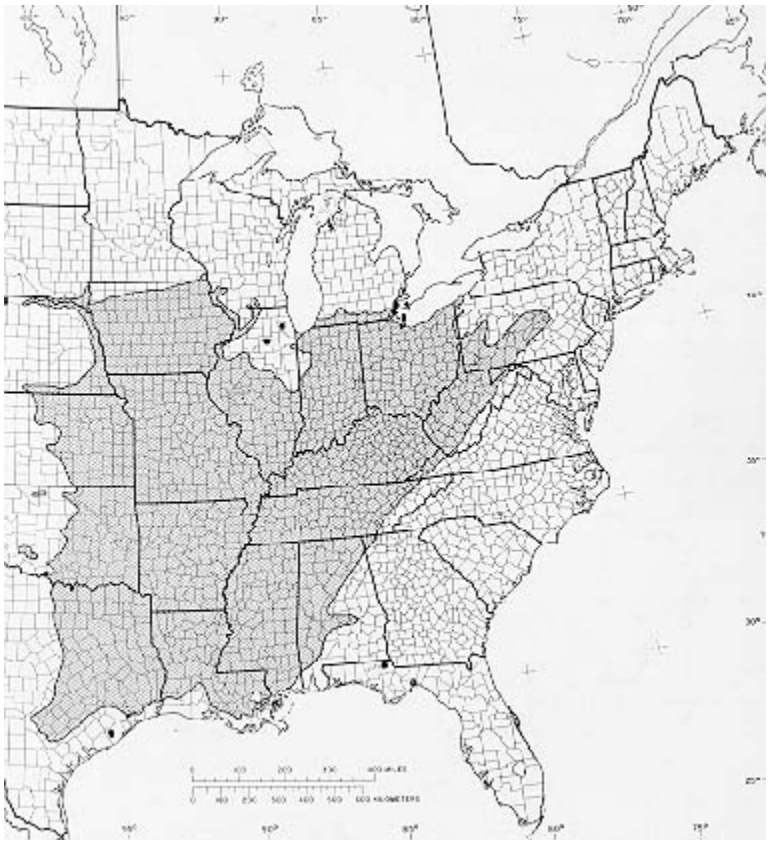
Robert M. Blair

Honeylocust *(Gleditsia triacanthos),* also called sweet-locust or thorny-locust, is a moderately fast growing tree commonly found on moist bottom lands or limestone soils. Because it has proven very hardy and tolerant of drought and salinity, it is widely planted for windbreaks and soil erosion control. The thornless variety has been planted to replace the elm in many urban areas. The wood is dense, hard, and durable but used only locally. Honeylocust pods are sweet and eaten by livestock and wildlife. The tree is relatively short lived, reaching the age of 125 years.

Habitat

Native Range

Honeylocust is found scattered in the East-Central United States from central Pennsylvania westward to southeastern South Dakota, south to central and southeastern Texas, east to southern Alabama, then northeasterly through Alabama to western Maryland. Outlying populations of the species may be found in northwestern Florida, west Texas, and west-central Oklahoma. It is naturalized east to the Appalachian Mountains from South Carolina north to Pennsylvania, New York, and New England (11). Honeylocust attains its maximum development in the valleys of small streams in southern Indiana and Illinois.



-*The native range of honey locust.*

Honeylocust, especially the thornless form, is widely cultivated as an ornamental and shade tree in all countries having a temperate climate.

Climate

In the western portion of its range honeylocust grows in a subhumid climate while in the middle and eastern portions the climate is humid. Normal annual precipitation varies from about 510 mm (20 in) in South Dakota and Texas to more than 1520 mm (60 in) in southern Louisiana, Mississippi, and Alabama. Average annual snowfall varies from none to 102 cm (40 in). Length of the growing season varies from about 150 days in the north and northeast to more than 300 days in the southern extremities of the range.

Honeylocust is tolerant of low temperatures and in the north it is hardy at -29° to -34° C (-20° to -30° F) (10). Northern races harden-off and become dormant relatively early, while growth of southern races continues later into the year. Southern races are subject to frost damage when planted in the north (7). Honeylocust also may suffer frost damage or dieback because of its indefinite or indeterminate annual growth pattern (4). Twigs may continue to elongate until stopped by cold, whereupon the tender terminal internodes are killed by the first frosts. New growth in the spring then comes from the lower lateral buds.

Soils and Topography

Honeylocust is found most commonly on soils in the orders Alfisols, Inceptisols, and Mollisols that originate from limestone or the rich alluvial floodplains of major rivers and streams. Growth is poor on gravelly or heavy clay soils and honeylocust often fails on shallow soils. Although ample soil moisture is necessary for best growth, the species is very resistant to drought. Because of this, it is a valuable species for shelterbelt planting in the Great Plains.

On 20 drought-resistant species of seedlings tested, honeylocust ranked third in alkali tolerance (7). The species is also tolerant of acid soils (26), but best development is usually on soils having a pH between 6.0 and 8.0. From tests incorporating artificially salinized soils, young honeylocusts were found to be tolerant of soil salinity (13). Seed germination was little influenced by as much as 0.20 percent of sodium chloride in the dry weight of soil (2). Salt tolerance has particular economic importance in the North where runoff from highway de-icing salts can damage plantings, and also where plantings are desired on saline soils in and states. Whether honeylocust can tolerate the cumulative effects of salinity over a period of years is still unknown.

Typically, honeylocust is a bottom land species, most commonly found only on moist fertile soils near streams or lakes. Although it is not common anywhere in the Mississippi River Delta, it frequently grows on low clay ridges and flats in first bottoms and on the secondary flood plains along the Missouri River tributaries in Nebraska.

Over its range honeylocust grows naturally below a maximum elevation of 610 to 760 m (2,000 to 2,500 ft), although the general upper elevational. limit for the species is reported as 1520 m (5,000 ft). A 20year-old plantation growing at 2100 m (6,900 ft) in Colorado had "good" survival, but trees averaged only 2.4 m (8 ft) in height (7).

Associated Forest Cover

Throughout its range, honeylocust generally occurs only as a minor component of natural forest stands. It is included in four forest cover types in the United States (19). It is an associated species on lowland sites in Bur Oak (Society of American Foresters Type 42), especially in the more southerly portions of the type range, and in Willow Oak-Water Oak-Diamondleaf Oak (Type 88). It is a minor associate in Sweetgum-Willow Oak (Type 92) and Sugarberry-American Elm-Green Ash (Type 93). Mesophytic species commonly associated with honeylocust include red maple *(Acer rubrum),* persimmon *(Diospyros virginiana),* blackgum *(Nyssa sylvatica),* pecan *(Carya illinoensis),* boxelder *(Acer negundo),* Kentucky coffeetree *(Gymnocladus dioicus),* black walnut *(Juglans nigra),* oaks *(Quercus spp.),* elms *(Ulmus spp.),* ashes *(Fraxinus spp.),* and hickories *(Carya spp.).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- Flowering occurs in late spring, the average date being about May 10 in the southern limit of the range and June 25 in the north (7). Honeylocust leaves are nearly full

grown when the flowers are produced, which is usually late enough in the year for the seed crop to escape frost damage.

The species is polygamo-dioecious; flowers are home in axillary, dense, green racemes (24). Racemes of staminate flowers are 5 to 13 em (2 to 5 in) long, pubescent, and often clustered. The calyx is campanulate, with five elliptic-lanceolate lobes; there are four to five petals, erect, oval, and longer than the calyx lobes; and up to 10 stamens, inserted on the calyx tube. The pistil is rudimentary or absent in the staminate flowers. Pistillate racemes are 5 to 8 ern (2 to 3 in) long, slender, with few flowers, and usually solitary. The pistils are tomentose, the ovary nearly sessile, and the style short; there may be two ovules or many. The stamens are much smaller and abortive in pistillate flowers.

Seeds, borne in long (15 to 41 cm, 6 to 16in), flat, indehiscent, and often twisted pods, ripen about mid-September in the southern portion of the range and around mid-October in the north. Soon after fruits mature they begin falling and dissemination often continues into late winter.

Seed Production and Dissemination- Honeylocust begins bearing seed at about 10 years of age, optimum production occurring between 25 and 75 years. Trees continue to bear fruit up to about 100 years of age (7). They generally bear fruit each year and produce abundant seed crops every year or two.

Honeylocust seeds, like those of many leguminous species, have impermeable coats and thus remain viable for long periods of time. Under natural conditions, individual seeds become permeable at different periods following maturation so that any one crop is capable of producing seedlings over a period of several years.

The seeding range or natural dispersal of honeylocust seeds is not extensive. The pods, however, are readily eaten by cattle, whereby seeds are scattered in the feces. Undoubtedly seeds are also disseminated by birds and other mammals that feed on the fruit. Cleaned seeds average about 6,170/kg (2,800/lb), with a commercial purity of 95 percent and a soundness of 98 percent (24). Viability can be retained for several years when seeds are stored in sealed containers at 0° to 7° C (32° to 45° F) (3).

Seedling Development- Germination is thought to be enhanced when seeds are eaten and passed undigested by birds and mammals (7). Passage through the digestive system apparently softens the impermeable seedcoat. Enhanced germination can also be achieved by mechanically scarifying the seeds or soaking them in concentrated sulfuric acid or hot water (880 C, 1900 F) for 1 to 2 hours. When hot water is used the water and seeds should be allowed to cool to room temperature or until seeds swell (3). Treated seeds should be sown promptly and not stored. Germination is epigeal.

Honeylocust seedlings show a growth pattern characteristic of deciduous hardwoods with sympodial. growth. Persistent terminal buds are not formed and the shoot tip often dies and falls off (5).

Nursery-grown seedlings from pretreated seeds attain suitable size-30 cm (12 in) or more in height-for field planting in 1 year (3). In southern Michigan, first-year seedlings grown in pots reached a height of 37 cm (14.6 in) by September 21, just before leaf abscission (5). The average root-to-shoot ratio was 2 to 3. Stem growth was slow in the spring but rapid in early summer and fall. Only 60 percent of the height growth was attained by mid-July. In an additional study in southern Michigan, nursery seedlings grown 3 years in pots and nearly two growing seasons outplanted in the field averaged 22 mm (0.9 in) in trunk diameter (16) by early autumn. The following year trunk diameter increased 4 min (0.15 in).

Dormant nursery-grown seedlings can be stored, barerooted, at about 0° C (32° F) for several weeks before outplanting with no appreciable loss in survival rate (15).

Vegetative Reproduction- Honeylocust coppices freely. Propagation, particularly of high quality clonal stock, can be achieved by grafting, budding, and cuttings from hardwood, softwood, and roots (7). Root cuttings appear to be the best method of reproducing desirable strains in large quantities at reasonable cost. At times other species or varieties are grafted onto the rootstock of honeylocust (24).

Honeylocust thorn production usually diminishes gradually and finally ceases in the upper and outer crown growth as the tree ages. Thorns may still be produced on the lower trunk and on lower-trunk and limb sprouts. Typical trees, 10 years old or more, show a definite thornless region in the upper and outer shoot growth. When hardwood cuttings for propagation are taken from this thornless area, the scions generally remain thornless (6). Tree breeders can control the sex of scions from honeylocust by selecting unisexual budwood when taking cuttings. Certain branches bear only one type of flower, and trees from cuttings from those branches will bear only that type (14).

Sapling and Pole Stages to Maturity

Growth and Yield- In natural stands honeylocust attains a height of 21 to 24 m (70 to 80 ft) and a d.b.h. of 61 to 91 cm. (24 to 36 in). On the best sites, trees may be 43 m (140 ft) in height and 152 to 183 cm (60 to 72 in) in d.b.h. On poor sites trees are stunted, wide-branched, and often covered with thorns. In eastern Nebraska, 18- to 35year-old honeylocust in plantations grew an average of 4.6 cm (1.8 in) in diameter each 10 years.

The average height growth of honeylocust planted in shelterbelts from North Dakota to Texas was 49 cm (19.2 in) per year during the first 7 years (7). This was a slower height growth than for plains cottonwood (Populus *deltoides* var. *occidentalis)* and Siberian elm *(Ulmus pumila)* but faster than that of American elm (U. *americana),* green ash *(Fraxinus pennsylvanica),* or hackberry *(Celtis laevigata),* all of which were frequently planted on the same shelterbelt projects. Under favorable conditions the annual diameter growth of young honeylocust is from 8 to 13 mm (0.33 to 0.50 in) (22). The species is an excellent tree for windbreaks.

Rooting Habit- Honeylocust is deep rooted with a widely spreading and profusely branched root system and a strong taproot. Deep soils are penetrated as far as 3 to 6 m (10 to 20 ft). The root system is responsive to environmental conditions. For example, in a Missouri study, 4- to 6-year-

old saplings on upland clay soil produced root systems that were about twice as long, with laterals covering twice the area, as those of older trees growing in lowland alluvial soil where the water table was higher (7). The generalized, well-developed root system enables this species to grow on both upland and lowland sites.

Reaction to Competition- Honeylocust is classed as intolerant of shade, and reproduction becomes established only beneath openings in the forest canopy (5). Both top and root growth are retarded where young trees are subjected to shade; therefore, for survival and optimum development, honeylocust must maintain a dominant position in the forest community. Lower limbs of forest-grown trees die when they are excessively shaded from the

sides, and the dead limbs often are retained for some time.

Honeylocust is occasionally a pioneer on midwest strip-mine spoil banks. It is also a pioneer in rocky limestone glades of Tennessee and Kentucky, where it is often succeeded by eastern redcedar *(Juniperus uirginiana).* In northern Ohio, honeylocust was found with shellbark hickory *(Carya laciniosa)* and bur oak *(Quercus macrocarpa)* in the elm-ash-soft maple association on areas that formerly were swampy (7).

Damaging Agents- With the increased popularity and plantings of honeylocust, particularly the cultivars of thornless varieties, there has been a corresponding increase in the kinds and numbers of attacking insects. Generally, insect attacks are not fatal but they do weaken the tree and retard growth. Honeylocust is a host of a number of leaf feeders and severe infestations can rapidly defoliate trees. A severe and widely distributed defoliator is the mimosa webworm *(Homadaula anisocentra) (1).* The search for webworm resistant trees has not been productive (17). *Eotetranychus multidigituli,* a spider mite common to the midwest, and other mites feed on honeylocust leaves. Heavy infestations, occurring particularly in hot dry weather, will defoliate a tree. The whitemarked tussock moth *(Orgyia leucostigma),* the honeylocust plant bug *(Diaphnocoris chlorionis) (25),* the leaf hopper *(Empoasca pergandei),* and several other species of pod galls, leaf rollers, leaf hoppers, moths, loopers, bagworms, and beetles feed on honeylocust foliage. The walkingstick *(Diapheromera femorata) is* also included among the many defoliators (21).

Agrilus difficilis, a flatheaded borer, important west of the Mississippi River, burrows beneath the bark and may eventually girdle the trunk or large limbs (18). Several other bark and wood borers attack honeylocust, such as the widely distributed *Xyleborus saxeseni.*

A number of scale insects, such as the European fruit lecanium *(Parthenolecanium corni),* which is widespread and particularly damaging to shade trees, and the cottony maple scale *(Pulvinaria innumerabilis),* injure the bark of honeylocust, especially on small branches, lowering the vitality and growth rate of trees (18). Weakened trees become subject to attack and further damage by various species of boring insects and bark beetles.

The twig girdler, *Oncideres cingulata,* prunes small branches and can inflict severe injury on nursery seedlings. Heavy infestations can also severely damage large trees. The larvae of *Amblycerus robiniae,* a bruchid weevil, feed on honeylocust seed (1). The female periodical

cicada *(Magicicada septendecim)* can damage honeylocust, especially young transplanted trees, by depositing eggs in the twigs.

Honeylocust is subject to few diseases, none of which interfere with its growth, except in isolated situations. The most noteworthy disease is the canker *Thyronectria austro-americana,* which can be fatal. Spiculosa cankers cause loss in merchantable wood volume or cull. Honeylocust is subject to several heart-rot and wood-decay fungi from species of *Fomes* and *Polyporus.*

Few leaf diseases attack honeylocust, and none mar the tree. The most widely distributed is tarry leaf spot caused by *Linospora gleditsiae (9).* In the seedling stage honeylocust is susceptible to cotton root rot *(Phymatotrichum omnivorum),* which is sometimes fatal (7). In shelterbelt planting tests in Oklahoma and Texas it was ranked as highly susceptible to certain *Phymatotrichum* root rots (27). Two other root diseases, *Ganoderma lucidum* and *G. curtisii,* can cause extensive root rot and tree fatality. The incidence of these root rots is not high.

In the southeast Texas area honeylocust was visibly damaged but not killed by air pollution, presumed to be mainly sulfur dioxide. In Illinois the species was ranked as highly resistant to ice damage and in Tennessee it was rated about average in resistance to flooding damage *(9).* It also appears to be resistant to salt spray when planted near the coast. Honeylocust is considered to be windfirm, but heavy limb breakage from wind was reported in Kansas. Because of its relatively thin bark it is easily damaged by fire (7). Rabbits sometimes inflict damage by gnawing the bark from young trees during the winter.

Special Uses

Honeylocust fruits are readily eaten by cattle and hogs. The beans of some cultivars contain as much as 12 to 13 percent protein, and the pods contain up to 42 percent carbohydrates (12,20). Livestock also eat the young vegetative growth and both the fruit and plants are eaten by snowshoe hares and cottontails. Fruits are also eaten by gray squirrels, fox squirrels, white-tailed deer, bobwhite, starlings, crows, and opossum (7,8). Honeylocust is a source of honey during the short flowering period in spring.

Both the common honeylocust and its thornless varieties are planted for erosion control and for wind breaks; the thornless varieties are widely planted as shade and ornamental trees. In many urban areas thornless honeylocust has been planted as a replacement for the American elm (26).

The wood of honeylocust possesses many desirable qualities but is little used because of its scarcity (23).

The sapwood is generally wide and yellowish in contrast to the reddish-brown heartwood, providing an attractive grain. The wood is dense, very heavy, very hard, strong in bending, stiff, resistant to shock, and is durable when in contact with soil. It is used locally for fence posts, and also as lumber for pallets, crating, and general construction.

Genetics

Races and Hybrids

The honeylocust has wide genetic variations that have enabled improvement through selection. The northern races show relatively good winter hardiness and southern races bear fruit that is much more nutritious for stock feeding than that found on the trees in the north (6).

A number of horticultural forms have been developed and are widely cultivated, especially for shade and as ornamentals (24). Thornless honeylocust *(Gleditsia triacanthos* var. *inermis* Willd.) is thornless, or nearly so, and slender in habit; bushy honeylocust *(G. triacanthos* var. *elegantissima* [Grosdemangel Rehd.) is unarmed and densely bushy; Bujot honeylocust *(G. triacanthos* var. *bujotii* [Neuml Rehd.) has slender pendulous branches and narrow leaflets; and dwarf honeylocust *(G. triacanthos* var. *nana* [Loud.] A. Henry) is a small compact shrub or tree. Selected cultivars of the thornless forms have been patented. About 60 percent of the seedlings grown from thornless honeylocust seed are thornless (7).

Gleditsia x texana Sarg., the Texas honeylocust, is considered to be a hybrid of *G. aquatica* Marsh. and *G. triacanthos* L. (24). Its range is largely restricted to the Brazos River bottoms in Texas, with additional trees found along the Red River in Louisiana and occasionally along the Mississippi River in Indiana and Mississippi.

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Live Oak

Quercus virginiana Mill.

Other Common Names:

Virginia live oak

Brief Description:

Live oak is an evergreen tree that grows in a variety of forms from shrub-like forms to large and spreading shapes. It has been widely used ornamentally and holds a special historical and cultural significance in many areas. The species wood qualities and favor in ship building resulted in the creation of one of the nation's first federal forest plantations (Naval Live Oaks, Pensacola, Florida). Its acorns are desirable to birds and animals. Live oak can hybridize with oaks such as bur oak and post oak.

Habitat:

Live oak is native to the lower coastal of the Southeastern United States west to South and Central Texas. It typically grows on the sandy soils of lower coastal areas. It is nearly always found on sandy soils unless planted ornamentally.

Life History:

Live oaks flower in March through May and the acorns mature the following September and fall before December, all in the same year. Germination occurs shortly after seedfall if it is a moist warm site. The species is an abundant seeder. Dissemination is by gravity and animals. Live oak is an abundant producer of sprouts and can be difficult to control if it is unwanted. This species is susceptible to Oak Wilt.

Live oak and the Great Trinity Forest:

Live oak has been reported to occur in the forest in a limited extent. It will possibly be used to a limited extent in planting mixes.

Quercus virginiana Mill.

Live Oak

Fagaceae -- Beech family

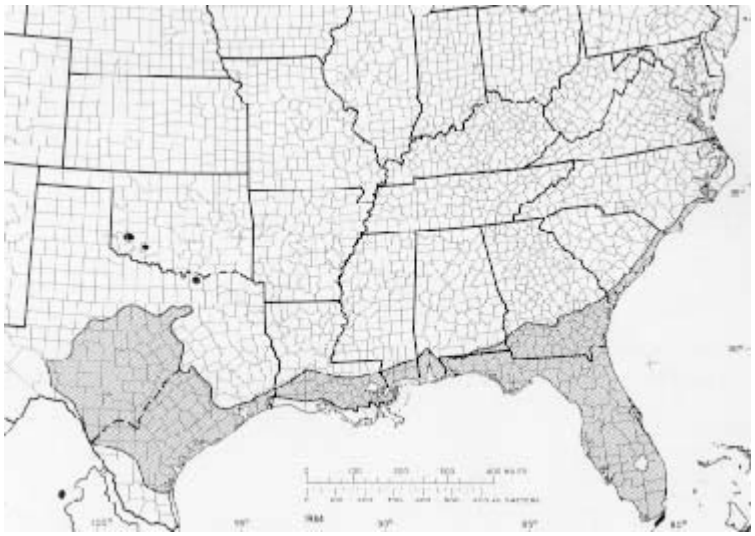
W. R. Harms

Live oak *(Quercus virginiana),* also called Virginia live oak, is evergreen with a variety of forms, shrubby or dwarfed to large and spreading, depending upon the site. Usually live oak grows on sandy soils of low coastal areas, but it also grows in dry sandy Woods or moist rich woods. The wood is very heavy and strong but is little used at present. Birds and animals eat the acorns. Live oak is fast-growing and easily transplanted when young so is used widely as an ornamental. Variations in leaf sizes and acorn cup shapes distinguish two varieties from the typical, Texas live oak *(Q. uirginiana* var. *fusiformis* (Small) Sarg.*)* and sand live oak *(Q. virginiana* var. *geminata* (Small) Sarg.*)* (4).

Habitat

Native Range

Live oak is found in the lower Coastal Plain of the Southeastern United States from southeastern Virginia south to Georgia and Florida including the Florida Keys; west to southern and central Texas with scattered populations in southwestern Oklahoma and the mountains of northeastern Mexico (4).



-The native range of live oak.

Climate

The climate is humid. Annual precipitation varies from 810 mm (32 in) in Texas to 1650 mm (65 in) along the Gulf Coast to 1270 mm (50 in) along the Atlantic coast and Florida. During the growing season, March through September, rainfall averages from 460 mm (18 in) in the west to 660 to 760 mm (26 to 30 in) in the east and south, with summer droughts more common in the western part of the range than elsewhere. The average summer temperature is 27° C (80° F). The average winter temperature ranges from 2° C (35° F) in the east and west to 16° C (60° F) in the south. The frost-free period is 240 days in the east and west and more than 300 days in southern Florida (5).

Soils and Topography

Live oak nearly always grows on sandy soils belonging to the Ultisols, Spodosols, Histosols, and Entosols (5). Its resistance to salt spray and high levels of soil salinity makes it a dominant species in the live oak woodland on the barrier islands of the Atlantic and Gulf Coasts. In South Carolina it is found in dry sandy woods, moist rich woods, and wet woods. It is present in nearly every habitat in Florida from sandhills to hammocks, where it is generally the dominant species. In Louisiana, live oak is the dominant species on well-drained ridges bordering coastal marshes (3).

Associated Forest Cover

Live oak makes up the majority of the stocking of the forest cover type Live Oak (Society of American Foresters Type 89) (1). Common associates are water oak *(Quercus nigra),* laurel oak *(Q. laurifolia),* southern magnolia *(Magnolia grandiflora),* and sweetgum *(Liquidambar styraciflua).* On less welldrained sites it is accompanied by sugarberry *(Celtis laevigata),* green ash *(Fraxinus pennsylvanica),* and American elm *(Ulmus americana).* On the Atlantic Coast and Florida, common associates also include southern bayberry *(Myrica cerifera),* yaupon *(Ilex vomitoria),* tree sparkleberry *(Vaccinium arboreum),* cabbage palmetto *(Sabal palmetto),* and saw-palmetto *(Serenoa repens).* American holly *(Ilex opaca),* flowering dogwood *(Cornus florida),* southern crab apple *(Malus angustifolia),* hawthorn *(Crataegus* spp.), pignut hickory *(Carya glabra),* Carolina jessamine *(Gelsemium sempervirens),* and Japanese honeysuckle *(Lonicera japonica)* are also common associates.

Live oak is a minor species in seven other forest cover types: Longleaf-Scrub Oak (Type 71), Southern Redcedar (Type 73), Cabbage Palmetto (Type 74), Slash Pine (Type 84), South Florida Slash Pine (Type 111), Ashe Juniper-Redberry Juniper (Type 66), and Mohrs Oak (Type 67).

Life History

Reproduction and Early Growth

Flowering and Fruiting- Live oak is monoecious. Flowers are produced every spring, March through May. The acorns, long and tapered and dark brown to black, mature in September of the first year and fall before December.

Seed Production and Dissemination- Acorn crops are produced annually, often in great abundance. There is no published information on minimum seed-bearing age or size of the acorn crop. Number of sound acorns averages 776/kg (352/lb). Dissemination is by gravity and animals.

Seedling Development- The acorns germinate soon after falling to the ground if the site is moist and warm. Germination is hypogeal. Probably few acorns remain viable over winter because weevils invade them, and they are eaten by many animals and birds. There is no published information on seedling growth and development.

Vegetative Reproduction- Live oak sprouts abundantly from the root collar and roots. When tops are killed or when the tree is girdled, roots near the ground surface send up numerous sprouts. The capacity to sprout makes live oak difficult to kill by mechanical or chemical means.

Sapling and Pole Stages to Maturity

Growth and Yield- Live oak never attains great height, but the crown may have a span of 46 in (150 ft) or more. Open-grown specimens may have trunks 200 cm (79 in) in d.b.h. and average 15 in (50 ft) in height. Since the species is of little commercial importance except as an ornamental, growth and yield information has never been developed.

Rooting Habit- There is no published information on rooting habits, but the ability of live oak to grow and mature on sites subject to hurricane-force winds suggests that it is a deep-rooted species.

Reaction to Competition- Live oak may be most accurately classed as intermediate in tolerance to shade. In the northern part of its range, live oak assumes dominance only near the coast, where it is freed from competition by the greater sensitivity of all other broad-leaf trees to salt spray. The exclusion of fire has increased its presence in the Lower Coastal Plain. Once established in a favorable habitat, the tree is very tenacious and withstands all competition.

Damaging Agents- Young live oak is highly susceptible to fire. Its thin bark is readily killed by even light ground fires, leaving the trunk open to insects and fungi. The species is also susceptible to damage by freezing temperatures.

Live oak decline, a wilt disease attributed to *Ceratocystis fagacearum*, has been reported in Texas where it is killing thousands of trees annually. The disease is also suspected to occur in other Southern States as well and is considered a potentially serious problem (2,3). Leaf blister, caused by *Taphrina caerulescens*, periodically results in considerable defoliation.

A borer, *Archodontes melanopus*, commonly attacks roots of young oaks on the Atlantic Coast and may prevent the trees from developing normal form.

In some localities, mistletoe *(Phoradendron* spp.*)* grows on the branches. Spanish moss *(Tillandsia usneoides),* though an epiphyte, may damage trees because it accumulates in great abundance and decreases light reaching the interior and lower parts of the crown (6).

Special Uses

Because of live oak's habit of forming a low, widespreading crown, it is widely used as a shade tree and an ornamental. Its acorns are sweet and much sought as food by birds and animals. During the era of wooden ships it was used extensively in shipbuilding because of its hardness and strength.

Genetics

Two varieties of live oak are recognized: *Quercus uirginiana* var. *fusiformis* (Small) Sarg., Texas live oak, and *Q. virginiana* var. *geminata* (Small) Sarg., sand live oak.

Live oak hybridizes with *Quercus bicolor (Q. x nessiana* Palmer); *Q. durandii; Q. lyrata (Q. x comptoniae* Sarg.); *Q. macrocarpa; Q. minima;* and *Q. stellata (Q. x harbisonii* Sarg.).

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Osage-Orange

Maclura pomifera (Raf.) Schneid.

Other Common Names:

Hedge, hedge-apple, bodark, bois-d'arc, bowwood, and naranjo chino.

Brief Description:

Osage-orange played a strong role in the settlement of the plains. It has no true commercial timber value although it was once used as fencing material and extractives are of many uses. It is noted as being picturesque rather than beautiful. It is readily identifiable by its form and the presence of its white milky sap. The milky sap can cause skin rash.

Habitat:

Osage-orange in the Dallas area is located in the center of its native range which extends to the Oklahoma and Arkansas and South to the San Antonio and Houston area. It has been planted as a hedge in all of the lower 48 states with success. Historically it could be found in areas known as "bodark swamps" as a pure stand. These were not actually swamps in the conventional sense, but areas of frequent inundation. Most of these areas have now been converted to agriculture. The best quality trees were found on the tributaries of the Red River. It readily invades areas of exposed soil and natural regeneration seems to rely more on a lack of competition than that of a particular soil type.

Life History:

Osage-orange is dioecious meaning that there are male and female trees. Female trees will bear fruit in the absence of a male tree but it will contain no seeds. Seed dissemination is by birds, livestock, and mammals. Regeneration relies on bare mineral soil and full sunlight. Isolated trees on good sites can reach heights of 70 feet but in crowded settings heights averaging 30 feet are more common. Mature trees are shrubby in nature even on good sites. Thorns appear on branches in full direct sunlight. Osage-orange is highly variable, but is probably moderately shade tolerant.

Osage Orange and the Great Trinity Forest:

Reports indicate that Osage-orange groves can be found in the forest. Typically they are mostly dead stems though. Perhaps these areas are remnants of these "bodark swamps"? Due to this tree's hardiness, it should be considered as a planting on exposed degraded sites. By possibly restoring a "bodark swamp" as an interpretive area and by using this species occasionally to stabilize exposed soils and create to visual breaks this species will add to the visual diversity of the forest. Its propensity to spread on better sites and difficulty to control once established should be a consideration when planting it, though.

Maclura pomifera (Raf.) Schneid.

Osage-Orange

Moraceae -- Mulberry family

J. D. Burton

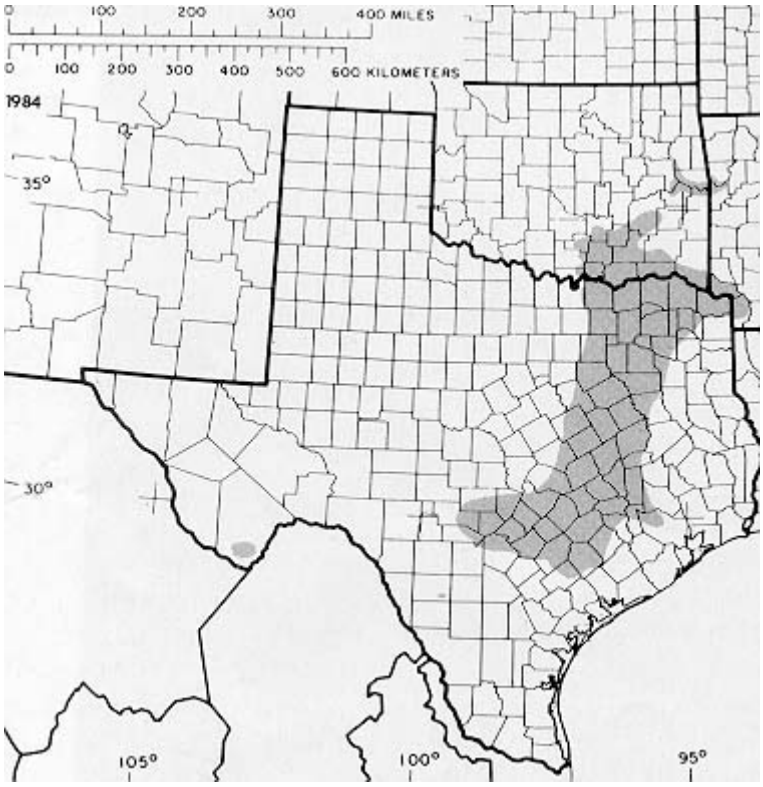
Osage-orange *(Maclura pomifera)* produces no sawtimber, pulpwood, or utility poles, but it has been planted in greater numbers than almost any other tree species in North America. Known also as hedge, hedge-apple, bodark, bois-d'arc, bowwood, and naranjo chino, it made agricultural settlement of the prairies possible (though not profitable), led directly to the invention of barbed wire, and then provided most of the posts for the wire that fenced the West. The heartwood, bark, and roots contain many extractives of actual and potential value in food processing, pesticide manufacturing, and dyemaking. Osage-orange is used in landscape design, being picturesque rather than beautiful, and possessing strong form, texture, and character.

Habitat

Native Range

The natural range of Osage-orange is in the Red River drainage of Oklahoma, Texas, and Arkansas; and in the Blackland Prairies, Post Oak Savannas, and Chisos Mountains of Texas (28). According to some authors the original range included most of eastern Oklahoma (34), portions of Missouri (49,54), and perhaps northwestern Louisiana (28,49).

Osage-orange has been planted as a hedge in all the 48 conterminous States and in southeastern Canada. The commercial range includes most of the country east of the Rocky Mountains, south of the Platte River and the Great Lakes, excluding the Appalachian Mountains.



-The native range of osage-orange.

Climate

Within the natural range of Osage-orange, average annual temperature ranges from about 18° to 21° C (65° to 70° F), July temperature averages 27° C (80° F) and January temperature ranges from 6° to 7° C (43° to 45° F) with an extreme of -23° C (-10° F). The frost-free period averages 240 days. Average annual precipitation ranges from 1020 to 1140 min (40 to 45 in), and April to September rainfall from 430 to 630 min (17 to 25 in).

Osage-orange is hardy as far north as Massachusetts but succumbs to winter-kill in northeastern Colorado and the northern parts of Nebraska, Iowa, and Illinois (34,36).

Solis and Topography

Even within the limited native range, growth of Osage-orange before agricultural settlement was restricted to about 26 000 km² (10,000 mi²) , and probably half that area produced no trees of merchantable size (17,32). Some pure stands covered as much as 40 ha (100 acres), but most were much smaller. Pure stands appeared on rich bottom-land Soils and were called "bodark swamps" (colloquialism for bois-d'arc). Though not true swamps, these areas frequently became inundated. Over much of its natural range, particularly south of the Red River, Osage-orange grew in isolated small stands, either pure or mixed with other hardwoods, interspersed with prairie. The largest trees and those of the best quality grew on bottom lands of the Red River tributaries in Oklahoma. Most bodark swamps have been converted to fields, and within the Red River system today Osage-orange grows most commonly on sandy terraces not yet occupied by

other vegetation and on Blackland Prairie soils underlain by chalk or marl. Distribution and abundance of natural regeneration seem to depend more on lack of competition than on kind, quality, or condition of soil.

Osage-orange readily escapes from cultivation and invades exposed, eroding soil, particularly in overgrazed pastures. Thickets are characteristically found along fence rows, ditch banks, ravines, and around abandoned farmsteads.

Most observers report that Osage-orange grows vigorously on all soils (32,34). Some state, however, that hedges planted on soil from which the Al horizon is removed do not thrive as well as those on less eroded sites (48). On sandy soils where the topsoil has blown away, growth of Osage-orange (and other species) in the Prairie States Forestry Project is strongly retarded (33). Natural regeneration is abundant and vigorous on many soils (Alfisols, Ultisols, Vertisols, and Mollisols), including those too alkaline for most forest trees. The species is sensitive to soil compaction. It thrives best on moist soils but tolerates extreme drought. It is resistant to heat, road salt (22), and urban air pollution (42).

Associated Forest Cover

Osage-orange is not included in any of the forest types recognized by the Society of American Foresters (13). In moist, well-drained minor bottom lands in northwestern Louisiana and nearby parts of Oklahoma, Arkansas, and Texas, it is found with white oak *Quercus alba),* hickories *(Carya spp.),* white ash *(Fraxinus americana),* and red mulberry *(Morus rubra)* (37). In Nebraska and Kansas, it invades overgrazed pastures, accompanied by honeylocust *(Gleditsia triacanthos)* and is succeeded by black walnut *(Juglans nigra),* oaks *Quercus spp.),* hackberry *(Celtis spp.),* hickories, and elms *(Ulmus* spp.) (18). Among the most common associates on lime stone- derived soils in middle Tennessee and neighboring portions of Kentucky and Alabama are eastern redcedar *(Juniperus virginiana),* black walnut, hickories, and elms (45).

Life History

Reproduction and Early Growth

Flowering and Fruiting- Osage-orange is dioecious. The simple, green, four-part flowers appear soon after the leaves on the same spurs, opening from April through June, and are wind pollinated. Male flowers are long peduncled axillary racemes 2.5 to 3.8 cm (1 to 1.5 in) long on the terminal leaf spur of the previous season; female flowers are in dense globose heads, axillary to the leaves, about 2.5 cm (1 in) in diameter (2). The female flower in ripening becomes very fleshy, forming a large multiple fruit or syncarp composed of 1-seeded drupelets. The fruit ripens from September through October. The ripe fruit, 7.6 to 15 ern (3 to 6 in) in diameter, yellowish-green, resembles an orange, often weighing more than a kilogram (2.2 lb). Fruits average 23/dkl (80 to the bu) (53). When bruised, the fruit exudes a bitter milky juice which may cause a skin rash and which will blacken the fruit on drying.

Female trees often produce abundant fruit when no male trees exist nearby, but such fruit contains no seeds.

Seed Production and Dissemination- Female trees bear good seed crops nearly every year, beginning about the 10th year. Commercial seed-bearing age is optimum from 25 to 65 years, and 75 to 100 years may be the maximum (53). Germinative capacity averages 58 percent. Seeds are nearly I cm (0.4 in) in length. The number of clean seeds ranges from 15,400 to 35,300, averaging 30,900/kg (7,000 to 16,000, averaging 14,000/lb). Livestock, wild mammals, and birds feed on the fruit and disseminate the seed. The seeds have a slight dormancy that is easily overcome by soaking in water for 48 hours or by stratifying in sand or peat for 30 days. Fruit stored over winter in piles outdoors is easily cleaned in the spring, and the seed germinates promptly. Viability can be maintained for at least 3 years by storing cleaned, air-dried seeds in sealed containers at 5° C (41° F) (56). Recommended sowing depth is about 6 to 13 min (0.25 to 0.5 in); soil should be firmed.

Seedling Development- Germination is epigeal. Natural regeneration apparently requires exposed mineral soil and full light. A study of survival and growth in the Prairie States Forestry Project windbreaks indicated average survival of Osage-orange at age 7 years to be 68 percent, ranking seventh of 16 "shrubs"; total height was 2.4 m (8 ft), ranking fifth of 16; and crown spread was 1.8 m (6 ft). Osage-orange was usually planted in the shrub (outer) rows and sometimes in the tree (inner) rows. It grows too fast, however, to be considered a shrub and often overtops slower growing conifers (33).

Vegetative Reproduction- Osage-orange may be vegetatively propagated using root cuttings or with greenwood cuttings under glass. To propagate thornless male (nonfruiting) clones for ornamental use, scions or cuttings should be taken only from the mature part of the crown of a tree past the juvenile stage. Perhaps the easiest way to grow selected stock is by grafting chip buds onto nursery-run seedlings and plastic-wrapping the graft area (30,31).

Sapling and Pole Stages to Maturity

Growth and Yield- Osage-orange is a small tree or large shrub averaging 9 m (30 ft) in height at maturity. Isolated trees on good sites may reach heights of as much as 21 m (70 ft); crowded trees usually do not grow so tall. In windbreak plantings on the Great Plains, Osage-orange grew 6 m (20 ft) tall on average sites during a 20-year period; on some sites it grew 12 m (40 ft) tall (39).

Branchlets growing in full sunlight bear sharp, stout thorns. Slow-growing twigs in the shaded portions of the crown of mature trees are thornless. The thorns, 1.3 to 2.5 cm (0.5 to 1 in) long, are modified twigs. They form in leaf axils on 1-year-old twigs. Shade-killed lower branches remain on the tree many years. Regional estimates, based on the 19641966 Forest Surveys, indicated virtually no Osage-orange of commercial size and quality on forest land in Oklahoma, Texas, and Louisiana. There are two reasons for this: the species usually grows on nonforest land, and merchantability standards for forest trees do not apply to Osage-orange. Mature trees have short, curved boles and low, wide, deliquescent crowns. Even in closed stands on good sites, less than half the stems contain a straight log, 3 m (10 ft) long, sound and free of shake.

Rooting Habit- Osage-orange is characteristically deep rooted, but because it has been planted so widely, the species is usually off-site, where its rooting habit is variable. When the tree grows on shallow, fertile soils over limestone, the lateral rootspread is tremendous (32).

Excavation of root systems in 7-year-old or older shelterbelts revealed a lateral radius of 4.3 m (14 ft) and a depth of more than 8.2 m (27 ft) for Osage-orange near Goodwell, OK (9). The soil was Richfield silt loam. Most of the lateral roots were in the uppermost 0.3 m (1 ft) of soil. Excavations in Nebraska revealed a lateral radius of 2.1 m (7 ft) and a depth of 1.5 m (5 ft) for 3-year-old Osage-orange in Wabash silt loam; for 23-year-old Osage-orange in Sogn silty clay loam, lateral radius was 4.9 m (16 ft) and depth was 2.4 m (8 ft) (47). At both ages, there was a well-developed taproot, and most of the long laterals originated within the first 0.3 m (I ft) of soil. At 3 years, most of the long laterals were within the first 0.6 m (2 ft) of soil; at 23 years, laterals were as abundant in the eighth as in the first foot of soil.

Reaction to Competition- Osage-orange is tolerant according to some authors (6,37) and very intolerant according to others (3). Overall, it is most accurately classed as intolerant of shade. The occurrence and circumstances of natural regeneration suggest intolerance, but the growth of planted Osage-orange in hedges and shelterbelts, under strong competition, indicates tolerance. How vigorously and at how advanced an age the species responds to release has not been determined. Severe competition does not prevent abundant seed production. Osage-orange sprouts vigorously, even following cutting of interior rows in windbreaks.

No literature on the silviculture of naturally regenerated forest stands of Osage-orange is known.

Damaging Agents- Although Osage-orange is one of the healthiest tree species in North America, it is attacked by some parasites. Cotton root rot, caused by *Phymatotrichum omnivorum,* attacks Osage-orange and most other windbreak species in Texas, Oklahoma, and Arizona (59). Losses are greatest in plantings on dry soil where rainfall is scant. Cotton root rot is the only serious disease.

Two species of mistletoe, *Phoradendron serotinum* and *P. tomentosum,* grow in the branches and cause witches' brooms. Osage-orange ornamentals in the Northeast have occasionally succumbed to Verticilliurn wilt, caused by *Verticillium albo-atrum.* Leafspot diseases are caused by *Ovularia maclurae, Phyllosticta maclurae, Sporodesmium maclurae, Septoria angustissima, Cercospora maclurae,* and *Cerotelium fici*. Seedlings in a Nebraska nursery have been killed by damping-off and root rot caused by *Phythium ultimum* and *Rhizoctonia solani* (21). *Phellinus ribis* attacks stemwood exposed in wounds. *Poria ferruginosa* and P. *punctata* are the only two wood-destroying basidiomycetes reported on Osage-orange; they occur only on dead wood, mainly in tropical and subtropical parts of the western hemisphere (21). Maclura mosaic virus and cucumber mosaic virus have been identified in leaf tissue of Osage-orange in Yugoslavia (35).

Osage-orange trees are attacked by at least four stem borers: the mulberry borers *(Doraschema wildii* and *D. alternatum) (4),* the painted hickory borer *(Megacyllene caryae),* and the red-shouldered hickory borer *(Xylobiops basilaris)* (8). The twigs are parasitized by several scale insects including the European fruit lecanium *(Parthenolecanium corni),* the walnut scale

(Quadraspidiotus juglansregiae) the cottony maple scale *(Pulvinaria innumerabilis)* the terrapin scale *(Mesolecanium nigrofasciatum),* and the San Jose scale *(Quadraspidiotus perniciosus)* (25,46). The fruit-tree leafroller *(Archips argyrospilus)* feeds on opening buds and unfolding leaves.

Osage-orange is attacked by, but is not a principal host of, the fall webworm *(Hyphantria cunea)* (55), an Eriophyid mite, *Tegolophus spongiosus (51),* and the fourspotted spider mite, *Tetranychus canadensis (4).*

Osage-orange trees and several other species in 1 to 5-year-old plantations on old fields in the prairie region of Illinois were partially or completely girdled by mice. Severity of damage was greatest where weeds were most abundant (26).

Windbreaks on the Great Plains, unless given cultivation during their early years, are invaded by herbaceous vegetation, become sod bound, and are permanently damaged (33,38,39). This vegetation may harbor rodents. Grazing is not satisfactory for herbage control; multiple-row windbreaks should be fenced to exclude livestock.

Osage-orange sustained less damage by insects, diseases, drought, hail, and glaze than any other species planted in the Prairie States Forestry Project. Along with bur oak *(Quercus macrocarpa)* it survived better than any other deciduous species on uplands of the Southern Plains (7,38).

Special Uses

Osage-orange has been planted in great numbers, first as a field hedge, before barbed wire became available, secondly as a windbreak and component of shelterbelts, and thirdly to stabilize soils and control erosion.

The single-row field hedge proved to be a valuable windbreak on the prairie; evidence of this was the raised ground level under 15-year-old hedges, caused by accumulation of windborne soil material. Hedges around every quarter-section were common, especially in areas of deep sand (20,38). These hedges were a source of durable posts. Prairie farmers customarily clearcut hedges on a 10- to 16-year cycle, obtaining about 2,500 fence posts per kilometer (4,000 per mi) of single-row hedge. The slash was piled over the stumps to protect the new sprouts from browsing livestock. Pole-sized and larger Osage-orange trees are practically immune to browsing, but seedlings and tender sprouts are highly susceptible. Recommended practice is to thin the new sprout stands to 240 vigorous stems per 100 m (73/100 ft), 3 to 5 years after the clearcut, and to protect the sprouts from fire. If inadvertently burned, the sprouts should be cut back immediately to encourage new, vigorous growth (20).

Osage-orange heartwood is the most decay-resistant of all North American timbers and is immune to termites. The outer layer of sapwood is very thin; consequently, even small-diameter stems give long service as stakes and posts (40,43). About 3 million posts were sold annually in Kansas during the early 1970's. The branch wood was used by the Osage Indians for making bows and is still recommended by some archers today.

The chemical properties of the fruit, seed, roots, bark, and wood may be more important than the structural qualities of the wood. A number of extractives have been identified by researchers, but they have not yet been employed by industry (11,12,23, 24,44,58). Numerous organic compounds have also been obtained from various parts of the tree (16,44,57). An antifungal agent and a nontoxic antibiotic useful as a food preservative have been extracted from the heartwood (5,24).

Osage-orange in prairie regions provides valuable cover and nesting sites for quail, pheasant, other birds, and animals (20,33), but the bitter-tasting fruit is little eaten by wildlife. Reports that fruit causes the death of livestock have been proven wrong by feeding experiments in several States.

Osage-orange has been successfully used in strip mine reclamation. Its ease of planting, tolerance of alkaline soil, and resistance to drought are desirable qualities (1,14,29). These qualities plus growth, long life, and resistance to injury by ice, wind, insects, and diseases make Osage-orange a valued landscape plant (15,30,31).

Genetics

There is no known literature on the genetics of Osage-orange, and no information on geographic races is available. A thornless cultivar, *Maclura pomifera* var. *inermis* (André) Schneid., can be propagated by cuttings or scions taken from high in the crowns of old trees, where the twigs are thornless (30,31). The only known hybrid, x *Macludrania hybrida* André, is an intergeneric cross: x *Macludrania = Cudrania x Maclura. Cudrania tricuspidata* (Carr.) Bureau is a spiny shrub or small tree, native to China, Japan, and Korea. The *Maclura* parent is variety *inermis.* The hybrid is a small tree with yellowish furrowed bark and short, woody spines (2,41). Some authorities believe that the tropical dye-wood, fustic *& ChIorophora tinctoria* (L.) Gaud.é belongs in the genus *Maclura;* however, the majority opinion is that there is only one species of Osage-orange (28).

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Pecan

Carya illinoenensis (Wangenh.) K. Koch

Other Common Names:

Pecan hickory, sweet pecan, nogal morado, and nuez encarcelada.

Brief Description:

Pecan is a highly valued tree for its wildlife, wood, and aesthetic uses. Its native range spanned the Mississippi River Valley west to Central Texas and south to Northern Mexico.

Habitat:

Pecan is primarily found on well drained loam soils. In areas of poor drainage and prolonged flooding it is often replaced by a close relative, water hickory *Carya aquatic*. In bottomlands it is commonly found on ridges and well drained flats. Like bur oak, the pecans in the Great Trinity Forest are scarce. The remaining trees are typically large and probably are remnants of the days of agriculture. Due to their desirable qualities they were probably allowed to grow on the edges of fields etc.

Life History:

Periods of excessive rainfall have shown to prevent the pollination of pecan which occurs from April to May. Pecan seeds ripen in September thru October and are dispersed from September thru December. Dispersal is primarily by flood waters and animals such as squirrels. Germination occurs from April to June. Seed production occurs around the age of 20 for native trees. Good seed crops occur in intervals of about one to three years. Regeneration is also possible from the stump as long as the dominant shoot is trained. On good sites height growth of 3 feet per year has been observed indicating that it grows faster than the above mentioned bur oak.

Pecan and the Great Trinity Forest:

Pecan will be a highly desirable species to plant on bottomland ridges and areas of short duration of flooding. It would benefit the target wildlife and provide a consumable product to the public. Pecans, other hickories, and oaks also have a desirable aesthetic quality that would add the recreational experience of the forest.

Carya illinoensis (Wangenh.) K. Koch

Pecan

Juglandaceae -- Walnut family

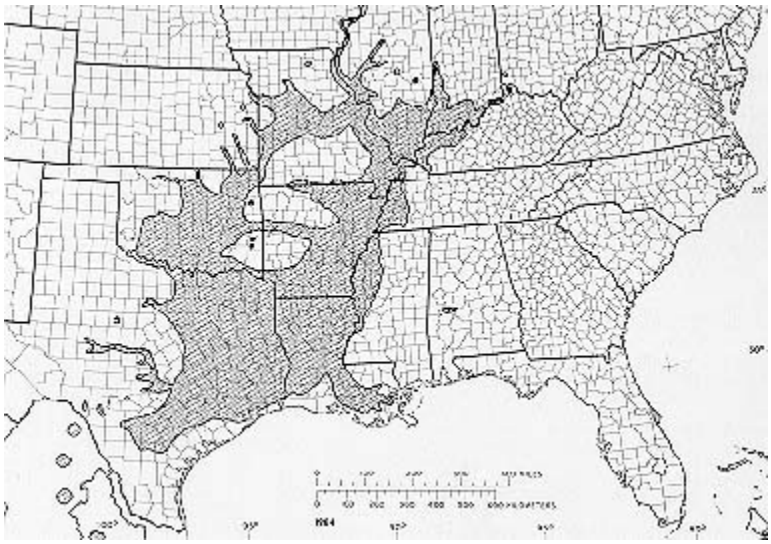
J. K. Peterson

Pecan *(Carya illinoensis)* is one of the better-known pecan hickories. It is also called sweet pecan and in its range where Spanish is spoken, nogal morado or nuez encarcelada. The early settlers who came to America found pecans growing over wide areas. These native pecans were and continue to be highly valued as sources of new varieties and as stock for selected clones. Besides the commercial edible nut that it produces, the pecan provides food for wildlife. Pecans are an excellent multipurpose tree for the home landscape by providing a source of nuts, furniture-grade wood, and esthetic value.

Habitat

Native Range

Pecan grows principally in the lower Mississippi Valley. Within this region it extends westward to eastern Kansas and central Texas, eastward to western Mississippi and western Tennessee. Sparse occurrence has been reported along the eastern margin of its range from southwestern Ohio to Kentucky and Alabama. Pecan also grows locally throughout northeastern and central Mexico (34).



-The native range of pecan.

Climate

Pecan grows in a humid climate; the minimum average annual rainfall approximates 760 mm (30 in) and the maximum reaches 2010 mm (79 in). At least 510 mm (20 in) of rain falls during the growing season. Annual snowfall varies from 0 to 50 cm (0 to 20 in). Mean summer temperatures range as high as 27° C (81° F), with extremes of 41° to 46° C (105° to 115° F). Average winter temperatures vary from 10° to -1° C (50° to 30° F), with extremes of -18° to -29° C (0° to -20° F) (2,26,27).

Soils and Topography

Sweet pecan grows commonly on well-drained loam soils which are not subject to prolonged flooding. However, it does appear on heavy textured soils, where it is limited to alluvial soils of recent origin. On such land forms its best development is on the ridges and well-drained flats. It rarely grows on low and poorly drained clay flats where it is replaced by water hickory *(Carya aquatica)* (2,21). These soils are most commonly found in the orders Entisols, Inceptisols, and Alfisols. Pecan seedlings can survive short periods of flooding (18).

Associated Forest Cover

Pecan is a major component of the Society of American Foresters forest cover type: Sycamore-Sweetgum-American Elm (Type 94) but is more prominent in a variant of this type: the Sycamore-Pecan-American Elm association. In addition, it is a component of Cottonwood (Type 63) and Black Willow (Type 95) (32). Other associated species are green ash *(Fraxinus pennsylvanica),* sugarberry or hackberry *(Celtis spp.),* boxelder *(Acer negundo),* silver maple *(A. saccharinum),* and water oak *Quercus nigra).* Some common understory components include pawpaw *(Asimina triloba),* giant cane *(Arundinaria gigantea),* and pokeweed *(Phytolacca americana).* Vines often present are poison-ivy *(Toxicodendron radicans),* grape *(Vitis spp.),* Alabama supplejack *(Berchemia scandens),* greenbriers *(Smilax spp.),* and Japanese honeysuckle *(Lonicera japonica).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- Flowering of pecan takes place from April through May. The species is monoecious; flowers are borne in staminate and pistillate catkins on the same tree. Staminate flowers appear in slender fascicled, sessile catkins, 8 to 15 cm (3 to 6 in) long. The calix is two- or three-lobed, with a center lobe that is longer than the lateral ones, and five or six stamens. Pistillate catkins are hairy, yellow, and not as numerous as staminate ones, with two to four stigmas (37). Most pecan cultivars are clones derived from wild trees. These cultivars generally show incomplete dichogamy. In some cultivars there is no overlap at all in the period of pollen dehiscence and stigma receptivity, thus requiring more than one cultivar for successful pollination and fruit set (20). Pecan is anemophilous, and excessive rainfall during the flowering period may prevent pollination.

Beginning in late summer, buds of pecan develop a physiological state of rest, characterized by loss of apical dominance and cessation of both terminal and lateral growth. Existence of a cold requirement was first indicated by Waite (38). Intensity and dissipation of rest depend on the temperature regimes and genetic factors (4).

Seed Production and Dissemination- Fruits ripen in September and October and are dispersed from September through December (8). Pecan fruits are ovoid, globose or pear-shaped nuts, enclosed in husks developed from the floral involucre. The green husks turn brown to black as they ripen. The husks become dry at maturity and split away from the nut in four valves along sutures starting from the base The minimum seed-bearing age is 2 to 4 years in some cultivars and up to 20 years for individuals in natural stands. The maximum seed-bearing age also varies considerably; a maximum of 300 years has been reported (37). The cleaned nuts average about 220 to 350/kg (100 to 160/lb). Good crops are produced at intervals from 1 to 3 years. Seed dispersal is principally by water and animals. The floating nuts can be carried considerable distances by flood water. Aerial dispersion is mainly by squirrels (21).

Seedling Development- Seeds can be stored for 3 to 5 years in closed containers at 5° C (41° F) an 90 percent relative humidity (8). Seed stratification and germination conditions have been reported b various authors (3,6,12,36). As with all hickories, germination is hypogeal. Seeds of pecan show delayed germination, since the shell mechanically restricts radicle elongation. To overcome this delay the nuts are stratified at 2° to 5° C (36° to 41° F) for 30 to 90 days, followed by incubation at room temperature. However, the restriction can be nullified by incubating the nuts at 30° to 35° C (86° to 95° F), without prior stratification. Under this regime, uniform and rapid germination occurs and is completed in 20 days. Germination without prior stratification is greatly enhanced by soaking the nuts in gibberellic acid (7).

Under natural conditions, pecan nuts remain dormant until spring when germination starts in early April and extends to early June. Exceptionally dry weather or heavy aerial competition greatly reduces survival. On loamy soils height growth averages about 90 cm (35 in) per year for several years under favorable weather conditions (21).

Vegetative Reproduction- Rooting experiments with shoot cuttings gave highly variable success rates. The principal variables were time of collection, thickness and origin of cuttings, chemical treatments, and genetic factors. Softwood cuttings are easier to root than hardwood or semi-hardwood cuttings. The time of shoot collection, however, seems most important. Juvenile cuttings, taken about midway of the dormant season and dipped in 10,000 p/m indolebutyric acid, gave 100 percent rooting; adult wood rooted 85 percent under these conditions (31). Shoots derived from adventitious buds root better than other shoots, especially when terminal buds are removed (14). The optimum collection period for pecan cuttings appears to be during mid-rest or after 200 to 400 hours of field chilling below 72° C (45° F) have accumulated. Cuttings collected after 500 hours chilling force buds rather than roots (19). Softwood cuttings may root in 15 days and flush after 35 days (30). Air-layering is also successful in pecans; the timing of this treatment is very essential (25). Pecan can also be regenerated from the stump. If the strongest shoot is trained as the new tree, while the others are removed, vigorous growth will result (40). Commercial cultivars may be propagated by grafting on improved root stocks.

Sapling and Pole Stages to Maturity

Growth and Yield- On loamy soils, height growth may average 90 cm (35 in) per year for several years (21). Diameter growth of pecan parallels the average for bottom lands. The average 10-year diameter growth in natural unmanaged stands in the northeast Louisiana delta is 5 cm (2.0 in) in the 15 to 30 cm (6 to 12 in) diameter class, 7 cm (2.7 in) in the 35 to 45 cm (14 to 18 in) diameter class, 5 cm (2 in) in the 50 to 70 cm (20 to 28 in) diameter class, and 6 cm (2.3 in) in the 75 cm (30 in) diameter class (5).

Mature pecan is a medium to very large straight-stemmed tree reaching up to 55 in (180 ft) in height and occasionally 180 to 210 cm (70 to 83 in) in d.b.h. (21) (fig. 2).

Rooting Habit- No information available.

Reaction to Competition- Pecan is classed as intolerant of shade but more tolerant than cottonwood and willow. It is a subclimax species. Pecan responds well to release in all age groups, provided that the trees have good vigor (21).

Damaging Agents- Only the most common fungal diseases are listed here. A spot anthracnose, *Elsinoe randii,* causes an important nursery blight. Small reddish lesions form on both leaf surfaces. Tissue falls out of the spots, producing holes and ragged leaf margins (39). *Cladosporium effusum* (pecan scab) is a limiting factor in nut production in parts of the South. Lesions along the veins and underside of the leaves are produced (15). *Gnomonia nerviseda* (vein spot), *G. caryae,* and *G. caryae* var. *pecanae* (liver spot) are common (34). *Microstroma juglandis* causes leafspot or white mold as well as witches' brooms. *Cercospora halstedii,* the conidial stage of *Mycosphaerella dendroides* (9), causes leaf blotch. *Mycosphaerella caryigena,* known as downy spot, causes frosty spots on the lower leaf surfaces (23).

A large number of fungi rot the woody cylinder of living hickories. Some rot heartwood; others rot senescent or dead sapwood. Prominent genera are *Fomes, Poria,* and *Polyporus (15). Poria spiculosa is* a most damaging and common canker that produces thick, deep callus folds. It appears as rough circular swellings on the bole (33). *Phomopsis* tumor is a widespread gall-forming fungus. It produces from warty growths on twigs to large burls on trunks (34).

Among the common root rot diseases are *Clitocybe tabescens, Phymatotrichum omnivorum* (Texas root rot), and *Helicobasidium purpureum* (violet root rot). Feeder root necrosis is produced by *Fusarium solani, F oxysporum,* and *Pythium irregulare.*

Other diseases include *Criconemoides quadricornis,* a "ring" nematode (16), and *Agrobacterium tumefaciens,* an economically important bacterial disease in pecan. In the South pecan is affected by a viral brooming disorder that results in a dense growth of willowy shoots (22). Pecan rosette is a common bunching disease in the South caused by zinc deficiency (10).

Many insects feed on pecan leaves, nuts, twigs, wood, and roots (11,24). Among the beetles are *Goes pulcher,* the living hickory borer, whose larvae feed on trunks and branches; they are common throughout the United States. *Oncideres cingulata,* twig girdler, and *0. pustulatus,*

hinsache girdler, are wood borers that at times become numerous. Adult females girdle branches, which then die and fall off. Occasionally young seedlings may be cut off near the ground. The hickory bark beetle *(Scolytus quadrispinosus)* bores into boles and branches and can do considerable damage. Severe outbreaks causing extensive tree mortality occur when precipitation is insufficient in summer. The flat oak borer *(Smodicum cucujiforme)* attacks heartwood of trees as well as cut lumber. This beetle occurs throughout the Eastern United States. The so-called pinhole borers *(Xyleborus affinis, X. ferrugineus,* and *Xyleborinus saxesensi)* inhabit trunks and stems of many hardwoods, including pecan, in the Southeastern United States. They primarily attack trees weakened by drought, mechanical damage, or cold injury. Occasionally they attack healthy trees but rarely cause serious damage since the larvae cannot subsist on wood with good sap flow. The hickory shoot curculio *(Conotrachelus aratus)* feeds on unfolding buds and young shoots of pecan and may cause extensive damage. The nut curculio *(Conotrachelus hicoriae)* attacks immature pecan nuts. Both beetle species occur in the Pecan Belt. The flatfooted ambrosia beetle *(Platypus compositus)* causes injuries in freshly felled trees due to extensive burrowing. This beetle occurs throughout the Southern United States. The tilehorned root borer *(Prionus imbricornis)* and the broadnecked root borer *(Prionus laticollis)* are beetles whose larvae feed on root bark of living trees. They soon enter the roots, completely hollowing and occasionally severing them.

Other injurious insects include the following: the sycamore lacebug *(Corythucha ciliata),* which feeds on leaves of pecan, and is common in the Eastern United States (13); the forest tent caterpillar *(Malacosoma disstria)* and the walnut caterpillar *(Datana integerrima),* which defoliate pecan trees; and the pecan carpenterworm *(Cossula magnifica),* found throughout the Eastern United States, whose larvae attack small twigs, bore into the pith, and soon burrow into heartwood. The pecan weevil *(Curculio caryae)* at times destroys most of the nut crop in the southern part of the pecan range. Heavy attacks by the obscure scale *(Chrysomphalus obscurus)* cause small limbs to die.

Pecan is susceptible to fire damage at all ages. Fire in the bottom lands moves rapidly along the soil surface, killing most tree reproduction and occasionally scorching the sensitive bark of older trees. Particularly hot fires may kill mature pecan trees.

Special Uses

Improved cultivars are extensively grown in the United States and abroad for commercial nut production. Pecan nuts are eaten by a number of birds, fox and gray squirrels, opossums, raccoons, and peccaries (37).

The demand for pecan wood has steadily increased in recent decades. It is used for furniture, cabinetry, panelling, pallets, and veneer. The wood has good machining properties, resembling those of true hickories (2,35).

Genetics

Population Differences

Studies of variation in natural pecan stands throughout Louisiana indicated a large genetic diversity within populations. Also, there was a high degree of variation between breeding populations, indicating a close relationship (inbreeding) among trees in small stands. Genotype x environment interaction was highly significant between progeny tests of open pollinated selected trees. Heritability estimates for height growth indicated ample genetic variation to anticipate significant gains in breeding programs (1,28,29).

Races and Hybrids

More than a hundred horticultural clones have been listed (37). These were selected primarily for various characteristics concerning commercial nut production. More recently several cultivars have been developed for the same purpose.

Complex hybridized natural populations are common. Natural interspecific hybridization occurs with *Carya aquatica (C. x lecontei* Little), *C. cordiformis (C. x brownii* Sarg.), *C. laciniosa (C. x nussbaumeri* Sarg.), *C. ovata,* and *C. tomentosa (C. x schneckii* Sarg.) (17).

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Post Oak

Quercus stellata Wangenh.

Other Common Names:

Iron oak

Brief Description:

This drought resistant, slow growing, oak is abundant throughout the South Central and Southeastern United States. It has a very durable wood that can be used effectively as fence posts, hence, its name.

Habitat:

Post oak ranges across most of the Southern United States and into southern parts of states like Indiana, Ohio, and Pennsylvania. It is common throughout the central and eastern portions of Texas. Post oak is commonly found on dry sites. It makes up the dominant part of the "Cross Timbers" forest type that occurs in Texas. Some varieties of post oak such as delta post oak can be found in bottomlands of East Texas, Louisiana, West Mississippi, and South Arkansas.

Life History

Flowers appear at the same time as the leaves, which is usually about March. The acorns mature in one growing season and drop soon after ripening, from September through November. The tree begins to bear acorns at about 25 years of age. In some areas of Texas, post oaks that are less 6 inches in DBH will produce no acorns. Post oaks do not exhibit any dormancy and germinate in the autumn. The best seedbed is moist soil with one inch or more of leaf litter. Post oaks up to 10 inches in DBH will sprout prolifically. Post oak is intolerant of shade and competition. It exhibits slow growth, but will often dominate droughty sites because of its drought hardiness more so than its superior growth.

Post oak and the Great Trinity Forest:

Post oak occurs occasionally on the non-flooding and well drained coarse textured soils of the forest. It is a good choice for planting on these types of sites and its presence will be promoted.

Quercus stellata Wangenh.

Post Oak

Fagaceae -- Beech family

John J. Stransky

Post oak *(Quercus stellata),* sometimes called iron oak, is a medium-sized tree abundant throughout the Southeastern and South Central United States where it forms pure stands in the prairie transition area. This slow-growing oak typically occupies rocky or sandy ridges and dry woodlands with a variety of soils and is considered drought resistant. The wood is very durable in contact with soil and used widely for fenceposts, hence, the name. Due to varying leaf shapes and acorn sizes, several varieties of post oak have been recognized-sand post oak *(Q. stellata* var. *margaretta* (Ashe) Sarg.), and Delta post oak *(Quercus stellata* var. *paludosa* Sarg.) are included here.

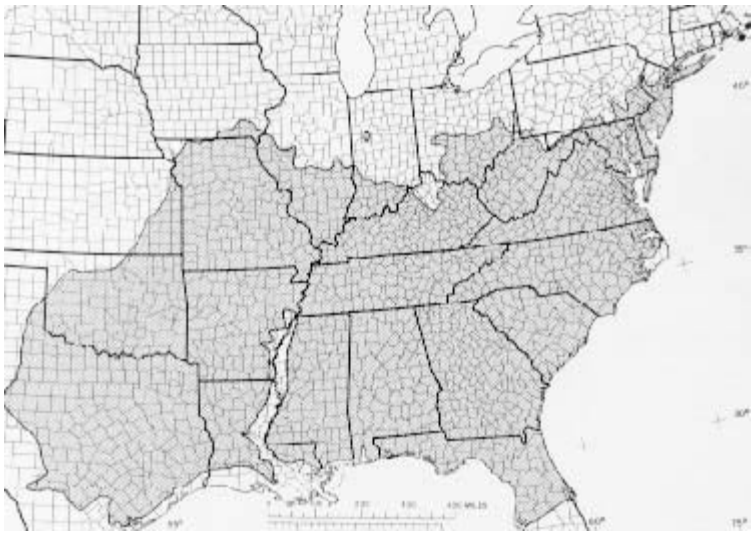
Habitat

Native Range

The range of post oak extends from southeastern Massachusetts, Rhode Island, southern Connecticut and extreme southeastern New York (including Long Island); west to southeastern Pennsylvania and West Virginia, central Ohio, southern Indiana, central Illinois, southeastern Iowa and Missouri; south to eastern Kansas, western Oklahoma, northwestern and central Texas; and east to central Florida (10).

It is a large and abundant tree in the southern Coastal Plain, the Piedmont, and the lower slopes of the Appalachians. It is common in the southwest and grows in pure stands in the prairie transition region of central Oklahoma and Texas known as the "Cross Timbers" (2).

Sand post oak *(Quercus stellata* var. *margaretta* (Ashe) Sarg.) ranges from southeastern Virginia, west to Missouri and eastern Oklahoma, south to central Texas, and east to central Florida. Delta post oak *(Q. stellata* var. *paludosa* Sarg.) is found in bottom lands of the Mississippi River in western Mississippi, southeast Arkansas, and Louisiana, and west to east Texas (10).



-The native range of post oak.

Climate

The range of post oak reaches from the humid East to semiarid portions of Oklahoma and Texas. Within this region, average annual precipitation varies from more than 1520 mm (60 in) in west Florida and parts of Louisiana to less than 560 mm (22 in) in central Texas. Annual snowfall varies from 760 cm (30 in) in southeastern Iowa to a trace in Florida (15).

Mean annual temperatures vary from 10' C (50' F) in southern New England and southeastern Iowa to 22' C (72' F) in central Florida. January temperatures average from -6' C (22' F) in southeastern Iowa to 17' C (62' F) in Florida; in July they range from 23' C (73' F) in southern New England to 290 C (85' F) in Texas. Temperature extremes of -11' C (12' F) in Kansas, Oklahoma, and Texas and -400 C (-40' F) in central Missouri have been recorded.

From northwest to southeast the average frost-free period increases from 165 to 300 days, 60 to 90 percent, respectively, of the annual precipitation occurring during this period.

Soils and Topography

Post oak grows on a variety of sites and soils. Its range coincides mostly with that of the Utisols but also includes some Alfisols in the western portion of its distribution. Typically, it grows on dry sites. Rocky outcrops, ridges, and upper slopes with southerly or westerly exposures are common.

Soils are generally well drained, sandy, coarse textured, deficient in nutrients, and low in organic matter. The surface soil is generally thin but post oak, and especially the scrubby sand post oak, grows on deep sandy, gravelly soils.

Delta post oak grows in fine sandy loam soils on the highest first-bottom ridges in terraces. There is seldom standing water, but the site may be wet due to slow drainage.

Associated Forest Cover

In the Northern Forest Region, post oak is found in the forest cover type White Pine-Chestnut Oak (Society of American Foresters Type 51) (4). On dry ridges and upper slopes its other associates are scarlet, white, and black oaks *(Quercus coccinea, Q. alba,* and *Q. uelutina),* hickories *(Carya* spp.*),* and pines *(Pinus* spp.*).*

In the Central Forest Region, post oak is most abundant in Post Oak-Blackjack Oak (Type 40). It extends over a wide area from eastern Kansas south to Texas and east to the Atlantic Coastal Plain. On heavier, clay soils a post oak variant of this type is found, and in the Texas "Cross Timbers" area and in Oklahoma, a post oak savanna. Along with other oaks, post oak is a common associate in several other cover types: Bear Oak (Type 43), Chestnut Oak (Type 44), White Oak-Black Oak-Northern Red Oak (Type 52), White Oak (Type 53), Black Oak (Type 110), Pitch Pine (Type 45), and Eastern Redcedar (Type 46).

In the Southern Forest Region, sand post oak is a chief hardwood component of Sand Pine (Type 69). Sand post oak and post oak grow on drier sites of Longleaf Pine (Type 70) and in Southern Scrub Oak (Type 72). Post oak is a common associate in Longleaf Pine-Slash Pine (Type 83), Shortleaf Pine (Type 75), Virginia Pine (Type 79), Loblolly Pine (Type 81), and Loblolly Pine-Shortleaf Pine (Type 80), and on better drained sites of Slash Pine (Type 84). In the oak-pine types post oak is a common associate in Shortleaf Pine-Oak (Type 76), Virginia Pine-Oak (Type 78), and the Loblolly Pine-Hardwood (Type 82); sand oak is an important component of Longleaf Pine-Scrub Oak (Type 71).

Delta post oak is found in Swamp Chestnut Oak-Cherrybark Oak (Type 91). In Mesquite (Type 68) of east central Texas, post oak appears in mixture with mesquite *(Prosopis* spp.*).*

The most common hardwoods associated with typical post oak are blackjack oak *(Quercus marilandica),* black oak, and the hickories. Less common associates include southern red oak *(Q. falcata),* white oak, scarlet oak, chestnut oak *(Q. prinus),* shingle oak *(Q. imbricaria),* live oak *(Q. uirginiana),* chinkapin oak *(Q. muehlenbergii),* bluejack oak *(Q. incana),* Shumard oak *(Q. shumardii),* blackgum *(Nyssa sylvatica),* sourwood *(Oxydendrum arboreum),* red maple *(Acer rubrum),* winged elm *(Ulmus alata),* hackberry *(Celtis occidentalis),* chinkapin *(Castanea* spp.), and dogwood *(Cornus* spp.). Coniferous associates are eastern redcedar *(Juniperus virginiana),* shortleaf pine *(Pinus echinata),* Virginia pine *(P. virginiana),* pitch pine *(P. rigida),* loblolly pine *(P. taeda),* and occasionally longleaf and slash pines (P. *palustris* and P *elliottii).* At higher elevations eastern white pine *(P. strobus)* and hemlock *(Tsuga* spp.*)* are sometimes associates.

Delta post oak is commonly associated with cherrybark oak *(Quercus falcata* var. *pagodifolia),* water oak (Q. *nigra), willow* oak (Q. *phellos),* swamp chestnut oak (Q. *michauxii),* white oak, sweetgum *(Liquidambar styraciflua),* blackgum, American elm *(Ulmus americana),* winged elm, white ash *(Fraxinus americana),* hickories, and loblolly pine.

In the South, where post oak is a major component in many stands, the following small trees are common associates: shining sumac *(Rhus copallina),* smooth sumac *(R. glabra),* gum bumelia

(Bumelia lanuginosa), hawthorns *(Crataegus spp.),* yaupon *(Ilex vomitoria),* possumhaw *(J. decidua),* redbud *(Cercis canadensis),* and rusty blackhaw *(Viburnum rufidulum).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- Post oak is monoecious; staminate and pistillate flowers are on the same tree in separate catkins (aments). Flowers appear at the same time as the leaves. Flowering usually begins in March in the South and extends through May further north. Staminate flowers are borne in pendant catkins 5 to 10 cm (2 to 4 in) long. The calyx is yellow, pubescent, and five-lobed; the lobes are acute and laciniately segmented, with four to six stamens and pubescent anthers. Pistillate catkins are short-stalked or sessile and inconspicuous; the scales of the involucre are broadly ovate and hairy with red, short, enlarged stigmas (18).

The acorns mature in one growing season and drop soon after ripening, from September through November. Late freezes after the start of flowering and leafing may cause seed crop failures. The acorns are sessile or short-stalked, borne solitary, in pairs, or clustered; acorns are oval or ovoid-oblong, broad at the base, 13 to 19 mm (0.5 to 0.75 in) long, striate, set in a cup one-third to one-half its length. The cup is bowl-shaped, pale, and often pubescent within. Externally it is hoary-tomentose. The scales of the cup are reddish brown, rounded or acute at the apex, and closely appressed (18).

Seed Production and Dissemination- In common with many other oaks, post oak begins to bear acorns when it is about 25 years old. Good acorn crops are produced at 2- to 3-year intervals; although at several locations in Missouri over a 6-year period, post oak consistently averaged only 200 seeds per tree per year while white, blackjack, black, and scarlet oaks of the same size on the same site bore from 500 to 2,400 acorns per tree. Isolated trees in open fields in east Texas consistently produced well. Elsewhere in Texas, trees less than 15 cm (6 in) in d.b.h. had no acorns (12).

The number of post oak acorns per kilogram averages 838 (380/lb) but may range from 441 to 1,340 (200 to 608/lb) (17).

In a sampling of post oak acorn yields from 736 trees for 18 years (1950-67) in western Louisiana and eastern Texas, the average number of fresh acorns per kilogram was 476 (216/lb) with 39 percent moisture content (5). Mast yield increased linearly with increasing bole size. Expected acorn yield was 1.6 kg (3.6 lb) from trees 30.5 cm (12 in) in d.b.h., and 3.6 kg (8.0 lb) from trees 50.8 cm (20 in) in d.b.h. The percentage of acorn-producing trees also increased with increasing d.b.h. from 42 percent on 15.2 cm (6 in) trees to 76 percent on 55.9 cm (22 in) trees. Expected acorn yield rose from 0.9 kg (2 lb) on trees with a 3.0 ni (10 ft) crown diameter to 5.5 kg (12.1 lb) on trees with a 6.1 m (20 ft) crown diameter. Average acorn yield per tree over the 18-year observation period varied from a low 0.03 kg (0.07 lb) in 1962 to a high 4.4 kg (9.7 lb) in 1965.

Seedling Development- Post oak acorns germinate in the autumn soon after dropping. They do not exhibit dormancy. Germination is hypogeal. The best seedbed is a moist soil covered with 2.5 cm (I in) or more of leaf litter.

Vegetative Reproduction- Post oaks up to 25 cm (10 in) in d.b.h. sprout prolifically after being cut or burned. Along the southwestern margins of its range, post oak spreads rapidly into former grasslands after periodic prairie fires were stopped, and much of this extension appears to be of sprout origin. In one study in which potted seedlings were deprived of moisture until the aboveground parts died, two to three times as many post oaks sprouted after normal moisture was restored than did white, blackjack, northern red, or scarlet oaks (12).

In a comparison of the sprouting habits of five oaks, post oak had more one-stem clumps and fewer sprouts per clump on the average than did black oak, chestnut oak, white oak, or scarlet oak. This characteristic would be important in culture by coppice except that post oak grows more slowly than the others.

Sapling and Pole Stages to Maturity

Growth and Yield- In the Southeast, mature post oaks are from 15.2 to 18.3 m (50 to 60 ft) tall and from 30 to 61 cm (12 to 24 in) in d.b.h. Maximum height rarely exceeds 30 m (100 ft), and diameters exceeding 122 cm (48 in) are uncommon. In the extreme western part of its range, mature trees are seldom larger than 9 to 12 in (30 to 40 ft) tall and 38 to 46 cm (15 to 18 in) in d.b.h. Height and diameter growth for post oak are usually slower than for any of the associated trees except blackjack oak ' Ten-year diameter growth generally averages less than 5 cm (2 in), and in central Oklahoma it may be only 13 mm (0.5 in).

Diameter growth of individual post oaks averaging 17 cm (6.7 in) in d.b.h. was stimulated when most of the stand was removed to favor forage production in Robertson County, TX (12). Post oak stands were thinned from an average of 14.9 m^2/ha (65 ft^2 /acre) basal area to 8.9, 6.0, and 3.0 m^2/ha (39, 26, and 13 ft^2 /acre). In the two ensuing growing seasons, average annual diameter growth for the heaviest thinning was twice that of the uncut check plots (3.6 mm. compared to 1.8 mm, excluding bark, or 0.14 in compared to 0.07 in).

Average post oak stands in east Texas contain a volume of about 47.2 m^3/ha (7.5 cords or 675 ft^3/acre). In an Oklahoma woodland, typical of the dry upland post oak type, post oaks 30 cm (12 in) in d.b.h. and larger made up 64 percent of the sawtimber volume (Doyle rule) in a stand averaging nearly 28.0 m^3/ha (2,000 fbm/acre). The average post oak contained 0.4 m' (70 fbm).

Rooting Habit- Post oak seedlings have especially thick taproots, usually exceeding the shoot diameter; but overall root development is less than that of northern red *(Quercus rubra)*, scarlet, white, and blackjack oak (12). Although post oak seedlings do become established on sites having a tight clay subsoil, their growth is slow and most roots develop above the underlying clay (3). Post oak seedlings were found to be the most drought resistant of four Missouri oaks, primarily because of the greater drought tolerance of their leaf and root cells (13). In Alabama, post oak was the least tolerant of flooding of all species tested (6).

Reaction to Competition- Post oak is intolerant of competition and is classed as intolerant of shade. Because of its slow height growth it often is overtopped by other trees, including most other oaks. On poor sites, however, post oak tends to persist and become dominant because it is more drought resistant than many of its associates (12).

Damaging Agents- Post oak is susceptible to most insects, diseases, and pollutants that present a threat to other oaks. Regeneration efforts are hampered by acorns being destroyed by weevils. Insect defoliators, leafrollers, tent caterpillars, Gypsy moth, sawfly, leaf miners, and skeletonizers may cause growth losses, and when repeated, may cause mortality (14). The foliage also is susceptible to at tacks by aphids, lace bugs, various scales, gall wasps, and mites. The trunk, twigs, and roots may be damaged by carpenterworms, borers, beetles, twig pruners, white grubs, and cicadas (locusts). Some of these cause defects that render the wood unfit for many commercial purposes (1).

Chestnut blight fungus *(Cryphonectria parasitica)* causes many defects as well as mortality to post oak throughout its range (8). The tree also is subject to oak wilt *(Ceratocystis fagacearum),* a vascular disease prevalent mostly north of the 35th parallel, but not to the same degree as on red oaks. Soil-inhabiting fungi may cause heavy seedling mortality by damping off. Powdery mildews stunt and deform nursery seedlings.

Many fungi produce spots, blotches, blisters, and blights on the foliage. They rarely cause real damage but are unsightly.

Decay fungi cause cankers, rots, and discoloration of the upper and lower stem, as well as of the roots. The Texas root rot *(Phymatotrichum ormnivorum)* attacks mainly oaks planted on old farm fields or in subdivisions (14).

Several species of mistletoe are often found on branches and trunks of post oak. Infected branches may be stunted and eventually die. Trees usually are not killed.

Nonpoint source pollutants near large cities cause twigs of many oaks to die back, or kill the trees. The specific diagnosis is usually difficult. Sulfur dioxide, fluoride, ammonia, and some herbicides have been identified as probable agents.

Special Uses

Post oak is a valuable contributor to wildlife food and cover. Acorns provide high energy food during fall and winter and are considered important in the diet of wild turkey, white-tailed deer, squirrels, and many other rodents. When acorns are available animals fatten quickly, go through the winter in good condition, and are most likely to produce healthy young (7). Leaves are used for nest building by birds, squirrels, and raccoons (11). Cavities provide nests and dens for various birds and mammals.

Considered a beautiful shade tree for parks, post oak is often used in urban forestry. It is also planted for soil stabilization on dry, sloping, stony sites where few other trees will grow. It

develops an attractive crown with strong horizontal branches. Large trees are difficult to transplant and do not tolerate compaction or removal of soil in developments (19).

The wood of post oak, commercially called white oak, is classified as moderately to very resistant to decay (16). It is used for railroad ties, lathing, siding, planks, construction timbers, mine timbers, trim molding, stair risers and treads, flooring (its highest volume finished products), fenceposts, pulp, veneer, particle boards, and fuel. The bark provides tannin, decorative and protective mulch in landscaping, and fuel.

The tannin in oak leaves, buds, and acorns is toxic to cattle, sheep, and goats. Oak poisoning is a problem in the Southwest where annual livestock losses costing more than $10 million have been estimated. Poisoning occurs more frequently in drought years when other forage is in short supply. The most dangerous season is during the sprouting of new foliage, a period of about 4 weeks in March and April (9).

Genetics

The great variation in post oak and its tendency to hybridize creates a number of varieties and hybrids. The following hybrids with *Quercus stellata* have been recognized (10): *Q. alba (Q. x fernowii* Ti-el.); *Q. bicolor (Q. x substellata* Trel.); *Q. durandii (Q. x macnabiana* Sudw.); *Q. havardii* (unnamed); *Q. lyrata (Q. x sterrettii* Trel.); *Q. macrocarpa (Q. x guadalupensis* Sarg.); *Q. minima (Q. x neo-tharpii* A. Camus); *Q. mohriana* (unnamed); *Q. prinoides (Q. x stelloides* Palmer); *Q. prinus (Q. x bernardiensis* W. Wolf); *Q. virginiana (Q. x harbisonii* Sarg.).

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Red Mulberry

Moras rubra L.

Other Common Names:

Moral

Brief Description:

Red mulberry is a fast growing tree of valleys, flood plains, and low moist hillsides. The tree's fruit is eaten by people, birds, and small mammals. Red mulberry is also identifiable by its unique white milky sap.

Habitat:

Red mulberry ranges from Central Texas, north to the Great Lakes, and East to the Atlantic Ocean. It is also found in Bermuda. The tree's best development is on rich cove soils along streams. The tree never appears in pure stands or large groups of trees, but instead as scattered individuals. It is found on a variety of moist soils, though. Through seed dissemination by birds can also result in the tree being established on a variety of soils primarily on fence rows.

Life History:

Red mulberry flowers in April and May. The blackberry-like fruit reaches full development in June and August. Minimum seed production age is usually about 10 years. The seeds mature and fall to the ground where they are dispersed by animals and birds. Because the fruit is such a favorite of wildlife, seeds are often eaten before they are fully matured. Because it is often found as an understory tree, red mulberry is classed as being shade tolerant.

Red mulberry and the Great Trinity Forest:

This species has been noted in the forest inventory. It is probably not found on poorly drained soils, but should be promoted to a limited extent. Its fruit would be appealing both from a wildlife management and a forest visitor standpoint.

Morus rubra L.

Red Mulberry

Moraceae -- Mulberry family

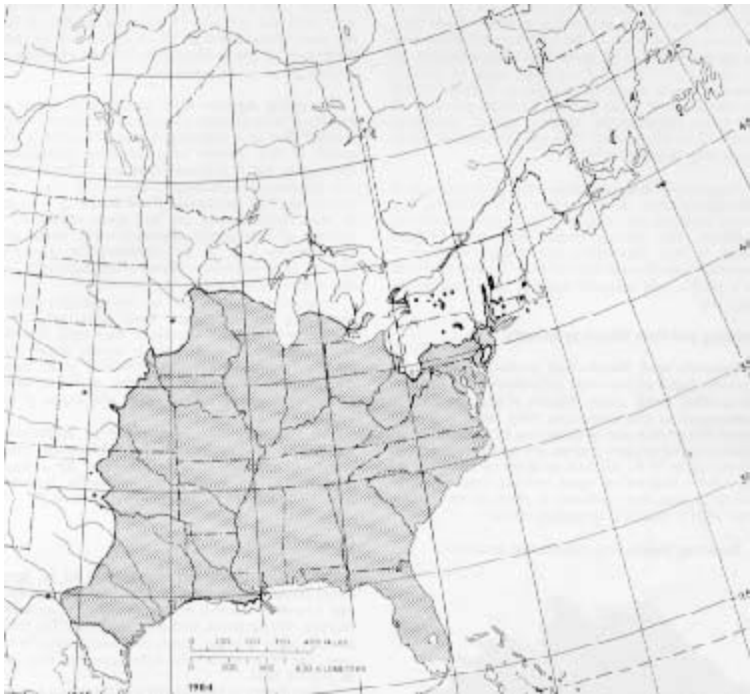
Neil 1. Lamson

Red mulberry *(Morus rubra)*, called moral in Spanish, is widespread in Eastern United States. It is a rapid-growing tree of valleys, flood plains, and low moist hillsides. This species attains its largest size in the Ohio River Valley and reaches its highest elevation (600 m or 2,000 ft) in the southern Appalachian foothills. The wood is of little commercial importance. The tree's value is derived from its abundant fruits, which are eaten by people, birds, and small mammals.

Habitat

Native Range

Red mulberry extends from Massachusetts and southern Vermont west through the southern half of New York to extreme southern Ontario, southern Michigan, central Wisconsin and southeastern Minnesota; south to Iowa, southeastern Nebraska, central Kansas, western Oklahoma and central Texas; and east to southern Florida. It is also found in Bermuda.



-The native range of red mulberry.

Climate

Red mulberry grows under a variety of conditions. The frost-free period ranges from 150 days in New England to 330 days in southern Florida. Total annual precipitation ranges from 1000 to 2000 mm (40 to 80 in). Best growth is in moist coves and flood plains in the southern half of its natural range. Mean annual snowfall ranges from zero in Florida to 150 cm (60 in) in New York.

Soils and Topography

Red mulberry grows on a variety of moist soils at elevations below 600 m (2,000 ft). Soil orders on which red mulberry is found include Alfisols, Inceptisols, Spodosols, and Ultisols. Seeds are carried great distances by birds so trees may be found on any soil that is not too dry. Best development is on well-drained, moist soils of sheltered coves along streams (7).

Associated Forest Cover

Associated species include sycamore *(Platanus occidentalis),* American elm *(Ulmus americana),* silver maple *(Acer saccharinum),* and sweetgum *(Liquidambar styraciflua)* in the southern parts of its range. Toward the north red mulberry is associated with American elm, red maple *(Acer rubrum),* boxelder *(Acer negundo),* and white ash *(Fraxinus americana).* It is a secondary species in succession and is seldom associated with primary invaders (2). Red mulberry is listed as a minor component in three bottom-land cover types (3): Cottonwood (Society of American Foresters Type 63), Sweetgum-Yellow-poplar (Type 87), and Sugarberry-American Elm-Green Ash (Type 93). Associated understory species are roughleaf dogwood *(Cornus drummondii),* flowering dogwood *(C. florida),* swamp-privet *(Forestiera acuminata),* Nuttall oak *Quercus nuttallii),* hawthorn *(Crataegus spp.),* and possumhaw *(Ilex decidua).* Herbaceous vegetation associated with red mulberry includes pokeweed *(Phytolacca americana),* stinging nettle *(Urtica dioica),* poison-ivy *(Toxicodendron radicans),* and greenbrier *(Smilax spp.).*

In the southern part of the range, red mulberry is often found in pastures and along borders of fields.

Life History

Reproduction and Early Growth

Flowering and Fruiting- Red mulberry is dioecious but can be monoecious, with male and female flowers on different branches of the same plants. Both male and female flowers are stalked axillary pendulous catkins and appear in April and May. The blackberry-like fruit reaches full development from June to August. Each fruit is composed of many small drupelets which develop from separate female flowers ripening together (8).

Seed Production and Dissemination- Minimum seed-bearing age is usually about 10 years, but 1-year-old trees planted in an abandoned field in east Texas produced fruits at age 4 (3). Optimum seedbearing age is 30 to 85 years; the maximum is 125 years. Good seed crops occur

every 2 to 3 years (2). The average number of red mulberry fruits per kilogram is about 8,600 (3,900/lb); the average number of cleaned seeds per kilogram is 795,000 (360,000/lb). One hundred kilograms (220 lb) of fresh fruit yield 2 to 3 kg (4 to 7 lb) of cleaned seeds (8).

Fruits that mature fall to the ground near the seed tree. However, because this relatively large, sweet fruit is a favorite food of most birds and some small animals, most of the fruits are eaten and dispersed by wildlife before they fully mature (6).

Seedling Development- Seeds can be extracted from fresh fruits by mashing and soaking them in water, and then passing them through a macerator, where pulp and empty seeds are skimmed or floated off. Storage temperatures of -23° to -18° C (-10° to 0° F) are recommended for dry mulberry seeds (8).

Seeds can be sown in fall without stratification or in spring following 30 to 90 days of stratification at 1° to 5° C (33° to 41° F) in moist sand. In nursery practice, seeds are sown in drills at the rate of 160 to 260/m (50 to 80/ft) in rows 20 to 30 cm (8 to 12 in) apart. Germination, which is epigeal, usually is from 12 to 50 percent. One-year bare-rooted seedlings may be outplanted (8).

Vegetative Reproduction- Red mulberry can be propagated from stem cuttings or by budding, but these methods are complex and require greenhouse facilities. The average rooting from stem cuttings taken in May, September, and January was only 7 percent, regardless of time of year (2). Red mulberry is a prolific root sprouter and can be reproduced by layering.

Sapling and Pole Stages to Maturity

Growth and Yield- Red mulberry is usually found as scattered individuals near streams or in other moist places. Stands of any size are not mentioned in the literature. Very little is known about the growth and development of this species. At maturity, red mulberry trees are an average of 5 to 21 in (15 to 70 ft) tall and as large as 76 in (30 in) in d.b.h., depending upon habitat conditions. In wooded areas, red mulberry is often an understory tree with a rounded, spreading crown.

Rooting Habit- No information available.

Reaction to Competition- Red mulberry has been planted in the Midwest because its fruits are a valuable food for wildlife, but because it provides very little soil stability or cover for wildlife, it has not been planted widely (8). It grows best in open conditions (3) but is classed as tolerant of shade as it often grows as an understory tree.

Damaging Agents- Red mulberry seems to be vanishing from at least a portion of its central range, possibly due to a bacterial disease. The effects and extent of this disease have not been investigated thoroughly, but it is known that red mulberry trees are becoming increasingly scarce (2). The only noteworthy leaf pathogens of red mulberry reported in the United States are leaf spots caused by a species of *Cercospora, Mycosphaerella mori,* and *Pseudomonas mori (4).* Red

mulberry also is susceptible to witches' broom, *Microstroma juglandis,* but the cause is unknown.

A variety of insects feed on red mulberry leaves, including the European fruit lecanium, *Parthenolecanium corni;* Comstock mealybug, *Pseudococcus comstocki;* and cottony maple scale, *Pulvinaria innumerabilis.* The American plum borer, *Euzophera semifuneralis,* and the mulberry borer, *Doraschema wildii,* attack twigs and stems of red mulberry (5).

Red mulberry has been rated as moderately tolerant of flooding as it usually withstands being inundated with up to a foot of water for a single growing season. It normally succumbs, however, after being flooded for two growing seasons (1).

Special Uses

The highest use of red mulberry is for its large, sweet fruits. These are a favored food of most birds and a number of small mammals including opossum, raccoon, fox squirrels, and gray squirrels. The fruits also are used in jellies, jams, pies, and drinks. In the past, the fruits were valued for fattening hogs and as poultry food.

Red mulberry is used locally for fenceposts because the heartwood is relatively durable. Other uses of the wood include farm implements, cooperage, furniture, interior finish, and caskets (7).

Genetics

Red mulberry hybridizes frequently with white mulberry *(Morus alba),* a native of China which has become naturalized throughout parts of the Eastern United States.

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Shumard Oak

Quercus shumardii Buckl.

Other Common Names:

Spotted oak, Schneck oak, Shumard red oak, southern red oak, and swamp red oak.

Brief Description:

Shumard oak is one of the larger southern red oaks and a producer of superior red oak lumber. It is noted as being a handsome shade tree. Shumard oak is commonly found in lowland areas of well-drained soils where it is intermixed with other hardwoods. Its acorns make excellent wildlife food. Mature Shumard oaks can have an allelopathic affect on understory vegetation.

Habitat:

Shumard oak ranges from Central Texas to North Florida and north to Indiana. It does not natively occur in some areas within this range such as the Appalachian region and the Mississippi River Bottom. Shumard oak is commonly associated with moist well drained loamy soils near streams, but it typically is not found deep within large river bottomlands. It can tolerate droughty areas such as Central Texas and Eastern Oklahoma.

Life History:

Shumard oak flowers appear from March to April. The acorns ripen and fall during September or October of their second year. Minimum seed bearing age is 25 years. Some seed dissemination occurs by animals hoarding them such as squirrels. Seedlings need full light to survive. Shumard oak is intolerant of shade, but has shown some tolerance to complete inundation. It is a dynamic species in terms of regeneration needs, and many factors such as light availability and the duration of inundation are considerations that must be made when regenerating this species.

Shumard oak and the Great Trinity Forest:

This tree is of limited occurance in the forest. It is a good mast producer and will be included in the planting mix. The presence of this tree in greater abundance will provide additional mast and increased species diversity. It is also an aesthetically pleasing tree.

Quercus shumardii Buckl.

Shumard Oak

Fagaceae -- Beech family

M B Edwards

Shumard oak *(Quercus shumardii)* is one of the largest southern red oaks. Other common names are spotted oak, Schneck oak, Shumard red oak, southern red oak, and swamp red oak. It is a lowland tree and grows scattered with other hardwoods on moist, well-drained soils associated with large and small streams. It grows moderately fast and produces acorns every 2 to 4 years that are used by wildlife for food. The wood is superior to most red oaks, but it is mixed indiscriminately with other red oak lumber and used for the same products. This tree makes a handsome shade tree.

Habitat

Native Range

Shumard oak is found in the Atlantic Coastal Plain primarily from North Carolina to northern Florida and west to central Texas; it is also found north in the Mississippi River Valley to central Oklahoma, eastern Kansas, Missouri, southern Illinois, Indiana, western and southern Ohio, Kentucky, and Tennessee. It is found locally north to southern Michigan, southern Pennsylvania, and Maryland (4).

-The native range of Shumard oak.

Climate

Usually Shumard oak grows in a humid, temperate climate, characterized by hot summers and mild, short winters. The growing season usually extends from 210 to 250 days through the major portion of the species commercial range. The average annual temperature is 16° to 21° C (60° to 70° F) with an average annual precipitation of 1140 to 1400 mm (45 to 55 in). The annual maximum temperature for this area is 38° C (100° F) and the annual minimum temperature is about -9° C (15° F). The majority of the rainfall occurs from April through September. Shumard oak tolerates drought well, as shown by its presence in parts of Texas and Oklahoma where the average annual rainfall is only about 640 mm (25 in) (7).

Soils and Topography

Shumard oak grows best in rich sites of the southern forests that have moist, well-drained loamy soils found on terraces, colluvial sites, and adjacent bluffs associated with large and small streams. It is found in hammocks of the Coastal Plain, but rarely on first-bottom sites. It appears to be tolerant of sites with high pH and associated nutrient deficiencies. In trial plantings, Shumard oak has grown well on alluvium with a pH near 7.5. Shumard oak is most commonly found on soils in the orders Alfisols, Inceptisols, and Vertisols.

Associated Forest Cover

Shumard oak is included in the forest cover type Swamp Chestnut Oak-Cherrybark Oak (Society of American Foresters Type 91), a bottom-land type of the Southern Forest Region (1). Shumard oak is a prominent hardwood associate of this type, along with green and white ash *(Fraxinus pennsylvanica* and *F. americana),* the hickories, shagbark *(Carya ovata),* shellbark *(C. laciniosa),* mockernut *(C. tomentosa),* and bitternut *(C. cordiformis),* as well as white oak *(Quercus alba),* Delta post oak *(Q. stellata* var. *paludosa)* and blackgum *(Nyssa sylvatica).* Main associates in the type are willow oak *(Quercus phellos),* water oak *(Q. falcata),* southern red oak *(Q. falcata* var. *falcata),* post oak *(Q. stellata),* American elm *(Ulmus americana),* winged elm *(U. alata),* water hickory *(Carya aquatica),* southern magnolia *(Magnolia grandiflora),* yellow-poplar *(Liriodendron tulipifera),* beech *(Fagus grandifolia),* and occasionally loblolly *(Pinus taeda)* and spruce *(P. glabra)* pines.

Shumard oak is often included in cover types Ash-Juniper-Redberry (Pinchot) Juniper (Type 66) and Mohrs (Shin) Oak (Type 67). Some of the other associates of Shumard oak include red buckeye *(Aesculus pavia),* devils-walkingstick *(Aralia spinosa),* American hornbeam *(Carpinus caroliniana),* flowering dogwood *(Cornus florida),* witch-hazel *(Hamamelis uirginiana),* American holly *(Ilex opaca),* red mulberry *(Morus rubra),* southern bayberry *(Myrica cerifera),* and American basswood *(Tilia caroliniana).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- Shumard oak is monoecious. Its flowers usually appear in March or April; they are unisexual, with stamens in glabrous 15 to 18 cm. (6 to 7 in) long aments and the pistils are single or paired on pubescent stalks. The fruit is an egg-shaped acorn 2.5 cm (1 in) long, enclosed at the base in a thick, flat, saucer-shaped cup with pubescent scales. The acorn ripens and falls during September or October of its second year.

Seed Production and Dissemination- The minimum seed-bearing age for Shumard oak is 25 years and optimum production is about 50 years. The interval between seed crops is 2 to 3 years. There are about 23 kg (50 lb) of seeds per 35 liters (bushel) of fruit. The range of cleaned seeds per kilogram is 172 to 282 (78 to 128/lb) with an average of 220 (100) (8). Acorns of Shumard oak are an excellent wildlife food and are consumed by birds, white-tailed deer, and squirrels. Animals that hoard the acorns also disseminate them. This species frequently produces multiseeded acorns.

Seedling Development- As with other oaks, germination is hypogeal (8). It appears that the microclimate, edaphic conditions, and several stand variables all have a definite influence on the quantity Of small established oak regeneration, but their effect is probably overshadowed by the seed supply. Where oak regeneration is to be favored in uneven-age management, large openings appear most desirable. In even-age management, when a seed-tree cut is contemplated, extremely large- or small-diameter trees should be left as seed producers only as a last resort (2).

The species needs full light to achieve good reproduction. In the Coastal Plain, Shumard oak is found mostly on sites with rich, well-drained soils and an abundance of moisture, but it may also inhabit dry, upland sites.

The stems of the young seedlings are smooth, brownish green or light gray, changing to gray or grayish brown by midseason of the first year. Buds are ovoid with acute apex, 6 min (0.25 in) long, smooth, with closely overlapping gray-brown or dull straw-colored scales (5).

Vegetative Reproduction- Shumard oak does not propagate readily on moist sites or by cuttings.

Sapling and Pole Stages to Maturity

Growth and Yield- Shumard oak grows quite large, especially on favorable bottom-land sites where it reaches a height of 30.5 m (100 ft) or more with a trunk diameter of 0.9 to 1.2 in (3 to 4 ft). Its shape is characterized by a clear trunk and spreading crown. In a report describing the concentration of hardwood species on pine sites, cubic volume is reported for all sites (pine and hardwood) as 7.3 million m^3 (259 million ft^3) in 11 Southern States. The total volume on pine sites is 3.4 million m^3 (120 million ft^3 (6). Heavy pole stands contain over 430 stems/ha (175 stems/acre) 13 to 28 cm (5 to 11 in) d.b.h. In old-growth, mixed stands with Shumard oak, there are total volumes of as much as 420 m^3/ha (30,000 fbm/acre).

Rooting Habit- No information is currently available.

Reaction to Competition- Shumard oak is classed as intolerant of shade and needs open areas as well as adequate moisture to become established; such openings are easily invaded by competing annuals that inhibit oak establishment. It is reported, however, that at maturity Shumard oak retards the growth of competing understory vegetation apparently by an allelopathic effect (3).

Shumard oak reproduction shows some tolerance to complete inundation, a requisite for survival on bottom-land sites. Conditions other than species-site relationships are important in determining the regeneration potential and succession of the species in bottom-land hardwood situations. Water is apparently most likely to become the limiting factor on sites that are consistently flooded for fairly long periods of time during the growing season, such as true swamps, deep sloughs, and backwater areas.

Shumard oak is one of the prominent oaks in oak-hickory regions but does not act as a dominant in the extensive range of the oak-hickory association. Therefore, the place of Shumard oak in the ecological succession is not clearly defined. It is probably not a true climax tree in most oak-hick communities where it is found.

Damaging Agents- This species is susceptible to wilts and leaf diseases. Oak leaf blister *(Taphrina caerulescens)* is common in certain years. Oak wilt *(Ceratocystis fagacearum)* has killed Shumard oak in Missouri. The most common wood-rotting fungi attacking this oak are *Fomes* spp., *Polyporus* spp., and *Stereum* spp.

No insects are specifically associated with Shumard oak, but many insects attack southern oaks, probably including Shumard. Insect defoliators are June beetles *(Phyllophaga* spp.), orangestriped oakworm *(Anisota senatoria)*, cankerworms *(Alsophila pometaria* and *Paleacrita vernata)*, forest tent caterpillar *(Malacosoma disstria)*, yellownecked caterpillar *(Datana ministra)*, variable oakleaf caterpillar *(Heterocampa manteo), and* the redhumped oakworm *(Symmerista canicosta)* (7).

The borers that attack healthy trees are red oak borer *(Enaphalodes rufulus)*, in cambium and other sapwood; carpenterworms *(Prionoxystus* spp.*)*, in heart and sapwood; and the Columbian timber beetle *(Corthylus columbianus), in* sapwood. Those attacking weakened trees include twolined chestnut borer (Agrilus *bilineatus), in* cambium; and the tilehorned prionus *(Prionus imbricornis), in* roots.

Dying trees are attacked by the oak timberworm *(Arrhenodes minutus).* The golden oak scale *(Asterolecanium variolosum)* kills reproduction and tops in older trees. The gouty oak gall *(Callirhytis quercuspunctata) and* horned oak gall *(C. cornigera)* injure small limbs, while the basswood leafminer *(Baliosus nervosus)* attacks the leaves (7).

As in many oaks, the nut is attacked by acorn weevils in the genus Curculio. A reliable method of sorting weeviled acorns from sound ones is by color of the cup scar on the nut; a bright, light tan indicates a good acorn, a dull brown, a bad one.

Special Uses

The acorns of Shumard oak serve as mast for numerous species of birds and mammals. In the Mohrs oak and Ashe juniper-redberry juniper types, Shumard oak acorns are probably an important source of food for the deer herd.

Commercially, Shumard oak is marketed with other red oak lumber for flooring, furniture, interior trim, and cabinetry.

Genetics

Shumard oak has two varieties-*Quercus shumardii* Buckl. var. *shumardii* (typical), and *Q. shumardii* var. *texana* (Buckl.) Ashe, Texas oak, found in central Texas, including the Edwards Plateau, and in southern Oklahoma in the Arbuckle Mountains.

Shumard oak hybridizes with *Quercus hypoleucoides; Q. imbricaria Q. x egglestonii* Trel.); *Q. marilandica (Q. x hastingsii* Sarg.); *Q. nigra (Q. x neopalmeri* Sudw.); *Q. nuttallii; Q. palustris (Q. x mutabilis* Palmer & Steyerm.); *Q. phellos (Q.* x *moultonensis A*she), *Q*. rubra *(Q.* x *riparia* Laughlin); and *Q. velutina Q. x discreta* Laughlin) (4).

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Sugarberry

Celtis Laevigata Willd.

Other Common Names:

Sugar hackberry, hackberry, Texas sugarberry, southern hackberry, and lowland hackberry.

Brief Description:

A common tree found on clay soils in flood plains of major southern rivers. It is a relatively fast growing and short-lived early successional tree. The abundant fruit is utilized by wildlife.

Habitat:

Sugarberry ranges southwide from Texas to the Atlantic. It is commonly found in broad flats or shallow sloughs within the flood plains of rivers. It is adaptable to other sites and is often planted ornamentally.

Life History:

Sugarberry seeds abundantly and begins production around the age of 15 years. Flowering occurs from mid March to May and the fruit ripens in September and October, and often remains on the tree until midwinter. Its fruit is widely dispersed by birds and water. The seeds germinate early the following spring. Seedlings are intolerant of flooding. Sugarberry is tolerant of shade and responsive to release enabling it to overtake other trees. It is very susceptible to fire though. Any damage exposes sugarberry to rot-causing fungi to which it is very susceptible. Research has shown that sugarberry can have an allelopathic effect on vegetation.

Sugarberry and the Great Trinity Forest:

This species occurs as a mix with both ash and elm. Its fruit is beneficial to birds but it should be controlled in areas where any understory planting is to occur due to its responsiveness to release and possible allelopathic effects.

Celtis laevigata Willd.

Sugarberry

Ulmaceae -- Elm family

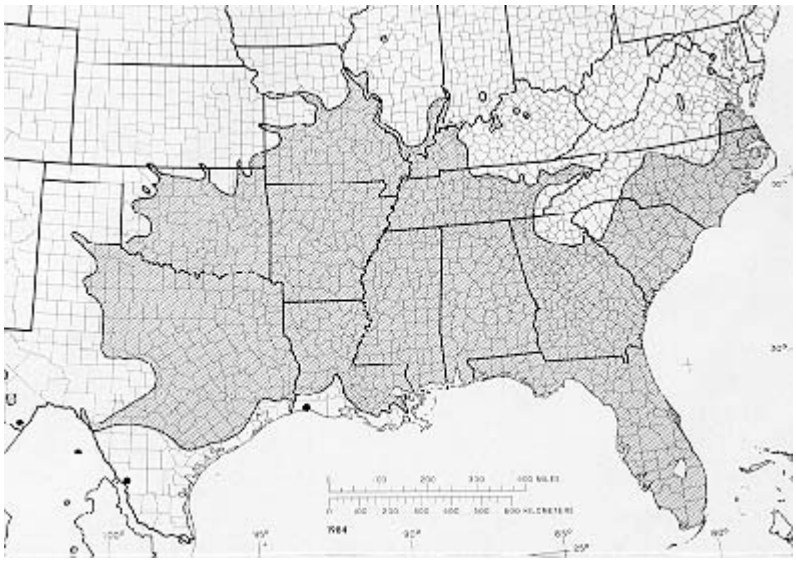
Harvey E. Kennedy, Jr.

Sugarberry (Celtis laevigata), a common medium-size tree of moderate to fast growth, is most often found on clay soils of broad flats or shallow sloughs within the flood plains of major southern rivers. It is also called sugar hackberry, hackberry, Texas sugarberry, southern hackberry, and lowland hackberry. Sugarberry is short lived, probably not living more than 150 years. The wood is of medium strength and hardness and much of the light yellow wood is used by furniture manufacturers. The abundant crops of fruits are eaten by wildlife, especially birds. The tree is planted as an ornamental and as a street tree in residential areas in the lower South.

Habitat

Native Range

Sugarberry ranges south from southeastern Virginia to southern Florida, west to central Texas and northeastern Mexico, and north to western Oklahoma, southern Kansas, Missouri, southern Illinois, southern Indiana, and western Kentucky. It is local in Maryland, the Rio Grande Valley, and northeastern Mexico. Its range overlaps the southern part of the range of hackberry *(C. occidentalis).*



-*The native range of sugarberry.*

Climate

Sugarberry grows in a humid climate except for part of its range in Oklahoma and Texas which lies west of a north-south line through Galveston Bay. There the climate is semihumid to semiarid. The average precipitation varies from 510 to 1520 mm (20 to 60 in) per year, the lightest being in central Texas and Oklahoma. An average of 380 to 760 mm (15 to 30 in) occurs during the frost-free period. Annual snowfall ranges from 0 to 51 cm (0 to 20 in).

Summer temperatures vary from an average of 27° C (80° F) to extremes of 46° C (115° F). Average winter temperatures are from -1° to 10° C (30° to 50° F), with an extreme of -29° C (-20° F).

The average length of the growing season varies from 150 to 270 days.

Soils and Topography

Sugarberry is most common on Inceptisols and Entisols found in broad flats or shallow sloughs within flood plains of major southern rivers (9), but will grow under a considerable range of soil and moisture conditions. It is widely distributed on bottom lands except in deep swamps and is found to a minor extent on upland sites. It is also common on deep moist soils derived from limestones, notably in the Black Belt of Alabama (10).

Associated Forest Cover

Sugarberry appears with the following forest cover types (11): Cottonwood (Society of American Foresters Type 63), Sweetgurn-Willow Oak (Type 92), Sugarberry-American Elm-Green Ash (Type 93), Sycamore-Sweetgurn-American Elm (Type 94), Black Willow (Type 95), and Overcup Oak-Water Hickory (Type 96).

Other tree associates are cedar elm *(Ulmus crassifolia),* winged elm *(U. alata),* water oak *Quercus nigra),* blackgum *(Nyssa sylvatica),* persimmon *(Diospyros virginiana),* honeylocust *(Gleditsia triacanthos),* red maple *(Acer rubrum),* and boxelder (A. *negundo).* Some important noncommercial tree and shrub associates are swamp-privet *(Forestiera acuminata),* roughleaf dogwood *(Cornus drummondii),* and hawthorn *(Crataegus spp.).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- The small, greenish flowers appear with the leaves in the early spring-from mid-March to May, depending on latitude (1). Sugarberry is polygamo-monoecious. The fruit ripens in September and October, and often remains on the trees until midwinter. Sugarberry fruits are spherical drupes 6 to 13 mm (0.25 to 0.5 in) in diameter with a thin pulp enclosing a single bony nutlet. Late spring frosts sometimes kill the flowers and reduce the seed crop.

Seed Production and Dissemination- Seed production starts when trees are about 15 years old (7). Optimum seed-bearing age is from 30 to 70 years old. Sugarberry bears good seed crops in most years and some nearly every year. There are between 4,400 and 5,300 cleaned seeds per kilogram (2,000 to 2,400/lb). The seed is widely dispersed by birds and water.

Mature fruits can be picked by hand from trees as late as midwinter. Collection is easier after trees have completely dropped their leaves. Branches of sugarberry can be flailed to knock the fruits onto sheets of plastic or other suitable material spread under the trees.

If seeds are to be used for seedling production in a nursery, then both fall sowing of untreated seeds and spring sowing of stratified seeds are satisfactory. Seeds may be broadcast or drilled in rows and should be covered with 6 to 13 mm (0.25 to 0.5 in) of firmed soil. Beds should be covered with bird screens until germination starts. Experience at the Southern Hardwoods Laboratory, Stoneville, MS, has shown that if spring sowing is used, the seeds should be depulped before storage, dried to 8 to 10 percent moisture content, and stored in 6-mil-thick plastic bags or equivalent storage containers until stratification. Seeds should be stratified in moist sand or other suitable media for 60 to 90 days before sowing in the nursery. The seeds can be depulped by wet maceration. Depulping is not essential, but it has been reported to aid germination (1). Average germinative capacity is reported to be 55 percent for sugarberry.

Seedling Development- Sugarberry seeds lie dormant over winter and germinate early in the spring. Germination is epigeal (1). The seedlings become established under most stands of southern bottom land hardwoods. Best natural conditions for germination are moist, loamy soil, but the species is found mostly on clay soils. First-year growth usually produces a very slender but tough stem, 20 to 46 cm (8 to 18 in) in height. Under shade, the young seedling develops a crooked, short stem, often forked within a few feet of the ground. In the open, it tends to be very limby and short boled. Sugarberry is considered intolerant of flooding, at least in the seedling stage (2,3,4).

Vegetative Reproduction- Sugarberry can be propagated by cuttings (7). Small stumps sprout readily, and there is some sprouting from root collars of fire-damaged seedlings and saplings.

Sapling and Pole Stages to Maturity

Growth and Yield- Sugarberry is a small- to medium-sized tree. It often attains a height of 24 to 30 in (80 to 100 ft) at maturity. On best sites, 10-year diameter growth can be in excess of 6 cm (2.5 in) for dominant trees (9). The overall average is about 2.5 to 5 cm (1 to 2 in) in 10 years. On average sites, mature forest-grown trees average about 46 cm (18 in) in diameter and 24 in (80 ft) in height, with trunks clear of branches for approximately 9 m (30 ft).

An accurate estimate of the total growing stock is available for only a limited portion of the sugarberry range. Because of its scattered occurrence, forest surveys usually include sugarberry in a group of other species with limited frequencies. The only region containing enough sugarberry of sawtimber size to list separately is the Mississippi Delta (10). The principal States producing commercial quantities of sugarberry are Louisiana, Mississippi, and Arkansas. These States contain about 16 million m^3 (560 million ft^3) and about 9.4 million m^3 (1,650 million fbm)

of sugarberry sawtimber. In 1965, a rough estimate of the total sawtimber resource in the United States was in excess of 10.0 million m' (2,000 million fbm).

Rooting Habit- Sugarberry is a relatively shallow-rooted tree and does not develop a distinct taproot. The root system is saucer-shaped with good lateral root development. The tree is about average in resistance to windthrow.

Reaction to Competition- Sugarberry is classed as tolerant of shade. It grows fast when released and often outgrows more desirable forest species (5). Sugarberry becomes established in the understory and generally has very poor form in this situation. In dense, even-aged stands, however, it prunes itself well and produces a straight stem.

Damaging Agents- The bark is thin and easily injured by fire. A light burn kills back reproduction. Heavier bums may kill even the largest trees and wound others, making them subject to serious butt rot, which in sugarberry advances rapidly. Butt rot is a common name used to indicate the area of the decay in the butt log which may be caused by any one of 30 or more species of fungi belonging to the genera *Fomes, Polyporus, Hericium,* and *Plyeurotus.*

Ice also causes heavy damage to the crowns, breaking the main stem and branches which reduces growth and creates wounds that allow entrance of rot-causing fungi. There are some other diseases of the twigs and leaves, but none are of major importance.

Eastern mistletoe *(Phoraedendron flavescens)* may cause serious damage in the western part of its range (7). A number of scales attack the twigs, small branches, and sometimes the trunks, but none are considered very damaging. Leaf petiole galls caused by the hackberry petiole gall maker *(Pachypsylla venusta)* are common. In recent years, defoliation of large acreages in several Southern States by larvae of the hackberry butterfly *(Asterocampa celtis)* have been reported (12). No deaths or crown die-back among the trees was observed in the following years. Research has shown that the hackberry butterfly can be controlled by spraying trees with certain registered insecticides (8).

Special Uses

Sugarberry mixed with hackberry supplies the lumber known as hackberry. Small amounts are used for dimension stock, veneer, and containers, but the main use of sugarberry wood is for furniture. The light-colored wood can be given a light- to medium-brown finish that in other woods must be achieved by bleaching.

The dry sweet fruit is eaten by at least 10 species of birds, as well as other game and nongame animals (13).

Sugarberry is often used for street planting in the lower South and is also used as an ornamental in residential areas. A problem in such use is that leachates from the leaves reduce germination and growth of a number of grasses under the trees (6). These leachates have been identified in the soil as ferulic acid, caffeic acid, and p-coumaric acid.

Genetics

Sugarberry seems to present a considerable number of local variations that have prompted some botanists to name a number of varieties, while other botanists feel the distinctions are too slight to warrant such status (13).

Some varieties listed are Texas sugar hackberry, *C. laevigata* var. *texana*; Uvalde sugar hackberry, *C. laevigata* var. *brachyphylla*; scrub sugar hackberry, *C. laevigata* var. *anomala*; small sugar hackberry, *C. laevigata* var. *smallii*; Arizona sugar hackberry, *C. laevigata* var. *brevipes*; net-leaf sugar hackberry, *C. laevigata* var. *reticulata*.

There are no known races or hybrids of sugarberry.

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Sycamore

Platanus occidentalis L.

Other Common Names:

American planertree, buttonwood, American sycamore, and buttonball-tree.

Brief Description:

Sycamore is one of the fastest growing lowland trees and one of the largest in eastern deciduous forests. It is often planted as a shade tree because of its aesthetic bark and shading crown.

Habitat:

Sycamore is distributed over most of the Eastern United States. It grows best on alluvial soils along streams and in bottomlands. It is tolerant of wet soil conditions, but is best suited to sandy loams with a good supply of ground water, typically on the edges of lakes and streams where the water level drops enough during the growing season to permit good soil aeration. It is relatively intolerant of flooding during the growing season and will die after two weeks of total inundation. In the South this tree rarely invades fields or grows on well-drained ridges in the first bottoms.

Life History:

Flowers appear in late March in the South and the fruits ripen by September or October and remain on the tree till the next spring when they break up and fall from the tree. The seed is light and disseminated by the wind and by water. Some birds feed on the seeds. Seedlings need direct light to survive. The species sprouts readily when young and smaller in size. Sycamore is classified as being intermediate in shade tolerance. It can successfully compete with cottonwood and black willow. Sycamore is usually succeeded by elm and ash species.

Sycamore and the Great Trinity Forest:

Sycamore occurs to a limited extent in the forest. It probably inhabits the same sites as cottonwood and willow.

Platanus occidentalis L.

Sycamore

Platanaceae -- Sycamore family

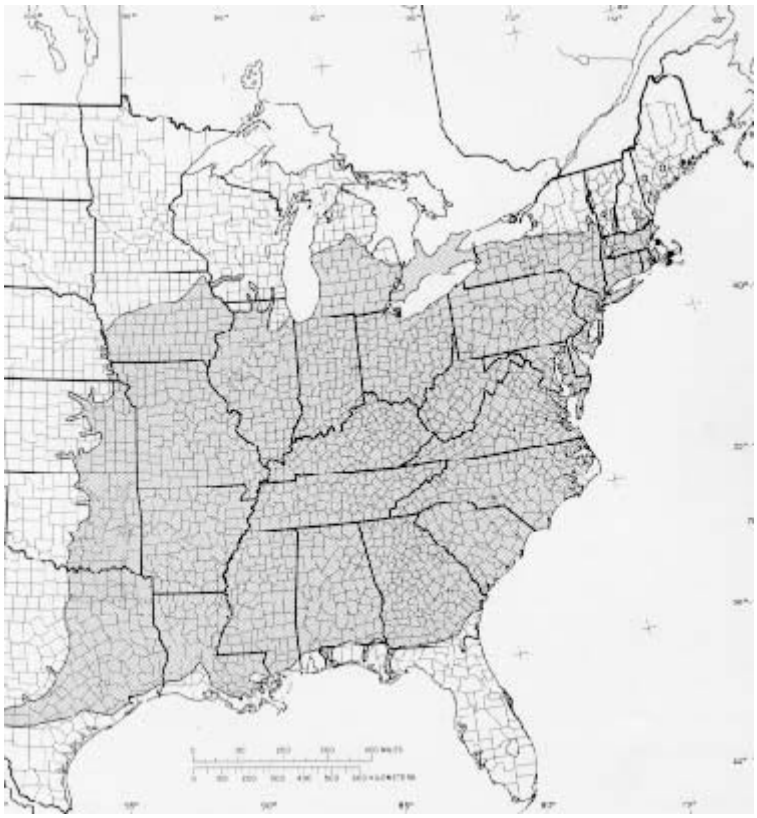
O. O. Wells and R. C. Schmidtling

Sycamore *(Platanus occidentalis)* is a common tree and one of the largest in the eastern deciduous forests. Other names are American planetree, buttonwood, American sycamore, and buttonball-tree. It is a fast-growing and long-lived tree of lowlands and old fields. Sycamore is valuable for timber and is also widely planted as a shade tree because of its distinctive white, exfoliating bark and broad, dense crown. Recently, it has become a favored species for use in intensively cultured "biomass farms" in the Southeastern United States.

Habitat

Native Range

Sycamore grows in all States east of the Great Plains except Minnesota. Its native range extends from southwestern Maine west to New York, extreme southern Ontario, central Michigan, and southern Wisconsin; south in Iowa and eastern Nebraska to eastern Kansas, Oklahoma, and south-central Texas; east to northwestern Florida and southeastern Georgia. It is also found in the mountains of northeastern Mexico.



-The native range of sycamore.

Climate

Within the range of sycamore, average annual temperatures vary from 4° to 21° C (40° to 70 ° F), with average annual extremes from 41° to -34° C (105° to -30° F); the lowest temperature recorded was -40° C (-40° F). Average annual precipitation varies from 760 to 2030 mm (30 to 80 in), and the frost-free period is from 100 to 300 days. The natural occurrence of this species in eastern North America is probably limited in the North by frosts and low temperatures, and in the West by the dry climate of the Great Plains.

Soils and Topography

Sycamore is most common and reaches its largest size on alluvial soils along streams and in bottom lands. It is found most commonly on Entisols, Inceptisols, and Alfisols, and occasionally on Vertisols, Histosols, and Mollisols. The tree is tolerant of wet soil conditions, and in the northern part of its range it grows on the edge of streams and lakes and small depressions having slow drainage, as well as on wet muck land, shallow peat soils, and soils associated with river bottoms and flood plains. Farther south it commonly grows on the alluvial soils of flood plains adjacent to larger rivers, on former streambanks except in sloughs and swamps (21), and in the moist coves, lower slopes, and ravines. In general, this tree grows best on sandy loams or loam with a good supply of ground water, typically on the edges of lakes and streams when the summer water table drops enough to permit good soil aeration during the growing season (18).

Sycamore is relatively intolerant of flooding during the growing season and will die if the entire tree is inundated for more than 2 weeks.

Sometimes sycamore is a pioneer tree on upland old-field sites. This is particularly true in the central part of its range. In the South, however, it rarely grows on old fields or even on well-drained ridges in the first bottoms.

Although sycamore becomes established on old eroded fields, it seldom grows well on these sites. On 60 old fields in southeastern Ohio, it was a minor constituent of the tree reproduction (21). However, it is sometimes found in excellently stocked natural stands on coal-stripped land of the Central States. In Missouri, too, sycamore is often found in pure stands or in mixture with other hardwoods that volunteer on spoil banks (21), and it is one of the pioneer species on the ridges of strip-mined land in Vermillion County, IL. It is recommended for planting on all types of coal-stripped land in many of the Northeast and Central States (21).

In Tennessee, sycamore prospers in well-drained, gravelly and cherty, terrace soils, in a heavy weed cover (21). It grows at elevations from just above sea level in some sections to 305 in (1,000 ft) in the northern part and 762 in (2,500 ft) in the southern part of the Appalachian Mountains. It also is found in coves, on lower east and north slopes, and on the moist soils of steep slopes and ravines facing major stream bottoms.

Associated Forest Cover

Sycamore grows singly or in small groups with other trees but seldom in extensive pure stands in the northern part of its range. In the Mississippi bottom lands of the South, however, it does grow in pure stands of 16 to 40 ha (40 to 100 acres). Sycamore is the predominant tree in two forest cover types (7). In River Birch-Sycamore (Society of American Foresters Type 61) the associate trees include sweetgum *(Liquidambar styraciflua),* eastern cottonwood (Populus *deltoides),* red maple *(Acer rubrum),* black willow *(Salix nigra),* and other moist-site hardwoods. This type is widespread, occurring in southern New England, southern New York, New Jersey, Pennsylvania, southern parts of the Lake States, and south into Oklahoma, Missouri, and Tennessee. It is also found in the Allegheny and Piedmont Plateaus of the Appalachian Mountains.

In Sycamore-Sweetgurn-American Elm (Type 94), the chief associates are boxelder *(Acer negundo),* green ash *(Fraxinus pennsylvanica),* sugarberry *(Celtis laevigata),* silver maple *(A. saccharinum),* eastern cottonwood, black willow, water oak *(Quercus nigra),* Nuttall oak *(Q. nuttallii),* sweetgum, and river birch *(Betula nigra).* This type is found throughout the southern part of the range of sycamore, usually on the alluvial flood plains of major rivers. A Sycamore-Pecan-American Elm valiant type is found on river fronts in the Mississippi River Valley. A comprehensive survey of mixed hardwood species conducted in 14 Southeastern States by North Carolina State University showed that sycamore comprised 0.1 percent of the total basal area on wet flat sites, from 0.5 to 8.8 percent on various classes of bottom-land sites, 0.7 percent on lower slope coves, and 0.1 percent on upland slopes and ridges (26).

Other forest types with which sycamore grows are Black Ash-American Elm-Red Maple (Type 39) in the northern part of the sycamore range, Sugarberry-American Elm-Green Ash (Type 93)

in the South, Sweetgum-Yellow-Poplar (Type 87) in the Atlantic Coastal Plain and Piedmont, and Black Willow (Type 95), which grows throughout the range of sycamore.

Sycamore is also an important tree in Cottonwood (Type 63), a valuable pioneer type, characteristic of fronts on all major streams in the South except in sloughs and swamps (21).

Life History

Reproduction and Early Growth

Flowering and Fruiting- Sycamore is monoecious; the male flower clusters grow on short stalks on branchlets of the previous year and the female flower clusters grow on short stalks on older branchlets. They appear in May in the North and as early as late March in the South. The fruit is a ball composed of many closely packed, long, narrow fruits that ripen by September or October and often remain on the tree over winter, breaking up or falling off the following spring. The seed is an achene with a light-brown, hairy, thin but hard seedcoat.

Seed Production and Dissemination- Plantation-or open-grown sycamore begins to bear seeds in 6 or 7 years. Dense natural stands begin to produce an appreciable number of seeds at about 25 years, with optimum production between 50 and 200 years. Generally, sycamore is not dependable for seed after the age of 250 years. The tree usually bears good seed crops every 1 or 2 years and some seeds are produced every year. Late spring frosts commonly kill the flowers, leaves, and even the twigs, reducing seed production (21).

Sycamore seeds average about 441,000/kg (200,000/lb) and are dispersed from February through May of the spring following ripening. As the seed balls break up, the seeds are released and float down slowly. The hairs act as parachutes, and the seeds are widely scattered by the wind. Several birds feed on the seeds and also may disseminate them to a minor extent. Moreover, the seeds are carried by water and are often deposited on mudflats or sandbars where conditions are usually favorable for germination (21).

Seedling Development- Pregermination treatments are not required (3). A large percentage of sound seeds usually germinate, but the great variation in number of sound seeds in a lot results in a wide range of germinative capacity.

Germination is epigeal and is affected by light. In tests made at temperatures ranging between 23° to 27° C (73° to 810 F), the mean germination under artificial light was 17.5 percent and only 3.1 percent in the dark (21). Seeds failed to germinate in the river-bottom soils of southern Illinois wherever litter was more than 2 inches deep. Sycamore seedlings must have direct light to survive; under favorable conditions they develop a strong, spreading root system and grow rapidly, as much as 91 to 122 cm (36 to 48 in) in height the first year. Roots also penetrate deeper in loess soil than in alluvial or clay soils.

Vegetative Reproduction- Sycamore sprouts readily from the stump when young (sapling or pole size) and the species has good potential for coppice regeneration, especially in short-rotation

biomass plantings (27). The best coppice reproduction has been obtained by late dormant-season March harvesting (23).

Slips or cuttings made from young, fast-growing stems root readily and may be used for propagation. Healthier top growth has been noted on cuttings that were made closer to the root collars than other parts of the stem, and fall-planted cuttings grew better than those planted in the spring (21). Cuttings from mature trees cannot be rooted by conventional methods, but a modified air-layering technique consisting of girdling and application of growth-promoting hormones on the tree before the cuttings are taken has been successful (10).

Sapling and Pole Stages to Maturity

Growth and Yield- Sycamore grows fast throughout its life. Within its range, only cottonwood and, under some conditions, a few of the pines, soft maples, and black willow grow faster. Average 10-year diameter growth rates for sycamore of three size classes in five States were as follows (21):

State	Seedlings and saplings	Pole-size trees	Sawtimber
	cm	**cm**	cm
Illinois	8.2	--	8.6
Indiana	8.9	6.6	6.4
Kentucky	6.0	6.9	8.1
Missouri	6.0	7.8	9.1
Ohio	7.4	3.6	6.0
	in	**in**	**in**
Illinois	3.2	--	3.4
Indiana	3.5	2.6	2.5
Kentucky	2.4	2.7	3.2
Missouri	2.4	3.1	3.6
Ohio	2.9	1.4	2.4

These are average growth rates for a range of sites and should not be considered as indicative of growth that might be expected on either poor or good sites.

Sycamore in a 17-year-old North Carolina stand had an average d.b.h. of more than 23 cm (9 in) and an average height of 21.3 in (70 ft). There was a total volume of 126 m^3/ha (1,800 ft^3/acre) or 32.3 m^3/ha (2,310 fbm/acre) of sawtimber plus 75.6 m^3/ha (1,080 ft^3/acre) of pulpwood. This stand was expected to have a volume of 140 m^3/ha (10,000 fbm/acre) of sawtimber by age 22 (21). This figure is slightly higher than average yield for mixed hardwoods in the southeastern United States. Annual hardwood yields in the major bottom-land type (where sycamore made up

8.8 percent of the stand) were found to average about 4.0 m^3/ha (57 ft^3/acre) in stands from 20 to 60 years old (26).

The potential for plantation-grown sycamore seems much higher than the yields for natural stands. A survey conducted by North Carolina State University found that annual plantation yields ranged from 7.7 m^3/ha (110 ft^3/acre) at age 5, to 14.3 m^3/ha (204 ft^3/acre) at age 25 (25). Most of the plantations in this survey were not cultivated to optimum intensity after establishment and in all likelihood do not represent the ultimate or even the practical maximum attainable yield.

Annual yield at age 11 in a sycamore plantation in central Georgia was 17.2 m^3/ha (245 ft^3 /acre). Average d.b.h. was 15 cm (6 in) and average height was 19 in (63 ft) (2). The highest yields for sycamore under intensive culture were recorded on a "creek bottom-land site" in the Georgia Piedmont (14) and in the lower Mississippi River Valley for 4-year coppice rotation following 3 or 4 years in seedling rotation (6). Annual yields were from 24 to 32 m^3/ha (343 ft^3/acre). This yield is comparable to maximum yields obtained with other fast-growing genera such as Populus and Alnus that have been grown on "mini-rotations" (4).

The American sycamore grows to a larger diameter than any other North American hardwood. Trees are on record that exceeded 305 cm (120 in) in d.b.h. and 43 ni (140 ft) in height (21). An individual tree in Indiana was 320 cm (126 in) in diameter at 1.2 in (4 ft) above the ground and 51 ni (168 ft) tall (21).

Open-grown sycamores have a large irregular crown that may spread to 30 ni (100 ft) in diameter. Under forest conditions the tree has a relatively small crown and a long, slightly tapered bole that may be clear of branches for 20 or 25 m (70 or 80 ft).

Rooting Habit- No information available.

Reaction to Competition- Sycamore is classed as intermediate in tolerance to shade and in competitive ability. It can compete successfully with cottonwood and willow, which it replaces or succeeds unless special steps are taken to favor these trees (21).

In the Piedmont of North Carolina, sycamore and birch tend to replace pioneer trees like alder and willow on small islands or spits in streams after this land becomes stable and drained (21). Sycamore and birch, in turn, are usually succeeded by elm *(Ulmus* spp.), ash, and red maple. It was found, however, that sycamore seedlings grown under controlled light were at least as tolerant as American and winged elm (U. *americana* and U. *alata)* on the basis of observed height growth and top-to-root ratios (21).

On sand and gravel bars and on flood plains in Missouri, sycamore is a pioneer tree that persists throughout later successional stages in the sugar maple-bitternut hickory variant of Sugar Maple (Type 27) (21). This variant grows on wet sites where the soils are usually neutral to calcareous.

Sycamore is also found in forest types that are pioneer, transitional, subclimax, and climax in the succession. On moist or wet sites in subclimax, deciduous forests it grows in association with

oaks, black walnut *(Juglans nigra),* hackberry *(Celtis occidentalis), sweetgum, cottonwood,* and willow. It seems able to maintain itself in some of these subclimax and climax forest types because of its rapid growth and longevity. Usually it maintains a position in subclimax types only when they are in bottom land or other moist situations. On dryer sites sycamore usually has only pioneer or transitional status and is eventually replaced by tolerant trees or trees having less demanding moisture requirements.

Epicormic sprouting is not a serious problem in sycamore. Pruning widely spaced, open-grown natural trees 9 years old did not result in serious sprouting. In a Georgia thinning study, epicormic branching of sycamore was appreciable only where basal area was reduced to less than 18.4 m^2/ha (80 ft^2/acre), which was two-thirds or less of the original basal area. Heavier thinning resulted in 14 to 15 epicormic branches per tree (21).

Damaging Agents- Many insects feed on sycamore but none are of economic importance in forests. Some may, however, seriously damage individual trees planted for landscaping purposes. Probably the insects that attack sycamore do not kill healthy trees, but when they attack a tree of reduced vigor, they may cause severe injury or death. The more important insects are the sycamore lacebug *(Corythuca ciliata),* the flathead sycamore-heartwood borer *(Chalcophorella campestris),* and the sycamore tussock moth *(Halisidota harrisii).* Other insect enemies include leaf feeders and hoppers, periodical cicada *(Magicicada septendecim),* aphids, scales, crosswood borers, flatheaded borers, roundheaded borers, bark borers, darkling *beetles (Tenebrionidae),* ambrosia beetles, moths, and caterpillars, leaf rollers, and horntails *(Siricoidea).* Sycamore is also *subject to* ant attacks, which often cause ingrown bark pockets that reduce the quality of the wood (21).

Diseases of sycamore have become more important with its increased culture in plantations. In the mid-1970's, potentially serious infection involving leaf scorch, dead branches, top dieback, and lethal cankers occurred in Illinois and adjacent States (22).

A 1973 survey of 26 plantations in Tennessee, Mississippi, Louisiana, and Alabama revealed leaf scorch, top dieback, and lethal bole cankers in four bottom-land plantations (9). In two progeny tests in Mississippi the same symptoms were evident, so severely in one test that it was a total loss within 5 years (5). The primary organism causing lethal bole cankers has not been established. A complex of organisms seems to be involved, but *Ceratocystis fimbriata* and *Botryodiplodia theobromae* are prime suspects. When seedlings were inoculated with either of these organisms by the bark-flap technique, cankers developed on the stem within 30 days; when 8-year-old *trees were* inoculated with *Ceratocystis fimbriata,* cankers appeared and some trees died within a year (19). *Temperature also seems* to be *a* factor (15,16,17). *Acremonium diospyri* has also been identified in trees displaying these symptoms.

Sycamore is susceptible to anthracnose, the same disease that attacks oaks (21). This fungus attacks in the spring and sometimes completely defoliates the trees. Severe attacks also kill twigs, and frequently cankers are formed up to 25 mm (1 in) in diameter. Usually, a second set of leaves is produced following defoliation and few trees die from an attack. Anthracnose may weaken a tree, however, making it susceptible to attack by other diseases. Heavy attacks by this

disease also reduce radial and terminal growth. Sycamore is host to the eastern mistletoe *(Phoradendron* spp.) but damage usually is not serious.

Weather damage and damage caused by insects and disease are commonly confused. For example, anthracnose attacks are often mistaken for frost damage. Although low winter temperature may injure the cork cambium and cause the outer bark to be sloughed off, the health of the tree is not affected. Late spring frosts may kill sycamore buds over a wide area, and where this occurs, the damaged trees characteristically have long dead twigs with bushy masses of leaves around their bases by midsummer.

A limited study of sycamore shade trees following a sleet storm in west-central Illinois indicated that the tree is susceptible to ice damage (21). But in forest stands, it is seldom damaged by such storms.

Because it develops a widespread, strongly branched root system, sycamore is a windfirm tree. However, large sycamores are likely to develop windshake, a wood defect that reduces their value for lumber and other products.

Special Uses

Establishment of sycamore plantations increased during the 1960's and 1970's. As of 1979, about 1500 ha/yr (3,700 acre/year) were being planted to sycamore of a total 4170 ha/yr (10,300 acre/yr) of hardwoods planted in the Southeast (30). In general, establishment of these plantations has been characterized by intensive site preparation, cultivation and fertilization for several years after planting, high initial costs, and fast growth. Sycamore has fast initial growth rate on a wide range of sites, including relatively infertile "pine" sites. After only a few years, however, its growth declines and it stagnates on the less fertile sites unless fertilizer is added.

Some plantations have been established at very close spacing and are being reproduced by coppice on short rotations in a silvicultural scheme aimed at maximum fiber production. This kind of culture has been termed "short-rotation forestry" (27) or "silvicultural biomass farms" (11). The entire aboveground portion of the plant is harvested and estimates of annual biomass production in parts of the United States range from 11.2 to 29.1 dry ton equivalents/ha (5 to 13 dry ton equivalents/acre) at rotations of 4 to 10 years (4).

Nutrient drain on the site is greater than with conventional long rotation management (1,32) and fertilization is usually necessary, especially with rotations shorter than 5 years (28).

In spite of the high initial cost, one analysis in the Coastal Plain of Virginia and North Carolina estimated that over a 36-year period (three 12-year coppice rotations) total yield of four hardwood species including sycamore would be increased at least 50 percent over natural stands at one-third the cost of a system of natural regeneration (20).

Genetics

Genetic experiments with sycamore in the eastern United States have demonstrated heritable variation in growth and other traits (8,13,24,29,31). Tree improvement programs are in progress (20) and genetic gains in early growth rate have been obtained (13,31).

Geographic variation in sycamore is extensive, and, noted in many other widely distributed species, trees of southern origin have a potential for faster growth than trees of more northern origin when planted near or slightly north of their point of origin (8,13,24,29,31).

Sycamore is unique among North American tree species in displaying a strong north-south gradient in resistance to a killing stem canker disease. In two progeny tests of half-sib families selected along the Mississippi and Chattahoochie Rivers, families of northern origin (Missouri and northern Georgia) were attacked much more severely than were families from farther south (southern Georgia and Louisiana) (5).

Two varieties of sycamore have been named in addition to the typical variety. *P. occidentalis* var. *glabrata* is common in western Texas and Mexico but is considered by some taxonomists to be synonymous with the typical variety. *P. occidentalis* var. *attenuata* is apparently intermixed with the typical variety, but its status is in need of clarification. The London plane of the Old World, *P. x acerifolia,* is considered a collection of advanced generation hybrids and backcrosses between *P. orientalis* and *P. occidentalis* (12). London plane is an important street tree in cities of the United States and Europe because of its resistance to diseases and especially the air pollution found in the urban environment.

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Texas Ash

Fraxinus texensis (Gray) Sarg.

Other Common Names:

Mountain ash, Texas white ash

Brief Description:

A close relative of white ash that is often mentioned as a variety of white ash (*Fraxinus americana*). In the literature it typically appears under the context of ornamental plantings and is noted for its durability. Some sources indicate that it can be differentiated from white ash by a more sharply notched leaf scar, a lighter shade of green on the underside of leaves and by there being predominantly 5 leaflets per leaf. There is hybridization between the two species.

Habitat:

Texas ash ranges only in Central Texas north into a few counties in Southern Oklahoma. Val Verde County is its westernmost range. It grows on the limestone soils of Central Texas and into the Balcones Escarpment. In its range it can be found on rocky slopes and in canyons on thin soils. It can tolerate higher pHs. Literature searches offer contradictory comments on this species in terms of range and abundance.

Life History:

Texas ash has a life history similar to that of white ash. It flowers in the spring with or before bud break and seeds are mature by the fall when they are disseminated by wind.

Texas ash and the Great Trinity Forest:

Texas ash has been noted in the Corps of Engineers reports as occurring in the area. In their publication it is listed as an individual species as it is here. The species probably occurs commonly in the area but is misidentified.

ENH429

UNIVERSITY of FLORIDA
IFAS Extension

Fraxinus texensis: Texas Ash[1]

Edward F. Gilman and Dennis G. Watson[2]

Introduction

Texas Ash creates a wonderful shade tree, its short trunk supporting a broad, rounded crown of seven-inch-long leaves divided into leaflets. Unfortunately, it is rare in the trade. Trees slowly grow to about 50 feet tall but most are seen 25 to 30 feet tall. The leaves are dark green to olive green above and paler green below and cast a medium shade beneath the tree. Petioles are an attractive pale red to pink, and fall color is showy ranging from orange/red to purple. The inconspicuous flowers appear before the leaves emerge in spring, and are followed by the production of 1.5-inch-long, light red to pink, winged fruit, or samara. It often grows as a multi-stemmed tree in the wild on limestones soils in central Texas.

Figure 1. Middle-aged *Fraxinus texensis*: Texas Ash

General Information

Scientific name: *Fraxinus texensis*

Pronunciation: FRACK-sih-nus teck-SEN-sis

Common name(s): Texas Ash

Family: *Oleaceae*

USDA hardiness zones: 5A through 9A (Fig. 2)

Origin: native to North America

Invasive potential: little invasive potential

Uses: reclamation; shade; street without sidewalk; deck or patio; specimen; parking lot island < 100 sq ft; parking lot island 100-200 sq ft; parking lot island

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2. Edward F. Gilman, professor, Environmental Horticulture Department; Dennis G. Watson, associate professor, Agricultural Engineering Department, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville FL 32611.

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> 200 sq ft; tree lawn 3-4 feet wide; tree lawn 4-6 feet wide; tree lawn > 6 ft wide; highway median

Availability: not native to North America

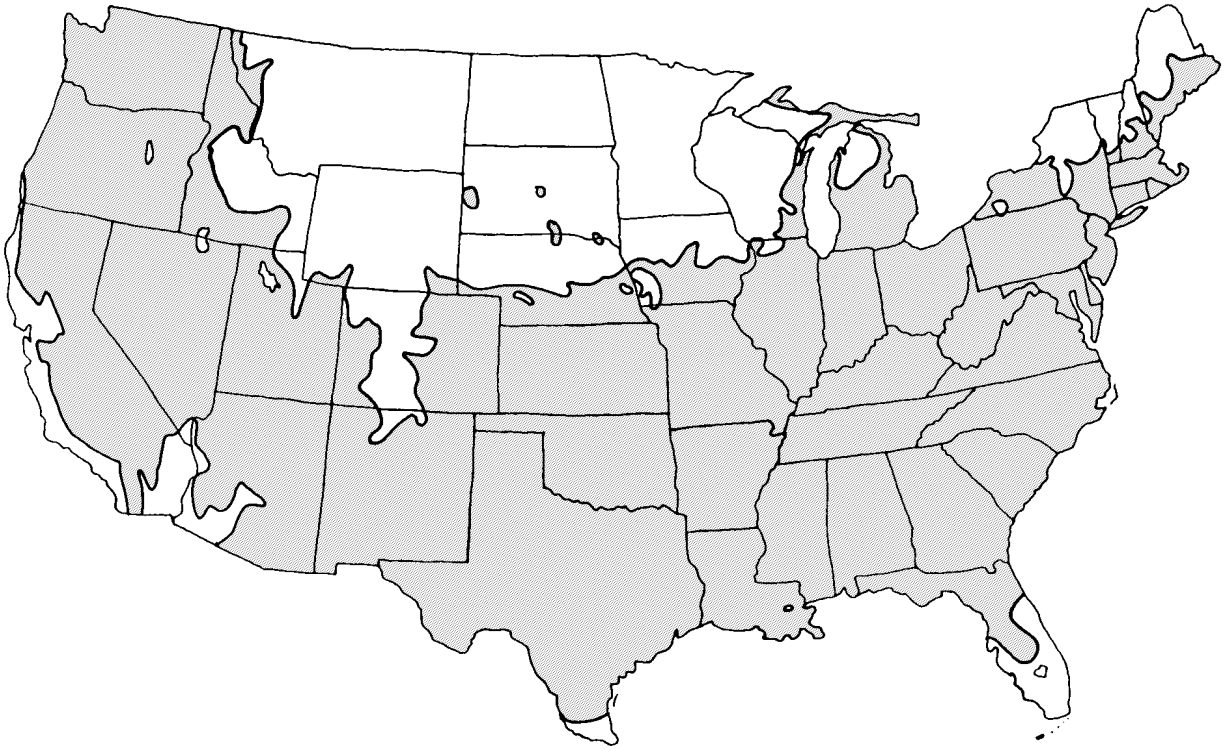


Figure 2. Range

Description

Height: 30 to 40 feet

Spread: 25 to 35 feet

Crown uniformity: symmetrical

Crown shape: oval, upright/erect

Crown density: moderate

Growth rate: slow

Texture: medium

Foliage

Leaf arrangement: opposite/subopposite (Fig. 3)

Leaf type: odd-pinnately compound

Leaf margin: serrate, entire

Leaf shape: ovate, obovate

Leaf venation: pinnate, reticulate

Leaf type and persistence: deciduous

Leaf blade length: less than 2 inches, 2 to 4 inches

Leaf color: green

Fall color: orange, red, purple

Fall characteristic: showy

Flower

Flower color: green

Flower characteristics: not showy

Fruit

Fruit shape: round

Fruit length: .5 to 1 inch

Fruit covering: dry or hard

Fruit color: pink

Fruit characteristics: does not attract wildlife; showy; fruit/leaves not a litter problem

Trunk and Branches

Trunk/bark/branches: branches don't droop; not showy; typically multi-trunked; thorns

Pruning requirement: needed for strong structure

Breakage: resistant

Current year twig color: gray, brown

Current year twig thickness: thick

Wood specific gravity: unknown

Culture

Light requirement: full sun

Soil tolerances: clay; sand; loam; alkaline; acidic; occasionally wet; well-drained

Drought tolerance: high

Aerosol salt tolerance: unknown

Other

Roots: not a problem

Winter interest: no

Outstanding tree: yes

Ozone sensitivity: tolerant

Verticillium wilt susceptibility: susceptible

Pest resistance: resistant to pests/diseases

Use and Management

Texas Ash grows in full sun on well-drained soil, either dry or wet, and prefers alkaline soil. It is very popular in Texas and Oklahoma, but could be cultivated and planted more in other areas. Trained to a central leader and a straight trunk it could be used for city street and parking lot tree planting. It could be grown in the east in areas with good drainage especially on sites which are not irrigated due to its low water requirement or drought tolerance. Texas Ash will tolerate both soil compaction and air pollution, making it well-suited for use as a street, parking lot or median tree. Not as susceptible to borers as other Ashes.

Propagation is by seed.

Pests and Diseases

No pests or diseases are of major concern. Probably borers on recently transplanted or stressed trees.

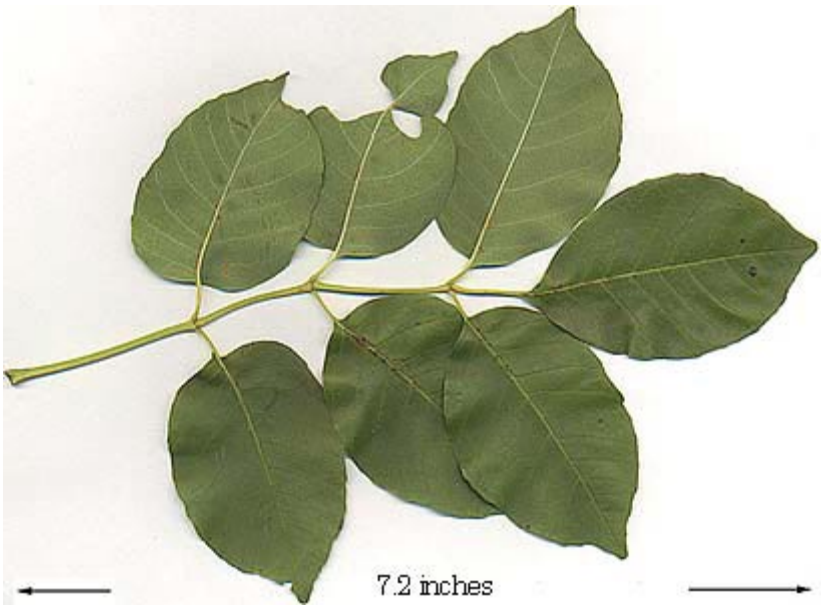
by Bob Harms (harms@mail.utexas.edu)

Ash / *Fraxinus*

F. texensis

The valley of upper Deadman's Creek in N. Hays County has both green ash/red ash (Fraxinus pensylvanica) and Texas (white) ash (F. texensis), and it would seem that hybridization has occurred. They grow along the creek or in bottomland areas that have strong seasonal moisture. 30 years ago the overgrazed land had three very large trees (trunks c. 2' in diameter) and a few saplings. One collapsed some 15 years ago, one large F. texensis (male [staminate]) is still present, and one, F. pensylvanica, has been reduced to a low trunk with a few smaller branches. But the saplings have become trees of moderate size (c. 25-30'), and many new saplings have appeared along the creek.

Determining the species of individual trees has been very challenging. Ash trees are unisexual (dioecious), so the use of samara form is available only for mature female (pistillate) trees. Key leaflet features (as in *Shinners & Mahler's Illustrated Flora of North Central Texas*) and underleaf coloration do not seem to provide clearcut distinctions for this populations.



"Blades of leaflets lighter green below but not noticeably pale" [p. 848]
— thus *F. pensylvanica*?

Only recently I discovered a key that employs leaf scars to distinguish the green ash (F. pensylvanica) from the white ash (F. americana). Numerous web sites illustrate this difference. (Google: "leaf scar" "green ash" "white ash".) Since Texas ash is commonly considered to be a variety of F. americana (i.e., F. americana var. texensis), leaf scars provide one possible test to distinguish the two species. With F. texensis the top of the leaf scar is more strongly notched, with a lateral bud in the notch. With F. pensylvanica the top is relatively flat or only slightly notched, with a lateral bud above the scar. This often demands the inspection of several recent leaf scars to make a determination – to locate tokens of an unambiguos scar. Older leaf scars are commonly misleading, as the growing bud has expanded into the top of the scar.

F. texensis

F. pensylvanica

The only remaining diagnostic requires a samara (winged fruit) [p. 848]:

F. texensis
Wing of fruit not decurrent on fruit body (wing ± ending where body of fruit begins
F. pensylvanica

Wing of fruit decurrent over half way on fruit body (wind extending along body of fruit)

F. texensis

F. pensylvanica

F. texensis

***F. texensis* on left; *F. pensylvanica* on right**

Clearly *F. pensylvanica*

Male, staminate, plants are best identified using leaf scars. The staminate flowers below appear to be on F. texensis, but I am unable to make a safe determination on the basis of this image:

Female, pistillate, flowers do seem to have distinctive calyces, but our sample may be too small to determine this.

F. texensis

F. pensylvanica

Fall leaf color may or not reveal the species difference. Numerous trees took on a maroon color. The F. texensis photo at the top of the page was taken the same day as the following, which had never produced samaras, but recent inspection of leaf scars show to be F. pensylvanica.

F. pensylvanica

Plant Resource Center Home Page — Flora of Texas — Hays County Flora

Texas Buckeye

Aesculus glabra var. *arguta* (Buckl.) Robins.

Other Common Names:

Buckeye, white buckeye, stinking buck-eye

Brief Description:

Texas buckeye is documented as a subspecies of Ohio buckeye. It is considered a shrub or small tree. The bark and seeds are considered poisonous to livestock leading many landowners to eradicate it. In urban areas, though, it is often an ornamental planting. The seed is prized as a good luck charm and squirrels have been observed consuming them also. The pith of branches has also been reported to have eaten by squirrels. This is because of a sweet sugar compound contained in the pith.

Habitat:

Texas buckeye ranges from Missouri, Arkansas, Oklahoma, and Texas. It has a variety of habitats listed but it is primarily suited to alkaline soils. In dry upland forests it is usually present only as a shrub. It also is listed as a tree that prefers river bottom and stream bank soils. It can also grow in deep soils from sand to heavy clay.

Life History:

Flowers appear from March to mid-May. Only the fruits near the base of the branches of a cluster are perfect and fertile. The seeds mature and are dispersed from September to late October by gravity, animals, and to a limited extent by water. Seeds generally geminate the following spring. No germination has been seen on dry soil surfaces. During the first year of growth it develops a strong tap root. Buckeye is considered to be tolerant of shade.

Texas buckeye and the Great Trinity Forest:

A large grove of these trees is a highlight of the Trinity Forest. Care will be taken to maintain these areas and further develop the ecological integrity of them.

Aesculus glabra Willd.

Ohio Buckeye

Hippocastanaceae -- Horsechestnut family

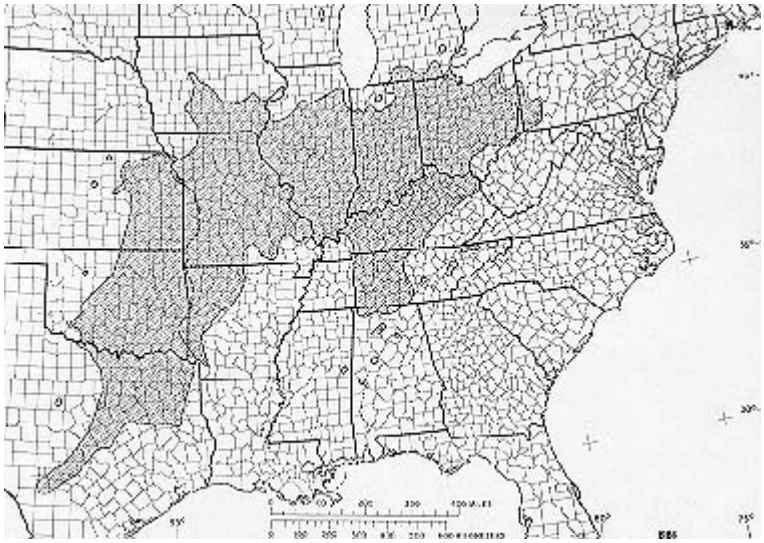
Robert D. Williams

Ohio buckeye *(Aesculus glabra)*, also known as American buckeye, fetid buckeye, and stinking buck-eye, derives its unflattering common names from the disagreeable odor that emanates when the leaves are crushed. The tree is an attractive ornamental, but it has limited commercial use as sawtimber because of the soft, light wood. The bark and seeds contain a narcotic glucoside considered poisonous to livestock, leading many landowners to eradicate it.

Habitat

Native Range

Ohio buckeye grows mostly on mesophytic sites in western Pennsylvania, Ohio, and southern Michigan west to Illinois and central Iowa. Its range extends south to eastern Kansas, southwestern Oklahoma, and central Texas; east to western Arkansas, Tennessee, and central Alabama with one location in eastern Mississippi (9). It has been planted in Europe and the eastern United States; in eastern Massachusetts, Minnesota, and western Kansas *(11).*



- *The native range of Ohio buckeye.*

Climate

The average annual temperature in the growing area of Ohio buckeye ranges from about 4° to 10° C (40° to 50° F) (6). Average minimum temperatures are not below -29° C (-20° F) within its range, but -40° C (-40° F) temperatures have been recorded where it grows in Missouri and Iowa. Maximum temperatures as high as 46° C (115° F) have occurred in the western part of its range. Average annual precipitation ranges from 760 mm (30 in) in Kansas and Oklahoma to 1020 mm (40 in) in Ohio and western Pennsylvania, and up to 1400 mm (55 in) in Mississippi and Alabama. Growing-season precipitation averages 510 to 640 mm (20 to 25 in). Snowfall ranges from 5 cm (2 in) in the southern part of the geographic distribution to 102 cm (40 in) in the northern part. About 160 days are frost-free in the northern part of the range and as many as 220 days in the southern part.

Soils and Topography

The buckeye is a moist-site tree and is most frequently found along river bottoms and in streambank soils. It is often found on the moist soils of the Early Wisconsin Drift Plain in Indiana (4). Ohio buckeye is most commonly found growing on soils of the order Alfisols. In the early 1800's buckeye and sugar maple *(Acer saccharum)* were prominent on the slope phase of the Miami silty clay loam in Ohio (9). Buckeye made up about 5 percent of the forest stand on this soil type. Since then its abundance has diminished.

Although Ohio buckeye is sometimes found on drier sites such as those supporting oak-hickory stands, and on clayey soils, it usually grows slowly in these situations and seldom becomes dominant. It is a shrub, only 1.2 to 1.5 m (4 to 5 ft) tall, on dry habitats in the oak-hickory association of eastern Oklahoma (9). Ohio buckeye also is found in hardwood stands on moist sites in the limestone-sink-and-cave section of the Bluegrass region of Kentucky and is infrequently found on the well developed flood plains along the Missouri River in southeastern Nebraska (9).

Associated Forest Cover

Ohio buckeye grows in mixed stands with bur oak *(Quercus macrocarpa),* chinkapin oak *(Q. muehlenbergii),* white ash *(Fraxinus americana),* hackberry *(Celtis occidentalis),* sugar maple, black walnut *(Juglans nigra),* black cherry *(Prunus serotina),* honeylocust *(Gleditsia triancanthos),* Kentucky coffeetree *(Gymnocladus dioicus),* shagbark hickory *(Carya ovata),* American elm *(Ulmus americana),* and red mulberry *(Morus rubra)* in the Bluegrass region of Kentucky (9). In Indiana, 6 percent of the trees in a mixed hardwood stand were buckeyes; 39, 11, 16, and 28 percent were sugar maple, American elm, black walnut, and miscellaneous species, respectively. In another stand in which more than 50 percent of the trees were beech *(Fagus grandifolia),* sugar maple, hackberry, and black walnut, buckeye constituted a little more than 10 percent.

In the mixed mesophytic climax forests of Marion and Johnston Counties, IN, in 1819, Ohio buckeye made up 6 and 2 percent, respectively, of the total number of stems (9), and less than 2 percent of these trees were more than 46 cm (18 in) in d.b.h. In a few stands, however, it made up as much as 17 percent of the total stems, ranking second in importance only to beech.

Buckeye is a frequent or even a common tree in association with beech, sugar maple, and American basswood *(Tilia americana)* in the Wabash River Basin in southern Illinois and Indiana (9).

Ohio buckeye is not listed by the Society of American Foresters as a major or minor component of any of the North American forest cover types (5), probably because of its relatively minor commercial importance and its increasing rarity. It is not a pioneer tree and thus is seldom found on old fields or spoil-bank sites.

Life History

Reproduction and Early Growth

Flowering and Fruiting- Ohio buckeye is polygamo-monoecious, bearing both bisexual and male flowers. The pale greenish-yellow flowers appear after the leaves in the spring from March to May and are borne in upright branched clusters. Only those near the base of the branches of a cluster are perfect and fertile; the others are staminate *(4,11).* The fruit is a leathery capsule containing one, two, or three seeds. The ripe seed is dark chocolate to chestnut brown, smooth and shiny, with a large, light-colored hilum so that it resembles an eye. 'The cotyledons are very thick and fleshy and contain no endosperm.

Seed Production and Dissemination- Seeds are dispersed from early September to late October by gravity, by animal activity, and sometimes by water. The number of hulled seeds per kilogram ranges from 105 to 150 (48 to 67/lb), and most seeds are sound *(11).* The seeds have a high moisture content and should be kept moist to avoid loss of viability.

Ohio buckeye begins bearing seeds at 8 years but no data are available on frequency and amount of seed produced *(11).*

Seedling Development- The seeds ordinarily germinate in the spring after wintering on the ground. Germination is hypogeal. If seeds are to be sown in a nursery, they should be sown in the fall or stratified about 120 days before spring sowing *(11).* No germination has been observed on dry surface soil, even with an ample seed supply.

Seedlings can grow under some shade, but the species seems to develop best as isolated individuals in openings along streambanks and on other moist sites. No data are available on early growth rates.

Vegetative Reproduction- No information available.

Sapling and Pole Stages to Maturity

Growth and Yield- Ohio buckeye generally develops a strong taproot the first year. Most of the shoot growth occurs early in the growing season. As a sapling it grows faster than most of the oaks but slower than yellow-poplar *(Liriodendron tulipifera).* In the open, it is characteristically branchy with a short, knotty trunk.

Fifty Ohio buckeyes measured in Jefferson County, IN, averaged 20.7 m (68 ft) in height and 84 cm (33 in) in d.b.h., 91 cm (36 in) above the ground (9). Apparently these trees were larger in diameter than average for buckeye, even though the diameter was measured lower on the bole than the standard breast height of 1.37 m (4.5 ft). This species generally does not grow taller than 9.1 m (30 ft) and seldom exceeds 21.3 m (70 ft) (9). In 1978, the largest living tree registered was 116 cm (45.5 in) in d.b.h., 44.5 m (146 ft) tall, and had a crown spread of 16.5 m (54 ft) *(1).* Trees larger than 61 cm (24 in) in diameter are rare. On good sites, the tree will reach usable sawtimber size at 60 to 80 years of age. On poor sites, it seldom has the form or size to produce saw logs.

Rooting Habit- No information available.

Reaction to Competition- Because Ohio buck-eye is often found in beech-sugar maple stands, it must be classed as shade tolerant. It only attains good form as a timber tree when it grows in reasonably dense stands. Side competition and shade foster straight boles and encourage natural pruning of this tree, which tends to have a large, branchy crown.

Damaging Agents- Ohio buckeye is relatively free of insect pests but the sapwood timberworm *(Hylecoetus lugubris),* the lacebug *(Corythucha aesculi),* the chrysomelid *(Derocrepis aesculi),* and the walnut scale *(Quadraspidiotus juglansregiae)* feed on buckeye *(2).*

Ohio buckeye also has relatively few diseases (6). It is susceptible to a leaf blotch *(Guignardia aesculi),* which begins as brown spots or blotches on the leaves and may eventually involve all the leaves, giving the tree a scorched appearance. This disease may slow the growth rate but does no permanent damage to the tree and can be controlled on ornamentals. One of the powdery mildews, *Uncincula flexuosa,* also attacks the leaves of buckeye.

A leaf rust of the Ohio buckeye that occurs in the western part of the species range was long known as *Aecidium aesculi* but has now been established by Baxter as *Puccinia andropogonis (3).*

Leaf blotch and leaf scorch, the latter involving a physiogenic response to heat and drought along urban streets, may be the most serious diseases (7). Air pollution may be more responsible for the leaf blighting than heat or drought.

Because Ohio buckeye leafs out early in the spring, the young leaves are sometimes killed by frost. This species is capable of withstanding severe winters, however and has been successfully introduced in Minnesota and Massachusetts. Moreover, the bole of the tree is not commonly damaged by frost, and the heavy branches of the crown are seldom severely damaged by heavy loads of sleet or snow. Apparently buckeye is not susceptible to sunscald either.

The common eastern leafy mistletoe, *Phoradendron serotinum,* occurs on Ohio buckeye, but damage is negligible (7).

Fungi capable of causing either rot of the central stem or rot at wounds of living trees include *Ganoderma applanatum, Oxyporus populinus, Phellinus johnsonianus,* and *Polyporus*

squamosus (7). Buckeye growing in forest stands is usually free of defect caused by decay unless the bole has been damaged by fire.

Special Uses

The seeds as well as the bark of Ohio buckeye are reported to be poisonous, and the *Aesculus* native to Illinois is known to contain a poisonous narcotic glucoside (9). The young shoots of buckeye are poisonous to cattle, and landowners in Indiana have exterminated buckeye in many areas because the seed is considered poisonous to livestock (9). On the other hand, some buckeye seed are apparently eaten by squirrels. In Ohio, it constitutes from 2 to 5 percent of the food of eastern fox squirrels during the fall, winter, and spring seasons. Other studies in Ohio list buckeye as an auxiliary food that was sampled by squirrels in September but not eaten in quantity (9). Thus, it seems probable that the use of buckeye seed for food by animals is not a limiting factor in its reproduction.

Fox squirrels in Illinois were observed eating the pith from terminal twigs (6). Buckeye pith contains 66 percent raffinose, a sweet-tasting 18-carbon sugar that is much sweeter and contains potentially more energy than sucrose.

The wood is light and soft and is used for pulpwood, woodenware, and occasionally for lumber*(10).*

Genetics

Texas buckeye *(Aesculus glabra* var. *arguta* (Buckl.) Robins.), a shrub or small tree, ranges from southeastern Nebraska southwest to central Texas*(8).*

Hybrids of *Aesculus glabra* with *Ae. octandra (Ae. marilandica* x Booth ex Dippel), *Ae. pavia (Ae. x bushii* Schneid.), and *Ae. octandra x pavia (Ae.* x *arnoldiana* Sarg.) have been recorded *(8).* Intermediate hybrids exhibiting the characteristics of both species occur as hybrid swarms, or most often, individual plants of one species have one or more characteristics of the other species from introgression *(4).*

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White Ash

Fraxinus Americana L.

Other Common Names:

Biltmore ash, Biltmore white ash, American ash.

Brief Description:

White ash is the most common and useful native ash. Its wood is useful due to its strength and shock resistance. Its seeds provide food for birds.

Habitat:

This species ranges from the Great Plains to the east. It is found in all states east of the Great Plains. White ash has demanding soil fertility and soil moisture requirements. It grows moist commonly on fertile soils with high nitrogen and calcium contents. It prefers moderately well drained soils and is intermediately tolerant of temporary flooding. It is seldom seen in swamps. In East Texas, white ash is always found in dryer areas than its relative green ash (Fraxinus pennsylvanica). It is mostly found on slopes of streams and not in low spots, flats, or depressions.

Life History:

White ash is dioecious; flowers appear with or just before the leaves in April and May beginning at the age of 20 years. Seed is dispersed by wind from September to December. Seeds have a pronounced dormancy that, even in controlled environments, requires months of stratification. Germination occurs in the spring. Seedlings develop best under 45% full sunlight. White ash sapling and seedling stumps sprout readily. Seedling growth can be slow initially as the tree develops a strong root system. It is defined as being shade intolerant.

White ash and the Great Trinity Forest:

White ash has been noted in the Corps of Engineers reports as occurring in the area. This is probably limited to very isolated cases.

Fraxinus americana L.

White Ash

Oleaceae -- Olive family

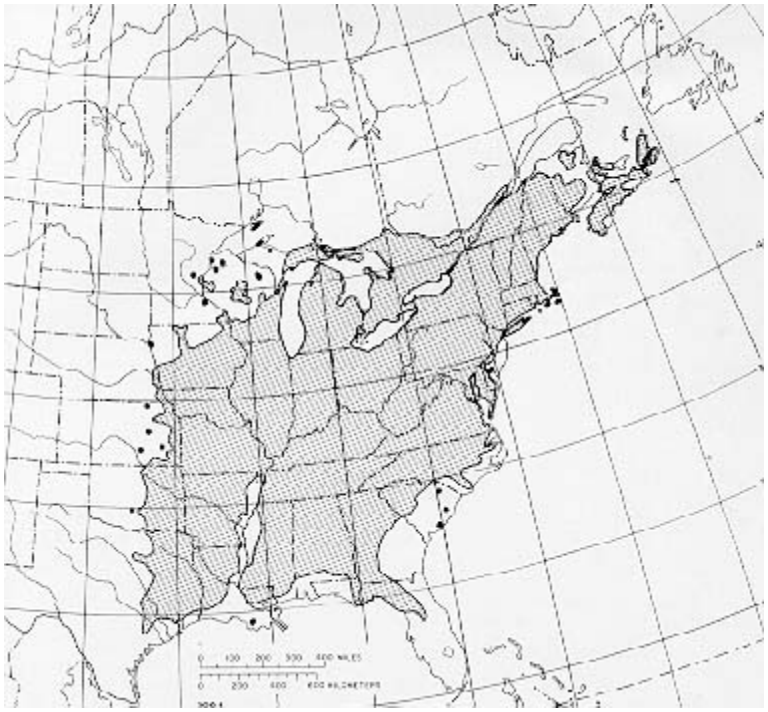
Richard C. Schlesinger

White ash *(Fraxinus americana),* also called Biltmore ash or Biltmore white ash, is the most common and useful native ash but is never a dominant species in the forest. It grows best on rich, moist, well-drained soils to medium size. Because white ash wood is tough, strong, and highly resistant to shock, it is particularly sought for handles, oars, and baseball bats. The winged seeds provide food for many kinds of birds.

Habitat

Native Range

White ash grows naturally from Cape Breton Island, Nova Scotia, to northern Florida in the east, and to eastern Minnesota south to eastern Texas at the western edge of its range (7).



-The native range of white ash.

Climate

The climate varies greatly within the natural range of this species. The length of the frost-free period is from 90 to 270 days. Mean January temperatures range from -14° C (7° F) to 12° C (54° F) and the mean annual minimum temperatures range from -34° C (-30° F) to -5° C (23° F). Mean July temperatures range from 18° C (64° F) to 27° C (81° F). The average annual precipitation is between 760 and 1520 mm (30 and 60 in), and the snowfall is from 0 to 250 cm (100 in).

Soils and Topography

White ash has demanding soil fertility and soil moisture requirements. These requirements may be provided by soils derived from a variety of parent materials-limestone, basalt, shale, alluvium, and fine glacial till. A large number of soil types may support white ash, many of which are included in the Hapludalfs and Fragiudalfs of the order Alfisols, Haplorthods and Fragiorthods of the order Spodosols, and Dystrochrepts and Fragiochrepts of the order Inceptisols (11).

White ash grows most commonly on fertile soils with a high nitrogen content and a moderate to high calcium content. Nutrient culture results show that an absence of nitrogen reduces seedling dry weight by 38 percent compared to seedlings grown in complete nutrient solution, and that calcium is the second most important macroelement, followed by sulfur (3). Its pH tolerance varies from 5.0 to 7.5.

Soil moisture is an important factor affecting local distribution. Best growth occurs on moderately well drained soils, including areas underlain by compacted glacial till; light textured, well drained, glacial drift; and sandy to clay loam soils in which roots can penetrate to a depth of 40 cm (16 in) or more. Although rarely found in swamps, white ash is intermediately tolerant of temporary flooding.

White ash is found in various topographic situations. It grows from near sea level in the southeastern Coastal Plain to about 1050 m (3,450 ft) in the Cumberland Mountains and up to 600 m (1,970 ft) in New York's Adirondack Mountains. In the hilly and mountainous areas of the Northeast, it grows on the mesophytic lower and middle slopes, usually stopping short of both the dry, oak-pine ridgetops and the cold, spruce-fir mountain tops. In the Coastal Plain, white ash usually is limited to the slightly elevated ridges in the floodplains of major streams. In the Central States it is most common on slopes along major streams, less common in upland situations, and rarely found in the flat bottoms of major streams or in depressions (16).

Associated Forest Cover

White ash is a major component in the forest cover type White Pine-Northern Red Oak-Red Maple (Society of American Foresters Type 20) and is a common associate in 25 other forest cover types (4):

19 Gray Birch-Red Maple
21 Eastern White Pine

22 White Pine-Hemlock
23 Eastern Hemlock
24 Hemlock-Yellow Birch
25 Sugar Maple-Beech-Yellow Birch
26 Sugar Maple-Basswood
27 Sugar Maple
28 Black Cherry-Maple
33 Red Spruce-Balsam Fir
39 Black Ash-American Elm-Red Maple
42 Bur Oak
52 White Oak-Black Oak-Northern Red Oak
53 White Oak
55 Northern Red Oak
57 Yellow-Poplar
58 Yellow-Poplar-Eastern Hemlock
59 Yellow-Poplar-White Oak-Northern Red Oak
60 Beech-Sugar Maple
63 Cottonwood
64 Sassafras-Persimmon
80 Loblolly Pine--Shortleaf Pine
82 Loblolly Pine-Hardwood
87 Sweetgum-Yellow-Poplar
91 Swamp Chestnut Oak-Cherrybark Oak

Some of the primary associates of white ash include eastern white pine *(Pinus strobus),* northern red oak *(Quercus rubra),* white oak *(Q. alba),* sugar maple *(Acer saccharum),* red maple *(A. rubrum),* yellow birch *(Betula alleghaniensis),* American beech *(Fagus grandifolia),* black cherry *(Prunus serotina),* American basswood *(Tilia americana),* eastern hemlock *(Tsuga canadensis),* American elm *(Ulmus americana),* and yellow-poplar *(Liriodendron tulipifera).* Understory shrubs and small trees frequently found growing with ash are downy serviceberry *(Amelanchier arborea),* pawpaw *(Asimina triloba),* American hornbeam *(Carpinus caroliniana),* flowering dogwood *(Cornus florida),* witch-hazel *(Hamamelis uirginiana),* eastern hophornbeam *(Ostrya uirginiana),* and mapleleaf viburnum *(Viburnum acerifolium).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- White ash is dioecious; flowers appear with or just before the leaves in April and May. A good seed crop is produced about every third year. The time between the first noticeable enlargement of the male flower buds until shedding is 2 to 3 weeks. Pollen shedding from an individual tree usually takes 3 or 4 days. The pollen is carried by wind as far as 100 in (328 ft) from the point of dispersion.

Female buds are completely open a few days after they begin to swell. Exposed flowers remain receptive for about I week, but once the stigmas discolor, the period of receptivity is past. Abundant seed crops are borne by about half of the flowering trees.

Good seeds are produced in all parts of the crown. Almost 99 percent of the fruits (samaras) contain one seed, about 1 percent contain two, and a very small percent have twin embryos. Vigorous trees may first flower when only 8 to 10 cm (3 to 4 in) in d.b.h., but white ash is usually 20 to 25 cm (8 to 10 in) in d.b.h. before it flowers abundantly.

Seed Production and Dissemination- The seed is dispersed by wind up to 140 in (460 ft) from the parent tree. White ash seed has a very pronounced dormancy. Although the embryo is completely developed morphologically at the time of seedfall (September to December), the physiological state of the endosperm and embryo inhibit germination. Seeds must be stratified under moist conditions for 2 or 3 months before they will germinate, and the average laboratory germination is 54 percent. The minimum seed-bearing age is 20 years (14).

Seedling Development- Germination is epigeal. Natural regeneration from seeds will occur if the soil, humus, or leaf litter is wet in the spring. Under experimental conditions, seedlings developed best in 45 percent of full sunlight (8). Thus silvicultural systems that can provide sunlight, such as shelterwood or clearcutting, have been recommended for white ash.

Photoperiodic response appears to vary with geographic location. North Carolina seedlings showed no growth response to a 14.5-hour daylength. In a Massachusetts test, however, northern seedlings ceased height growth and dropped their leaves well before the first frost, while southern seedlings continued height growth until late autumn.

Vegetative buds begin to enlarge in April or May. Height growth is 90 percent complete in 30 days, and 100 percent complete in 60 days. Diameter growth generally continues until August.

Young white ash exhibits strong apical dominance. Thrifty open-grown seedlings 2 in (6.6 ft) tall often have only two or three pairs of lateral branches, and sometimes none. If the terminal bud is removed, apical dominance is altered and new branches develop from the uppermost pair of lateral buds. Generally one of these grows faster than the other and soon assumes apical control.

Vegetative Reproduction- Stumps of freshly cut seedling and sapling white ash sprout readily. Usually only one or two stems are produced. This species can be propagated by conventional methods of budding, grafting, or layering. Even open field and bench grafting of unpotted stock are highly successful. Diploid, tetraploid, and hexaploid white ash have all been successfully grafted on diploid stock.

Sapling and Pole Stages to Maturity

Growth and Yield- Depending on the amount of root competition, a field-grown white ash tree in full sunlight may take from 3 to 15 years to become 1.5 m (5 ft) tall. By then, its root system is usually well established and white ash is able to grow rapidly even if surrounded by weeds. Post-

juvenile growth rates of dominant and codominant trees in unthinned, even-aged stands in central Massachusetts are as follows:

Age	D.b.h.		Height	
(yr)	(cm)	(in)	(m)	(ft)
20	10	4	12	39
30	18	7	17	56
40	25	10	21	69
50	30	12	23	75
60	36	14	25	82
70	43	17	27	89

Yield tables are not available for white ash in pure stands. However, for plantations in Canada ranging in age from 20 to 38 years, We growth of the dominant and codominant trees averaged 3 to 5 mm. (0.1 to 0.2 in) per year in diameter and 0.2 to 0.8 m (0.7 to 2.6 ft) in height (13). In mixed Appalachian hardwood stands, diameter growth ranged from 3 to 8 mm (0.1 to 0.3 in) per year, depending on site quality and individual tree variation.

Rooting Habit- White ash generally forms a taproot that in turn branches into a few large roots that grow downward. From these vertical roots, single lateral branches develop at intervals. Intraspecific grafting is common. The distribution of roots is strongly influenced by soil type. On a loamy sand, most of the roots, both large and small, were in the A horizon. On a fine sandy loam, the majority of the fine roots were in the B, horizon, and the large roots equally in the A and B1.

Knowledge of mycorrhizal associations is limited. *Gyrodon merulioides* has been reported on white ash. Seedlings inoculated with the endomycorrhizal fungi *Glomus mosseae* and *G. fasciculatus* grew markedly better than nonmycorrhizal controls (12).

Reaction to Competition- White ash is a pioneer species that establishes itself on fertile abandoned fields in several parts of the country. In the Southeast, much of the abandoned agricultural land is incapable of supporting white ash. On such sites, white ash establishes itself only after some site protection and improvement has been accomplished by pines. However, pioneer ash often do not develop into good timber trees unless other hardwoods or pines are also present to provide competition and reduce branchiness.

Open-grown trees commonly remain single stemmed and fine branched until they are 9 to 12 ni (30 to 40 ft) tall, although old specimens can become as broad crowned as an elm. With even slight crowding, the single-stemmed characteristic can easily be maintained throughout a rotation. Shade-killed branches drop quickly-small ones within a year or two and larger ones within 4 or 5 years (16).

Uninjured terminal buds suppress the growth of all lateral buds on the current year's growth, and they suppress the growth of other laterals to such an extent that each internode has only one pair

of branches that persist more than a few years. Even the strongest lateral branches grow only half as fast as the terminal except on old, open-grown trees. Little or no epicormic branching occurs on the boles of released trees. The branches of dominant trees emerge from the bole at about a 35° angle from the vertical, whereas the branches of intermediate trees emerge at about a 55° angle (16).

When young, white ash is a shade-tolerant tree. Seedlings can survive under a canopy with less than 3 percent of full sunlight but grow little under these conditions. Seedlings that receive sufficient sunlight grow rapidly. With increasing age, white ash becomes less tolerant of shade and is classed overall as intolerant. The decrease in shade tolerance with increasing age is reflected in the fact that young white ash is abundant in the understory of northern hardwood stands, but few grow into the overstory unless provided with light from above.

Despite its low shade tolerance, white ash is characteristic of intermediate as well as early stages of natural plant succession. Throughout its range it is a minor but constant component of both the understory and overstory of mature forests on suitable soils. It owes its position in the final overstory to its ability to persist for a few years in moderately dense shade and to respond quickly to openings in the canopy created by death or other causes.

White ash can be maintained more easily in a dense stand than can some of its more shade-intolerant associates, such as northern red oak. In contrast, dominant or codominant white ash responds readily to thinning and within a few years will increase its crown area to take full advantage of any reasonable release (16).

Damaging Agents- Ash decline (also called ash dieback) is the most serious problem affecting white ash. Especially prevalent in the northeastern part of the tree's range, this disease complex occurs from the Great Plains to the Atlantic coast between 39 and 45 degrees north latitude (10). The disease, ash yellows, caused by mycoplasma-like organisms (MLO), has been found associated with most of the dying trees where ash decline is conspicuous (9). However, since not all dying trees are infected with MLO, ash decline is thought to result from multiple causes. Drought-weakened trees may be invaded by cankercausing, branch-girdling fungi such as *Fusicoccum* spp. and *Cytophorna pruinosa*. Additional stresses that may be involved in the etiology of ash decline are air pollution, leaf-spotting fungi, and viruses. Control recommendations are based primarily on maintaining good tree vigor (6).

Air pollution damages white ash. It is rated as sensitive to ozone and is severely injured by stack gases from soft coal consumption and from industrial processes, both of which emit sulfur dioxide.

Two leaf spot fungi, *Mycosphaerella effigurata* and *M. fraxinicola,* are common in nurseries and in the forest and cause premature defoliation of white ash. Anthracnose *(Gloeosporium aridum)* also causes premature defoliation and is most serious following exceptionally wet springs. An ash strain of tobacco ringspot virus causes chlorotic areas on the leaves and has been associated with ash dieback.

A rust *(Puccinia peridermiospora) distorts* petioles and small twigs. Cankers caused by *Nectria galligena may* cause branches to break but are rarely found on main stems. Heartwood rots may be caused by *Perenniporia fraxinophilus, Phellinus* igniarius, *Pleurotus ostreatus, Tyromyces spraguei*, and *Laetiporus sulphureus.* These organisms usually enter through wounds or broken branches, mainly on older trees.

Of 26 species of nematodes reported from the roots or root zones of white ash, only one, *Meloidogyne* ovalis, has been associated with root injury. However, nematodes can be vectors for the ringspot virus (5).

Of the insect pests, the oystershell scale *(Lepidosaphes ulmi)* is the most serious. Severe infestations cause yellowing of the leaves, and if prolonged, may kill some trees. The cottony maple scale *(Pulvinaria innumerabilis) also* attacks white ash.

The brownheaded ash sawfly *(Tomostethus multicinctus)* and the blackheaded ash sawfly *(Tethida cordigera) are* defoliators that are of concern mainly on ornamental trees. The forest tent caterpillar *(Malacosoma disstria)* and the green fruitworm *(Lithophane antennata)* feed on forest trees and occasionally cause complete defoliation within small geographic areas. The larvae of sphingid moths-*Sphinx chersis* (the great ash sphinx), *S. kalmiae,* and *Ceratornia undulosa*-feed on the leaves of white ash, as does the notched-wing geometer *(Ennomos magnaria).* The larvae of two leaf roller moths, Spar*ganothis dilutocostana* and *S. folgidipenna*, also feed on ash.

The ash bark beetle *(Leperisinus aculeatus)* may cause slight injury when the adults bore into the bark to hibernate. The ash borer *(Podosesia syringae)* may seriously damage young shade and shelterbelt trees. The ash and privet borer *(Tylonotus bimaculatus)* attacks and kills branches, especially on older trees. Both the red-headed ash borer *(Neoclytus acurninatus)* and the banded ash borer *(N. caprea)* colonize cut logs and dead or dying trees (1).

White ash seedlings are easily damaged or destroyed by deer and cattle browsing. Rabbits, beaver, and porcupine occasionally use the bark of young trees for food.

Special Uses

One of the earliest reported uses of white ash was as a snake bite preventive. Ash leaves in a hunter's pocket or boots were "proved" to be offensive to rattlesnakes and thereby provided protection from them. Seeds of white ash are eaten by the wood duck, bob white, purple finch, pine grosbeak, and fox squirrel. White ash is used in yard, street, and roadside plantings and also has been planted on strip mines with some success.

Genetics

Population Differences

White ash contains several phenotypic variants of leaf form that appear to be genetically controlled even though they are randomly distributed throughout the natural range. Chief among these are 9-leaflet, narrow-leaflet, blunt-leaflet, ascidiate leaflet, partially pubescent, purple-keyed, and crinkle-leaf forms. A purple leaf variant is vegetatively propagated and grown as an ornamental.

White ash is a polyploid species. Diploids (2n=46) occur throughout the species range but most tetraploids (2n=92) are found south of latitude 35° N and hexaploids (2n=138) are concentrated between latitude 35° and 40° N. Although three ecotypes were previously recognized on the basis of seedling morphology and ploidy level (15), recent work has shown that the variation in several traits is closely related to latitude. This clonal variation and the strong effects of ploidy level on several other traits indicate that ecotypes probably do not exist in white ash (2).

Hybrids

White ash and Texas ash *(Fraxinus texensis* (Gray) Sarg.) intergrade in Texas. The pumpkin ash *(Fraxinus profunda* (Bush) Bush) behaves in many respects as if it were a true breeding hexaploid derivative of a cross between tetraploid white ash and diploid green ash *(Fraxinus pennsylvanica* Marsh.). However, attempts have failed to artificially cross the two species. It is likely that natural hybridization between white ash and other species is extremely rare (16).

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White Mulberry

Moras alba L.

Other Common Names:

Common mulberry

Brief Description:

White mulberry globally is used for silk production. In the United States it can be found as a cultivated ornamental species and as planting in windbreaks. Its fruit is edible and slightly more insipid than the other mulberry species. This plant is credited with the fastest plant movement of all other plants. Pollen is released from the plant at half the speed of sound. Altogether though, white mulberry should be considered an unwanted exotic plant because of its propensity to spread. It possesses a poisonous white milky sap.

Habitat:

White mulberry has naturalized in the urban interface across much of eastern North America. It occurs in every state except Arizona and Nevada. Originally it was introduced from northern China, but is now found cultivated across the globe. It is somewhat drought and wind hardy which has led to its use in shelterbelt plantings. Typically they like full sun and deep well drained loamy soils. White mulberry can tolerate extended flooding and clay alkaline soils. It can be found growing in shrub and tree forms.

Life History:

White mulberry flowers from May to June. Its fruit is ripe soon afterwards and seeds are disseminated by birds and other animals. It exhibits fast growth and readily inhabits fencerows and invades fields in some areas. It can sprout readily. Overall it is a short plant though. White mulberry also hybridizes with red mulberry. It can be distinguished from red mulberry by its smaller, thinner, shinier leaves; its bark is more orange and yellow; and its fruit is typically white or pink.

White mulberry and the Great Trinity Forest:

This species has been reported as invading the forest. A concerted effort needs to be made to remove all invasive species. Injection, basal bark, and foliar applications of herbicides are the most effective means of control due to its sprouting nature. There will be considerable difficulty in distinguishing between this tree and its relative, the native red mulberry.

Weed of the Week

White Mulberry *Morus alba*

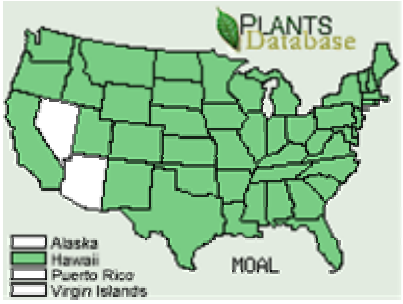
Common Names: Common mulberry, white mulberry

Native Origin: *Morus alba* was introduced during colonial times in an effort to establish a silkworm industry in the United States. It comes from Asia. It was widely cultivated in Europe during the 18th and 19th centuries for silkworms. It is still cultivated in China, India, Bangladesh and Pakistan.

Description: A deciduous shrub or tree, 30 to 50 feet in height and approximately 1.5 feet in diameter. It has low branches and a wide spreading crown. Bark is orange-brown with lenticels when young, becoming gray with long narrow irregular ridges. Glossy green leaves that turn yellow in autumn are 3 to 6 inches long, alternate, stipulate, and variable in shape. Unisex flowers are small, greenish-yellow, with dense spikes. The blackberry-like aggregate fruits, 1 to 1 1/4 inch long, turn from green to white to red to black as they ripen, May to August.

Habitat: White mulberry occurs naturally in sparse forests on hillsides at a wide range of elevations. It grows in part shade to full sun. It can grow in clay, loam, sand, acidic, alkaline, and well-drained soils. It tolerates extended flooding or droughty conditions.

Distribution: The seeds are spread by wildlife that feed on the fruits. It expands locally by producing new plants from its roots. It occurs throughout the US with exception of Alaska, Arizona and Nevada.



Ecological Impacts: Impacts include hybridization with and replacement of native mulberry. It transmits a harmful root disease to red mulberry and invades natural areas including fields, forest edges and roadsides.

Control and Management:

- **Manual**- Hand pull seedlings, cut trees, grind stumps, girdle large trees
- **Chemical**- Paint stumps with glyphosate

Diseases: Leaf spot, bacterial blight, powdery mildew, and cankers may infect this tree.

Natural Enemies: Fifty four species of fungi infect white mulberry; approximately 263 arthropods occur on this species

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Plant Invaders of Mid-Atlantic Natural Areas, p. 59,
Invasive Plants of Asian Origin Established in the United States and their Natural Enemies p. 110

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Ohio Perennial & Biennial Weed Guide

WHITE MULBERRY

Morus alba

Other Names | Origin & Distribution | Plant Description | Similar Species | Biology | Toxicity | Facts & Folklore

Family: Mulberry Family (Moraceae)

Other Names: *mulberry, Russian mulberry, silkworm mulberry.*.

Origin and Distribution: White mulberry is native to China and has long been cultivated in Europe. The British introduced it to North America prior to the American Revolution in a failed attempt to establish a silkworm industry, since the leaves are the primary food of silkworm caterpillars. Several varieties of this species have been widely planted in North America and have become naturalized. White mulberry is common in the eastern U.S., and is found in over three-fourths of the counties of Ohio, mostly along fencerows of unattended areas and in other open rural and urban habitats. It is not tolerant of shade and rarely grows in forested sites. But it is relatively tolerant of drought, salt, pollution and poor soils. This species is increasingly found in no-till corn or soybean fields where it may interfere with harvest.

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Plant Description: White mulberry is a small- to medium-sized, fast-growing, deciduous tree with a short, thick trunk that branches into numerous limbs to form a bushy, spreading crown. Several varieties exist, and they may have erect or weeping branches. This species is characterized by its furrowed orangish-brown bark, slender light orange twigs, shiny variously-lobed leaves and white to pink to purple berry-like fruit. In field crops, young trees are cut off annually by harvesting equipment and sprout new branches each spring, resulting in a highly branched shrub with a large trunk close to the ground. Twigs and leaves exude a milky juice (latex). The wood is light, soft and coarse-grained. White mulberry reproduces by seeds

- *Root system* - White mulberry produces wide-spreading, aggressive roots that are known to clog drains.
- *Stems* - The trunk is short, thick (8 to 16 inches in diameter, sometimes up to 5 feet) and multi-branched, resulting in a full, spreading crown. Central stems can grow 20 to 50 feet tall (sometimes up to 80 feet), but as a weed of roadsides and crop fields, it seldom grows over 15 feet tall. The bark is gray at first, turning an orangish- or yellowish-brown, with shallow furrows or ridges and an orange inner layer that is visible through the furrows. Secondary branches are generally slender and, depending on the variety, may be upright or hang casually toward the ground. Twigs are slender, erect and initially slightly hairy and reddish-brown, becoming smooth and light orange. Several shoots are produced from one node, giving the crown a branchy appearance.
- *Leaves* - The thin, bright, light green leaves are alternate, broadly oval and 2 to 4 inches long, with toothed margins (triangular teeth). The upper surface is smooth and shiny. The lower leaf surface is pale green and generally smooth, with hairs only along the main veins. Leaves can be unlobed (common on older trees) or have 2 to 5 unequal lobes (common on young trees and sprouts from older trees). The petiole (leaf stalk) is smooth.
- *Flowers* - Clusters of small petalless flowers are borne in a dense hanging spike. Male and female flowers are usually produced on separate plants (dioecious), but sometimes are produced on the same plant (monoecious). The male flower cluster is narrow and somewhat elongated and the female flower cluster is more oval.
- *Fruits & Seeds* - The berry-like 'fruit' is a tight, elongated cluster of white to pink (sometimes violet) smaller fruits. There are several horticultural varieties, some with dark fruit.

Similar Species: Red mulberry (*Morus rubra*) is a larger native version of its cousin, growing to heights of 50 to 70 feet with trunk diameters of 2 to 3 feet. It produces a light soft wood and rough brown bark. The red mulberry is indigenous to the eastern United States, and grows best in rich, river bottom woods and floodplains. Red mulberry is distinguished from white mulberry by the following: its leaves are larger, thicker, less shiny and have a downy lower surface; the bark and twigs are less orange or yellow; the fruits are longer and red to blackish but never white or pink; and it occurs in more natural, shaded habitats such as floodplain forests.

Biology: White mulberry flowers from April to June. Flowers are wind-pollinated. The fruits are very attractive to birds and mammals, which are probably responsible for its spread along fencerows and in fields. The plant has strong rooting ability and cut stems buried in soil are able to regenerate.

White mulberry is a fast-growing, short-lived plant that is becoming a problem in no-till fields. Once established, the roots will continue to produce sprouts even if the plant is cut back every year. White mulberry hybridizes with other *Morus* species through cross-pollination. This has raised concerns for the native red mulberry, because 'genetic swamping' could eliminate the native species.

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Toxicity: All parts of white mulberry, except for the ripe fruit, contain a milky sap (latex) that is toxic to humans. Although humans may consume ripe mulberry fruit, ingestion of unripe fruit can result in stomach upset, stimulation of the nervous system and hallucinations. The sap is also an irritant, and contact with leaves and stems may result in varying degrees of skin irritation. White mulberry pollen is highly allergenic and contributes to hayfever.

Facts and Folklore:

- The genus name, *Morus*, is Latin for 'delay', referring to the formation of winter buds late in the season after the weather has turned cold. The species name, *alba*, means 'white', referring to the whitish color of the buds.
- The silkworm is thought to prefer mulberries over all other plants due to a unique fragrance given off by the mulberry and to special organs in the caterpillar that respond to the taste of mulberry leaves. Silk proteins (fibroin and sericin) are derived only from mulberry leaves.
- White mulberry fruits vary greatly in sweetness, some being very sweet and others dry and tasteless. They lack the tartness of other mulberry species.

MULBERRY

Morus spp.

Moraceae

Common Names: Mulberry.

Species: White Mulberry (*Morus alba* L.), Black Mulberry (*M. nigra* L.), American Mulberry, Red Mulberry (*M. rubra* L.). Hybrid forms exist between *Morus alba* and *M. rubra*.

Related Species: Korean Mulberry (*Morus australis*), Himalayan Mulberry (*M. laevigata*).

Distant Affinity: Breadfruit (*Artocarpus altilis*), Jackfruit (*A. heterophyllus*), Fig (*Ficus* spp.), Che (*Cudrania tricuspidata*), African Breadfruit (*Treculia african*).

Origin: The white mulberry is native to eastern and central China. It became naturalized in Europe centuries ago. The tree was introduced into America for silkworm culture in early colonial times and naturalized and hybridized with the native red mulberry. The red or American mulberry is native to eastern United States from Massachusetts to Kansas and down to the Gulf coast. The black mulberry is native to western Asia and has been grown for its fruits in Europe since before Roman times.

Adaptation: The white mulberry, and to a lesser extent the red mulberry, are quite tolerant of drought, pollution and poor soil. The white mulberry is considered a weed tree in many parts of the country including urban areas. The black mulberry is more fastidious, faring less well in cold climates or areas with humid summers. The white mulberry is the most cold-hardy of the three species, although this varies from one clone to another. Some are damaged at 25° F, while others are unfazed at -25° F. Red mulberries are hardy to sub-zero temperatures. The black mulberry is the least cold-hardy of the three, although again cold tolerance seems to depend on the clone. In general it is limited to USDA Hardiness Zone 7 (0° to 10° F average minimum) or warmer. They have been planted only to a limited extent in America, mostly on the Pacific Coast. The mulberry makes a good town tree which will grow well in a tub.

DESCRIPTION

Growth Habit: All three mulberry species are deciduous trees of varying sizes. White

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mulberries can grow to 80 ft. and are the most variable in form, including drooping and pyramidal shapes. In the South on rich soils the red mulberry can reach 70 ft. in height. The black mulberry is the smallest of the three, sometimes growing to 30 ft. in height, but it tends to be a bush if not trained when it is young. The species vary greatly in longevity. Red mulberry trees rarely live more than 75 years, while black mulberries have been known to bear fruit for hundreds of years. The mulberry makes an attractive tree which will bear fruit while still small and young.

Foliage: The white mulberry is so-named for the color of its buds, rather than the color of its fruit. The thin, glossy, light green leaves are variously lobed even on the same plant. Some are unlobed while others are glove-shaped. Leaves of the red mulberry are larger and thicker, blunt toothed and often lobed. They are rough on their upper surfaces and pubescent underneath. The smaller black mulberry leaves are similar to those of the red mulberry, but with sturdier twigs and fatter buds. The species vary in the time of year they begin to leaf-out. White mulberries generally come out in early spring, almost two months before black mulberries.

Flowers: Mulberry trees are either dioecious or monoecious, and sometimes will change from one sex to another. The flowers are held on short, green, pendulous, nondescript catkins that appear in the axils of the current season's growth and on spurs on older wood. They are wind pollinated and some cultivars will set fruit without any pollination. Cross-pollination is not necessary. In California mulberries set fruit without pollination.

Fruit: Botanically the fruit is not a berry but a collective fruit, in appearance like a swollen loganberry. When the flowers are pollinated, they and their fleshy bases begin to swell. Ultimately they become completely altered in texture and color, becoming succulent, fat and full of juice. In appearance, each tiny swollen flower roughly resembles the individual drupe of a blackberry. The color of the fruit does not identify the mulberry species. White mulberries, for example, can produce white, lavender or black fruit. White mulberry fruits are generally very sweet but often lacking in needed tartness. Red mulberry fruits are usually deep red, almost black, and in the best clones have a flavor that almost equals that of the black mulberry. Black mulberry fruits are large and juicy, with a good balance of sweetness and tartness that makes them the best flavored species of mulberry. The refreshing tart taste is in some ways reminiscent of grapefruit. Mulberries ripen over an extended period of time unlike many other fruits which seem to come all at once.

CULTURE

Location: Mulberries need full sun and also adequate space. The distance between trees should be at least 15 ft. The trees should not be planted near a sidewalk. The fallen fruit will not only stain the walkway, but are likely to be tracked indoors. The trees are quite wind-resistant with some cultivars used as windbreaks in the Great Plains region.

Soil: Mulberries like a warm, well-drained soil, preferably a deep loam. Shallow soils such as those frequently found on chalk or gravel are not recommended.

Irrigation: Although somewhat drought-resistant, mulberries need to be watered in dry seasons. If the roots become too dry during drought, the fruit is likely to drop before it has fully ripened.

Fertilization: Mulberries generally thrive with minimal fertilization. An annual application of a balanced fertilizer such as 10:10:10 NPK will maintain satisfactory growth. In California mulberries usually need only nitrogen.

Pruning: No special pruning techniques are needed after the branches have been trained to a sturdy framework, except to remove dead or overcrowded wood. A mulberry tree can be kept to a tidy form by developing a set of main branches, and then pruning laterals to 6 leaves in July in order to develop spurs near the main branches. It is not advisable to prune the trees heavily since the plant is inclined to bleed at the cuts. Cuts of more than two inches in diameter generally do not heal and should be avoided at all cost. The bleeding will be less severe if the tree is pruned while it is dormant.

Propagation: Mulberries can be grown from seed, although the plants can take 10 years or more to bear. Seed should be sown as soon as extracted from the fruit, although white mulberry seeds germinate better after stratifying one to three months before planting.

Sprig budding is the most common method for grafting mulberries. A T-cut is made in the rootstock and a smooth, sloping cut is made on the lower end of the scion. The scion is then inserted into the T and wrapped and sealed. Other types of grafts are also usually successful, although there may be incompatibility between white and black mulberries. Hardwood, softwood and root cuttings also are suitable methods for propagating mulberries. Softwood cuttings of white mulberries root easily when taken in midsummer and treated with rooting hormone. Red mulberries are less easily rooted. Black mulberries are also somewhat difficult to propagate since they tend to bleed a lot.

Pests and Diseases: Mulberries are generally free of pests and diseases, although cankers and dieback can occur. In some areas "popcorn disease" is an occasional problem, in which fruits swell to resemble popped corn. *M. alba*/*M. rubra* hybrids are particularly prone to this condition. The disease carries on from one season to the next, so collecting and burning infected fruits help control it. The ripe fruit is very attractive to birds, but there is usually enough fruit left over for harvesting.

Harvest: White and red mulberry fruits (and hybrid fruits) are ready for harvest in late spring. The fruit of black mulberries ripen in summer to late summer. The fruits of white mulberries

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are often harvested by spreading a sheet on the ground and shaking the limbs. A surprising quantity can be gathered from a comparatively small and young tree. Black mulberry fruits are more difficult to pick. As the berries are squeezed to pull them loose, they tend to collapse, staining the hands (and clothing) with blood red juice. Unwashed the berries will keep several days in a refrigerator in a covered container. The ripe fruits of the black mulberry contain about 9% sugar with malic and citric acid. The berries can be eaten out of hand or used in any way that other berries are used, such as in pies, tarts, puddings or sweetened and pureed as a sauce. Slightly unripe fruits are best for making pies and tarts. Mulberries blend well with other fruits, especially pears and apples. They can also be made into wine and make an excellent dried fruit, especially the black varieties.

CULTIVARS

Black Persian

M. nigra. Large black fruit, over an inch long and almost as wide. Juicy with a rich, subacid flavor. The tree is fairly drought-resistant once established.

Collier

M. alba X *M. rubra.* Medium-sized, purplish-black fruit, 1-1/8 inches long and 3/8 inch in diameter. Flavor sweet, with just a trace of tartness. Quality very good, on par with Illinois Everbearing. Ripens over a long period. Tree of medium size, spreading , relatively hardy, very productive.

Downing

The original Downing was a *M. alba* var. *multicaulis* plant grown fromseed sown about 1846. The fruit was black with excellent flavor and ripened from June to September. Other varieties have subsequently been sold under the same name.

Illinois Everbearing

M. alba X *M. rubra.* Originated in White County, Illinois. Introduced in 1958. Black, nearly seedless fruit large and very long, averaging 12 per ounce. Flavor good to very good, very sweet, considered best by by many. Matures over along season. Tree vigorous and somewhat dwarfed, extremely hardy and productive.

Kaester

M. nigra. Originated in Los Angeles. Introduced in 1971 by Nelson Westree. Large black or deep purple, elongated fruit, 1-1/2 inches long and 1/2 inch in diameter. Flavor very sweet, with good sweet/tart balance. Tree bears heavily.

Pakistan

Originated in Islamabad, Pakistan. Extremely large ruby-red fruit 2-1/2 to 3-1/2 inches long and 3/8 inch in diameter. Flesh firmer than most other named cultivars. Sweet with a fine balance of flavors. Quality excellent. Tree spreading with large heart-shaped leaves. Recommended for the deep South and mild winter areas such as southern California, but usually performs satisfactorily in cooler areas.

Riviera

Originated in Vista, Calif. Elongated, deep purple-black fruits, 1 to 1-1/2 inches in

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length, 1/2 inch in diameter. Flesh slightly juicy and very sweet. Very good dessert quality. Ripens over a long period, from April to June.

Russian (Tatarica)
Introduced into Europe from China about 1,500 years ago. Fruit reddish-black, of good quality when completely ripe. Tree bushy, to 35 ft. tall, very hardy and drought resistant. Planted widely for windbreaks and wildlife food.

Shangri-La
Originated in Naples, Fla. Large, black fruit. Good mulberry for the Deep South and other areas. Hardy in U.S.D.A. Zones 7-9. Tree has very large, heart-shaped leaves.

Tehama (Giant White)
Originated in Tehama County, Calif. Very large, white-colored, plump fruit, 2-3/4 inches in length and 1/2 inch wide. Very sweet, succulent, melting flesh. Attractive, large-leaved tree. Probably best adapted to mild winter areas.

Wellington
Originated in Geneva, N.Y. Reddish-black medium-sized fruit, 1-1/4 inches long, 3/8 inch in diameter. Form long, slender and cylindrical. Flesh soft, of good flavor. Ripens over a period of several weeks. Tree is heavy producer. May be the old cultivar New American, which was also sold many years ago as Downing.

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See Index of CRFG Publications, 1969 - 1989 and annual indexes of Fruit Gardener for additional articles on the mulberry.

Here is the list of additional CRFG Fruit Facts.

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Questions or comments? Contact us.

Winged Elm

Ulmus alata L.

Other Common Names:

Cork elm and wahoo.

Brief Description:

Winged elm is a very hardy tree of small to medium size that can inhabit a wide range of habitats. It can be an invader of old fields and fallow ground. In these settings it can tolerate grazing and is also difficult to control with herbicides.

Habitat:

Winged elm ranges the southern Midwest and Southern United States. It can be found mixed with other trees on a variety of sites ranging from dry to rich and moist soils. Specific research on the Trinity River Corridor near Dallas, Texas indicates this species is common on sandy soils in the bottom lands.

Life History:

Winged elm flowers in March and April. The fruit ripens and is dispersed in April also. The seed is disseminated by wind, water, and birds and other animals. It is a light-demanding species and therefore reproduction is seldom seen in the understory of forested areas. In the open, though, growth is rapid. Despite this it is classified as shade tolerant. It is also classed as being flood tolerant even though it is not associated with standing water except for intermittent pools and puddles that occur after rains.

Winged elm and the Great Trinity Forest:

This species has been reported to occur in the forest. It can be difficult to discern from other elms in some instances.

Ulmus alata Michx.

Winged Elm

Ulmaceae -- Elm family

G. A. Snow

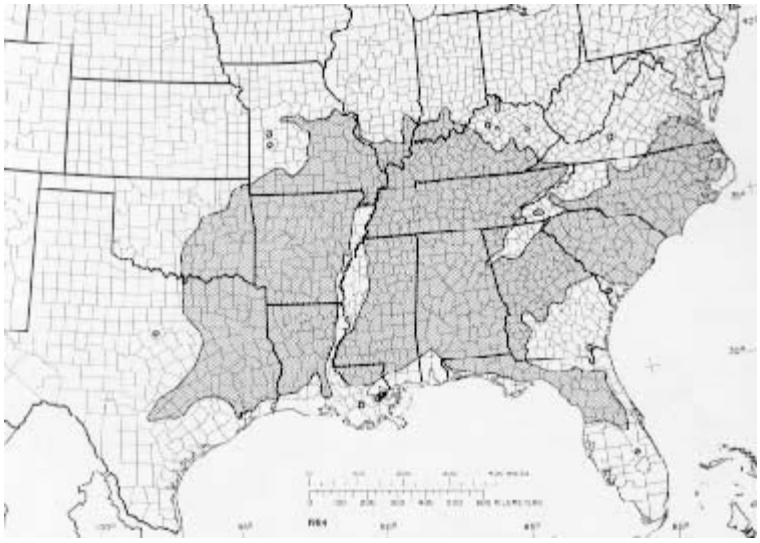
Winged elm *(Ulmus alata)* is a very hardy, small-to medium-sized tree in a wide range of habitats throughout much of the southern Midwest and Southeastern United States. Other common names are cork elm and wahoo.

On fertile soils with adequate moisture and drainage, winged elm grows well and is a useful component of several forest types. On poor dry sites it is stunted and gnarled and can be an undesirable invader of grazing land. Winged elm lumber is mixed with other elm. This tree is occasionally planted in southern landscapes.

Habitat

Native Range

Winged elm extends from southern Virginia west to Kentucky, southern Indiana and Illinois, and central Missouri; south to central Oklahoma and southeastern Texas; and east to central Florida. It is also found locally in Maryland (10,14).



-The native range of winged elm.

Climate

Within the natural range of winged elm, the climate varies from warm in the South to moderately cold in the North (20). The region is principally within the humid climatic province of the southeastern United States. Annual precipitation averages 1020 to 1520 mm. (40 to 60 in); half or more of this occurs during the growing season, April to September. Throughout the greater portion of the tree's range, the growing season averages from 180 to 300 days, and average annual temperatures are from 13° to 21° C (55° to 70° F). Average annual snowfall is from 38 cm (15 in) in the North to none in the South.

Solis and Topography

Winged elm is found on a great variety of soils. It grows fairly well on dry as well as on rich, moist soils. The species does particularly well in the silty uplands in Mississippi where site index values at base age 50 years are 21.3 to 27.4 rn (70 to 90 ft) on Memphis soils (4). On the Delta bottom lands it grows on terrace flats with tight silty soils of the order Inceptisols. In southern Illinois, it grows in old abandoned fields and along fence rows on upland clay soils. The species is generally associated with intermittent streams and other moist, lower slope sites. In the hill country of Tennessee and North Carolina, it may be found on upper or middle slopes, however. It is listed in forest types that are found at elevations up to 760 m (2,500 ft). The species is also common on sandy soils in bottom lands near Dallas, TX (11). Overall, winged elm is most commonly found on soils of the orders Alfisols and Ultisols.

Associated Forest Cover

Winged elm generally grows only as scattered trees in mixture with other hardwoods (14). It is not a major component of any forest cover type in the Eastern United States, but it is found in varying amounts in four major types (17): Post Oak-Blackjack Oak Society of American Foresters Type 40), White Oak-Black Oak-Northern Red Oak (Type 52), Swamp Chestnut Oak-Cherrybark Oak (Type 91), and Sugarberry-American Elm-Green Ash (Type 93).

In the southern part of the Central Forest Region, winged elm occurs as a minor species in Post Oak-Blackjack Oak. From the Central Forest Region southward through Tennessee, Arkansas, Mississippi, and Alabama it is associated with White Oak-Black Oak-Northern Red Oak. In the Southern Forest Region and within flood plains of major rivers, winged elm is found in either Swamp Chestnut Oak-Cherrybark Oak or in Sugarberry-American Elm-Green Ash. Here, associated understory trees are eastern hophornbeam *(Ostrya virginiana),* American hornbeam *(Carpinus caroliniana),* and American holly *(Ilex opaca).*

Life History

Reproduction and Early Growth

Flowering and Fruiting- The perfect flowers of winged elm are borne on threadlike pedicels in short, few-flowered drooping fascicles before the leaves appear in March and April (22). The fruit is a reddish or greenish samara, ovate to oblong and 6 to 8 mm (0.25 to 0.33 in) long. Fruits ripen in April and seeds are dispersed the same month (3). The seed is solitary and it and its wing

are flat and hairy, especially on the margin. The reddish samaras give the tree a reddish appearance when fruiting.

Seed Dissemination- Seeds are disseminated by wind and water. They are eaten by a variety of birds and small animals which likely serve as another means of dissemination.

Seedling Development- Germination is epigeal (3). The cotyledons are oval with shallowly notched apexes and heart-shaped bases (9). They are light green and smooth on both surfaces and persist on the plant for 1 to 2 months. The first leaves appear within 1 week after germination. They are small and sharp-pointed and have typical elm venation. The stem is circular, zig-zag, and slightly hairy to smooth. Two corky wings develop opposite each other on the stem late in the first year. The buds are slender and sharp-pointed, chestnut brown, slightly hairy, and 1.6 mm (0.06 in) long.

Winged elm is a light-demanding species and reproduction is often sparse in an understory (1). It is an invader of forest openings, old fields, and rangelands. It survives grazing as bushes and sprouts prolifically (15). Winged elm is difficult to kill with herbicides and its eradication has been the subject of several rangeland studies during the past decade (18).

Vegetative Reproduction- No information is currently available on the sprouting and rooting habits of winged elm.

Sapling and Pole Stages to Maturity

Growth and Yield- Winged elm is a mediumsized tree, usually 12 to 15 m (40 to 50 ft) in height but occasionally 24 to 30 m (80 to 100 ft), and is rarely more than 61 cm (24 in) in d.b.h. This species develops a short bole with branches ascending into a fairly open, round-topped crown. It has a lacy, or somewhat drooping habit. One special characteristic is the corky, persistent wings or projections often found on the branches. Winged elm grows rapidly in the open. Under forest conditions its growth rate is usually considered poor in relation to its associates. Diameter growth in a natural stand averages 50 to 64 mm (2.0 to 2.5 in) in 10 years (12).

Rooting Habit- No information available.

Reaction to Competition- Of all species of elms native to the United States, winged elm is perhaps the least tolerant of shade. It is, nevertheless, classed as a shade tolerant species (15). Normally, winged elm is not associated with standing water except in intermittent pools and shallow sheets of water after heavy rains. Winged elm is classified as tolerant of flooding (19).

Damaging Agents- A large variety of insects and diseases are reported for winged elm (2,7,8). This is not because the species is generally more susceptible to pathogens than other native hardwoods. The primary reason is that the species is susceptible to Ceratocystis u1mi, which causes Dutch elm disease, and to the mycoplasmalike organism which causes elm phloem necrosis. Both have been devastating to the elms native to North America and since these diseases are both transmitted by insects, a large amount of research has been done on all insects and diseases of elms in the United States. The Dutch elm disease is most prevalent across the

northern portion of the natural range of winged elm. As of 1976, it had not been found in Louisiana and Florida (21). Phloem necrosis was distributed throughout much of the north and central range of winged elm by 1975 (6). Both diseases have spread into the Southeastern States from the north; whether or not the warmer climate or other factors in these States will eventually stop the epidemics remains uncertain.

Special Uses

For commercial purposes the wood of winged elm is classed as hard elm or rock elm (5,13). Elm wood is used principally for furniture, hardwood dimension and flooring, boxes, and crates. Elm's excellent resistance to splitting has made it a choice wood for the manufacture of high quality hockey sticks. The manufacture of furniture continues to increase the demand for elm for bent parts of chairs such as rockers and arms.

The mast from winged elm is eaten by birds and animals, and the twigs and leaves are important for white-tailed deer (16). Both twigs and leaves are most succulent, nutritious, and digestible during spring and are less useful as food the rest of the year because after abscission, the leaves lose most of their quality and digestibility.

Genetics

Winged elm has little commercial value. As a consequence, no attempts to hybridize or improve the species have been reported.

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Understory Species Requirements

Descriptions of the understory vegetation.

Great Trinity Forest Management Plan

UNDERSTORY PLANTS

Aster spp.

(Gilman, Edward F. University of Florida. Fact Sheet FPS-56. October, 1999.)

UNIVERSITY OF FLORIDA
Cooperative Extension Service
Institute of Food and Agricultural Sciences

Fact Sheet FPS-56
October, 1999

Aster spp.[1]

Edward F. Gilman[2]

Introduction

Asters produce large clusters of flowers in white, purple, lavender, pink and red. The plants tolerate poor soil and dryness but bloom poorly in dry soil. They grow two to five feet tall and are spaced 15 inches apart. They multiply rapidly so may need frequent division. Tall varieties need staking or grow the shorter varieties. For best bloom, thin out shoots from large clumps. Asters grow best in full sun or light shade.

General Information

Scientific name: *Aster spp.*
Pronunciation: ASS-ter species
Common name(s): Aster
Family: *Compositaceae*
Plant type: herbaceous
USDA hardiness zones: 4B through 9A (Fig. 1)
Planting month for zone 7: year round
Planting month for zone 8: year round
Planting month for zone 9: year round
Planting month for zone 10 and 11: year round
Origin: native to Florida
Uses: mass planting; edging; attracts butterflies; cut flowers
Availablity: somewhat available, may have to go out of the region to find the plant

Description

Height: 1 to 3 feet
Spread: 2 to 4 feet
Plant habit: upright
Plant density: symmetrical habit with a regular (or smooth) outline and individuals having more or less identical forms
Growth rate: fast
Texture: fine

Foliage

Leaf arrangement: alternate
Leaf type: simple
Leaf margin: entire
Leaf shape: lanceolate
Leaf venation: none, or difficult to see
Leaf type and persistence: deciduous
Leaf blade length: 2 to 4 inches
Leaf color: green
Fall color: no fall color change
Fall characteristic: not showy

Flower

Flower color: lavender; white; pink; red; purple
Flower characteristic: summer flowering; fall flowering

Fruit

Fruit shape: unknown
Fruit length: unknown
Fruit cover: unknown
Fruit color: white
Fruit characteristic: inconspicuous and not showy

Trunk and Branches

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1. This document is Fact Sheet FPS-56, one of a series of the Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Publication date: October 1999. Please visit the EDIS web site at http://edis.ifas.ufl.edu.

2. Edward F. Gilman, professor, Environmental Horticulture Department, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

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Figure 1. Shaded area represents potential planting range.

Trunk/bark/branches: typically multi-trunked or clumping stems
Current year stem/twig color: green
Current year stem/twig thickness: thin

Culture

Light requirement: plant grows in full sun
Soil tolerances: acidic; slightly alkaline; sand; loam; clay;
Drought tolerance: moderate
Soil salt tolerances: unknown
Plant spacing: 18 to 24 inches

Other

Roots: not applicable
Winter interest: no special winter interest
Outstanding plant: not particularly outstanding
Invasive potential: not known to be invasive
Pest resistance: long-term health usually not affected by pests

Use and Management

Aster is grown from seed or division. Division is done in October or early spring when flowering deteriorates. The seed germinates in 15 days indoors, or 20 to 30 days outdoors.

Aphids feed on lower leaf surfaces and flower stems.

Japanese beetles feed on aster.

Pests and Diseases

Leaf spot fungi cause spots of various types on the leaves. The spotting may be worse in rainy seasons.

Downy mildew causes a downy mold on the lower leaf surfaces but is not important on aster.

Powdery mildew develops on the lower parts of crowded plants in late season. Symptoms are a whitish coating on the leaves.

Bacterial crown gall causes the formation of rough, rounded galls. The galls form near the soil surface. Avoid infested soil and destroy infected plants.

Verticillium wilt occasionally kills plants.

Great Trinity Forest Management Plan

UNDERSTORY PLANTS

Roundleaf Greenbriar

(TWC Staff 2007-01-01)

Smilax rotundifolia L.

Roundleaf greenbrier

Smilacaceae (Greenbrier Family)

USDA Symbol: SMRO

USDA Native Status: Native to U.S.

Listed as a threatened species by SARA (Species at Risk). It is found in Ontario between Niagara and Windsor.

Numerous birds and animals eat common greenbrier fruits. The persistent fruits are an important late winter and early spring food for wintering birds including northern cardinals and white-throated sparrows.

Common greenbrier is a pioneer species that forms impenetrable thickets of prickly branches which creates good cover for small mammals and birds. (USDA)

Plant Characteristics
Duration: Perennial
Habit: Shrub
Leaf Color: Green

Bloom Information

Bloom Color: Green, Brown

Distribution

USA: AL, AR, CT, DE, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NH, NJ, NY, NC, OH, OK, PA, RI, SC, SD, TN, TX, VA, WV, DC
Canada: NS
Native Habitat: Forest,Woodland

Growing Conditions

Water Use: Medium
Light Requirement: Part Shade
Soil Moisture: Moist
CaCO3 Tolerance: Low

Benefit

Use Wildlife: Birds
Warning: Thorns or prickles.
Attracts: Birds

Additional resources

USDA: Find *Smilax rotundifolia* in USDA Plants
FNA: Find *Smilax rotundifolia* in the Flora of North America (if available)
Google: Search Google for *Smilax rotundifolia*

Metadata

Record Modified: 2007-01-01
Research By: TWC Staff

Great Trinity Forest Management Plan

UNDERSTORY PLANTS

Japanese Honeysuckle

(Gilman, Edward F. University of Florida. Fact Sheet FPS-353. October, 1999)

UNIVERSITY OF FLORIDA
Cooperative Extension Service
Institute of Food and Agricultural Sciences

Fact Sheet FPS-353
October, 1999

Lonicera japonica[1]

Edward F. Gilman[2]

Introduction

Japanese Honeysuckle is a rampant vine that can easily grow out-of-control in the landscape (Fig. 1). It is considered a weed, a pest and an invasive plant in Florida. It has escaped cultivation and is reproducing in the wild. The fragrant flowers emerge white and turn yellow within a day or two. The plant remains in blooom for several weeks in the spring. Plants grow very fast, overtopping adjacent shrubs and growing into nearby trees. It should only be planted in a confined space such as in a container or planter.

General Information

Scientific name: *Lonicera japonica*
Pronunciation: lah-NISS-ser-ruh juh-PAWN-nick-kuh
Common name(s): Japanese Honeysuckle
Family: *Caprifoliaceae*
Plant type: vine
USDA hardiness zones: 4 through 10A (Fig. 2)
Planting month for zone 7: year round
Planting month for zone 8: year round
Planting month for zone 9: year round
Planting month for zone 10: year round
Origin: not native to North America
Uses: container or above-ground planter; naturalizing
Availablity: generally available in many areas within its hardiness range

Figure 1. Japanese Honeysuckle.

Description

Height: depends upon supporting structure
Spread: depends upon supporting structure
Plant habit: spreading
Plant density: moderate
Growth rate: fast
Texture: medium

1. This document is Fact Sheet FPS-353, one of a series of the Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Publication date: October, 1999 Please visit the EDIS Web site at http://edis.ifas.ufl.edu.

2. Edward F. Gilman, professor, Environmental Horticulture Department, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

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Figure 2. Shaded area represents potential planting range.

Foliage

Leaf arrangement: opposite/subopposite
Leaf type: simple
Leaf margin: entire
Leaf shape: ovate
Leaf venation: pinnate
Leaf type and persistence: semi-evergreen
Leaf blade length: less than 2 inches
Leaf color: green
Fall color: no fall color change
Fall characteristic: not showy

Flower

Flower color: white; yellow
Flower characteristic: spring flowering; summer flowering

Fruit

Fruit shape: round
Fruit length: less than .5 inch
Fruit cover: unknown
Fruit color: unknown
Fruit characteristic: inconspicuous and not showy

Trunk and Branches

Trunk/bark/branches: typically multi-trunked or clumping stems
Current year stem/twig color: reddish
Current year stem/twig thickness: thin

Culture

Light requirement: plant grows in part shade/part sun
Soil tolerances: slightly alkaline; clay; sand; acidic; loam
Drought tolerance: moderate
Soil salt tolerances: unknown
Plant spacing: 36 to 60 inches

Other

Roots: not applicable
Winter interest: no special winter interest
Outstanding plant: plant has outstanding ornamental features and could be planted more

Invasive potential: potentially invasive
Pest resistance: no serious pests are normally seen on the plant

Use and Management

Honeysuckle enjoys the full sun, but grows and flowers well in partial shade. Plants will also grow in the shade, but they flower poorly. Any soil, wet or dry, appears to be suited for this irrepressible vining shrub.

Pests and Diseases

No pests cause serious harm to Honeysuckle. It simply outgrows most problems.

Figure 3. Flower of Japanese Honeysuckle

Great Trinity Forest Management Plan

UNDERSTORY PLANTS

Poison Ivy

Toxicodendron pubescens P. Mill.

Atlantic poison oak

Anacardiaceae (Sumac Family)

USDA Symbol: TOPU2

USDA Native Status: Native to U.S.

Plant Characteristics

Duration: Perennial
Habit: Subshrub
Leaf Arrangement: Alternate
Leaf Complexity: Tripinnate
Leaf Margin: Lobed
Size Notes: Up to ten feet but usually 2 to 4 feet.
Fruit Length: 1/4 inch in diameter.
Fruit Color: Greenish white.

Bloom Information

Bloom Color: Yellow
Bloom Time: Mar, Apr
Bloom Notes: Flowers inconspicuous.

Distribution

USA: AL, AR, DE, FL, GA, IL, KS, LA, MD, MS, MO, NJ, NC, OK, SC, TN, TX, VA, WV, DC

Benefit

Warning: All parts toxic.
Interesting Foliage: yes

Additional resources

USDA: Find *Toxicodendron pubescens* in USDA Plants
FNA: Find *Toxicodendron pubescens* in the Flora of North America (if available)
Google: Search Google for *Toxicodendron pubescens*

Metadata

Record Modified: 2007-01-01

Great Trinity Forest Management Plan

UNDERSTORY PLANTS

Western Soapberry

(Fact Sheet ST-581. October 1994)

Fact Sheet ST-581
October 1994

Sapindus drummondii
Western Soapberry[1]

Edward F. Gilman and Dennis G. Watson[2]

INTRODUCTION

Western Soapberry is native to central and western Texas and an excellent shade or ornamental tree, reaching 40 to 50 feet in height with an equal spread, forming a billowy, deciduous crown (Fig. 1). The crown is usually quite open showing the trunk and some major limbs but this varies from tree to tree. Not a uniformly-shaped crown, some vase-shaped, others round. The medium green, glossy leaves have downy undersides and the leaves turn a beautiful, deep, yellow-gold hue in fall. The small, yellowish-white springtime blooms appear in 6 to 10-inch terminal panicles and are followed by translucent, yellow-orange, half-inch, grape-like, clustered fruits which persist through the fall, eventually ripening to black. The low-branching habit, furrowed, red-brown to grey-brown bark covering the strong, broad trunk, and clusters of translucent berries of Soapberry provides much winter interest when the branches are bare. The common name is derived from the fact that the fruits, when crushed in water, create great quantities of suds and were used by West Indian/Mexican natives as a laundry soap, floor wax and varnish.

GENERAL INFORMATION

Scientific name: *Sapindus drummondii*
Pronunciation: SAP-in-dus drum-AWN-dee-eye
Common name(s): Western Soapberry
Family: *Sapindaceae*
USDA hardiness zones: 6 through 9 (Fig. 2)
Origin: native to North America

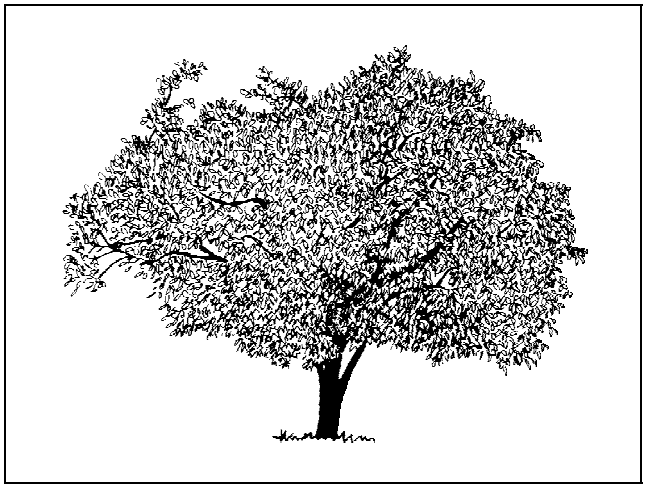

Figure 1. Middle-aged Western Soapberry.

Uses: wide tree lawns (>6 feet wide); medium-sized tree lawns (4-6 feet wide); recommended for buffer strips around parking lots or for median strip plantings in the highway; reclamation plant; shade tree; specimen; sidewalk cutout (tree pit); residential street tree; tree has been successfully grown in urban areas where air pollution, poor drainage, compacted soil, and/or drought are common
Availability: somewhat available, may have to go out of the region to find the tree

DESCRIPTION

Height: 40 to 50 feet
Spread: 40 to 50 feet
Crown uniformity: symmetrical canopy with a regular (or smooth) outline, and individuals have more or less identical crown forms

1. This document is adapted from Fact Sheet ST-581, a series of the Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Publication date: October 1994.

2. Edward F. Gilman, associate professor, Environmental Horticulture Department; Dennis G. Watson, associate professor, Agricultural Engineering Department, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville FL 32611.

Figure 2. Shaded area represents potential planting range.

Crown shape: round; vase shape
Crown density: open
Growth rate: medium
Texture: medium

Foliage

Leaf arrangement: alternate (Fig. 3)
Leaf type: even pinnately compound
Leaflet margin: entire
Leaflet shape: lanceolate; oblong
Leaflet venation: pinnate
Leaf type and persistence: deciduous
Leaflet blade length: 2 to 4 inches; less than 2 inches
Leaf color: green
Fall color: yellow
Fall characteristic: showy

Flower

Flower color: white; yellow
Flower characteristics: showy; spring flowering

Fruit

Fruit shape: round
Fruit length: .5 to 1 inch; < .5 inch
Fruit covering: dry or hard
Fruit color: black; orange; yellow
Fruit characteristics: attracts birds; fruit, twigs, or foliage cause significant litter; persistent on the tree; showy

Trunk and Branches

Trunk/bark/branches: grow mostly upright and will not droop; showy trunk; should be grown with a single leader; no thorns
Pruning requirement: needs little pruning to develop a strong structure
Breakage: resistant
Current year twig color: brown; gray
Current year twig thickness: medium

Culture

Light requirement: tree grows in part shade/part sun; tree grows in full sun

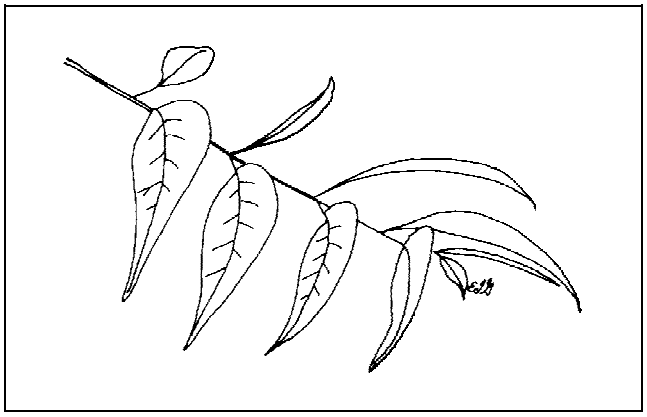

Figure 3. Foliage of Western Soapberry.

Soil tolerances: clay; loam; sand; acidic; alkaline; well-drained
Drought tolerance: high
Aerosol salt tolerance: none

Other

Roots: surface roots are usually not a problem
Winter interest: tree has winter interest due to unusual form, nice persistent fruits, showy winter trunk, or winter flowers
Outstanding tree: tree has outstanding ornamental features and could be planted more
Invasive potential: seeds itself into the landscape
Pest resistance: long-term health usually not affected by pests

USE AND MANAGEMENT

Fruit maintains showy orange-yellow color on the tree throughout the winter. Fruit drops while it is firm and does not rot to create a mess but people could roll on it and fall on a sidewalk. The abundant fruits may create an unwelcome invasion of seedling volunteers. Plant it in a lawn area where regular mowings prevent seedlings from developing. Due to the risk of dermatitis and possible poisoning from the fruit, use Western Soapberry as an ornamental or median-strip street tree away from where children would regularly contact the fruit.

A North American native, Western Soapberry grows in full sun or partial shade on a wide variety of soils. The crown is much denser in full-day sun. Western Soapberry is particularly well-suited to urban conditions, tolerating wind, drought, and infertile soils with ease. Transplants easily and establishes with only minimal irrigation. The close-grained, strong wood makes this tree very resistant to wind damage and adaptable to urban landscapes. Excellent for poor, compacted or alkaline soil. Root suckers can be a problem in sandy soil but apparently not in clay.

There may be a fruitless cultivar originating in Oklahoma which would make it suitable for a much broader usage including downtown streets and patios.

Propagation is by seed or hardwood cuttings. Seedlings transplant easily.

Pests and Diseases

No pests or diseases of major concern although dwarf mistletoe can be quite a problem. One of a few plants apparently resistant to root rot. Powdery mildew, leaf spot and leaf blight have been reported in Texas but it is usually a pest-free tree.

Great Trinity Forest Management Plan

UNDERSTORY PLANTS

Field Pansy

Viola Bicolor Pursch

Viola bicolor Pursh

Field pansy
Violaceae (Violet Family)
USDA Symbol: VIBI
USDA Native Status: Native to U.S.

The wild pansy is deep violet to pale lavender in color. Its leaves grow in clusters on the stem, and out of them grow 1 or 2 leafless stems with a blossom at the end. This is one of the smallest of Texas violets (248).

PLANT CHARACTERISTICS

Duration: Annual
Habit: Herb
Height (in feet): Less than 1

DISTRIBUTION

USA: AL, AZ, AR, CO, DE, FL, GA, ID, IL, IN, IA, KS, KY, LA, MD, MA, MI, MS, MO, NE, NJ, NM, NY, NC, OH, OK, PA, SC, SD, TN, TX, VA, WV, DC

BIBLIOGRAPHY

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ADDITIONAL RESOURCES

USDA: Find *Viola bicolor* in USDA Plants
FNA: Find *Viola bicolor* in the Flora of North America (if available)
Google: Search Google for *Viola bicolor*

METADATA

Record Modified: 2007-01-01
Research By: TWC Staff

Great Trinity Forest Management Plan

UNDERSTORY PLANTS

Common Blue Violet

Viola sororia Willd.

Viola sororia Willd.

Common blue violet, Florida violet, Hooded blue violet, Meadow violet
Violaceae (Violet Family)
Synonyms: *Viola floridana*, *Viola papilionaceae*
USDA Symbol: VISO
USDA Native Status: Native to U.S.

The glossy, heart-shaped leaves of this 6-10 in. violet are topped by purple flowers with conspicuous white throats; the three lower petals are somewhat hairy. The erect flower stem droops slightly, as if bending its head toward the ground. Perhaps that is why the flower is associated with modesty and decency (Andy Fyon).

In addition to the normal flowers there are often flowers near the ground that fail to open, but their whitish fruit produces vast quantities of seeds. Violet leaves are high in vitamins A and C and can be used in salads or cooked as greens. The flowers can be made into candies and jellies. The Marsh Blue Violet (*V. cucullata*), a similar species of very wet habitats, has dark blue-centered flowers borne well above the leaves.

PLANT CHARACTERISTICS

Duration: Annual
Habit: Herb
Fruit Type: Capsule
Size Notes: Less than 1'
Leaf Color: Green
Fruit Color: Green with purple
Height (in feet): Less than 1

BLOOM INFORMATION

Bloom Color: White, Blue
Bloom Time: Mar, Apr, May

DISTRIBUTION

USA: AL, AR, CT, DE, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NH, NJ, NY, NC, ND, OH, OK, PA, RI, SC, SD, TN, TX, VT, VA, WV, WI, DC
Canada: NB, NS, PE
Native Distribution: E. NC to FL & LA
Native Habitat: Rich, moist woods; swamps

GROWING CONDITIONS

Water Use: High
Light Requirement: Sun, Part Shade
Soil Moisture: Moist
CaCO3 Tolerance: High
Soil Description: Moist, rich soils.
Conditions Comments: Easily grown in average, medium wet, well-drained soil. Prefers humusy, moisture-retentive soils. Does not spread by runners, but freely self seeds to the point of being invasive in optimum growing conditions.

BENEFIT

Use Food: Violet leaves are high in vitamins A and C and can be used in salads or cooked as greens. The flowers can be made into candies and jellies. (Niering)
Conspicuous Flowers: yes
Attracts: Birds
Deer Resistant: High

PROPAGATION

Description: Not Available
Seed Collection: Not Available
Seed Treatment: Not Available
Commercially Availab: yes

ADDITIONAL RESOURCES

USDA: Find *Viola sororia* in USDA Plants
FNA: Find *Viola sororia* in the Flora of North America (if available)
Google: Search Google for *Viola sororia*

METADATA

Record Modified: 2007-01-01
Research By: LAL

Great Trinity Forest Management Plan

UNDERSTORY PLANTS

Virginia Creeper

(USDA NRCS Plant Guide)

United States Department of Agriculture
Natural Resources Conservation Service

Plant Guide

VIRGINIA CREEPER

Parthenocissus quinquefolia (L.) Planch.

Plant Symbol = PAQU2

Contributed by: USDA NRCS National Plant Data Center

Robert H. Mohlenbrock
@ USDA NRCS PLANTS

Warning: Virginia creeper berries are highly toxic to humans and may be fatal if eaten. Its sap can also cause skin irritation in some people.

Alternate Names
Woodbind, woodbine, false grapes, five leaves, American Ivy, five leaved Ivy, thicket creeper

Uses
Wildlife: The berries of this plant are eaten by many animals especially birds. Animals such as mice, skunks, chipmunks, squirrels, cattle and deer will munch on the leaves and stems. This plant provides great cover for small animals because of is thick foliage. The vines provide birds with perches, nesting places and leaf surfaces to find food.

Erosion Control: Virginia creeper is used as a ground cover to control soil erosion in shaded areas and on slopes.

Medicinal: The bark has been has been used in domestic medicine as a tonic, expectorant, and remedy. The berries have been found serviceable in rheumatic complaints and are found to help cure dropsy. The roots are used for diarrhea and the bark and twigs are made into cough syrup.

Ornamental: It is often cultivated as an ornamental because of its fall foliage and to replace many exotic plants. It is an excellent covering for walls, trellises, arbors or fences. It may also be grown on the ground to cover old stumps, rock piles and other “eyesores”.

Description
Vine Family (Vitaceae). Virginia creeper is a native, fast-growing, perennial, woody vine that may climb or trail along the ground. The leaves are compound, containing five leaflets. Leaflets range in size from 2-6 inches and have toothed margins. The leaflets are red when they first emerge but turn green as they mature. In the fall, leaves turn a bright red to maroon color. The inconspicuous green color flowers are borne in small clusters during the spring and followed by small clusters of fruit in early summer**.** This fruit is a 4 to 6 mm diameter bluish-black berry that usually contains two to three seeds. The vines adhere to surfaces by means of five to eight branched tendrils ending in cup-like adhesive tips. New stems are brownish-green and finely hairy but gradually acquire pale, raised dots and turn purplish-brown with age.

Virginia creeper is often confused with eastern poison ivy (*Toxicodendron radicans*), however; a clear distinction between the species is that eastern poison ivy has three leaflets and Virginia creeper has five leaflets. The PLANTS Web site at plants.usda.gov contains an image of eastern poison ivy.

Reproduction: Virginia creeper flowers from June to August, matures fruits from August to October and drops fruits from September to February. The seeds are dispersed by birds. The seeds usually germinate the first or second spring after dispersal.

Adaptation and Distribution
Virginia creeper is found throughout the southern, midwestern and eastern half of the United States. The plant is also native to northern Mexico and southeastern Canada from Nova Scotia to Ontario. Virginia creeper can be found in new and old forests and forest margins. It can also be found on the borders of clearings, on trees, along fencerows and streambanks. The plant thrives in partial shade to full sun. It prefers acidic soil, and tolerates a wide range

of soils from dry sandy soils to moist loamy soils. The plant is also salt tolerant. The species is cultivated as an ornamental in many moist temperate areas of the world.

For current distribution, please consult the Plant Profile page for this species on the PLANTS Web site.

Establishment
Seeds can be sown in the fall or in the spring after cold-moist stratification. Seeds should be drilled 3/8 inches deep in soil or mulch. Optimum planting is 10 plants per square foot. Virginia creeper can also be propagated from hardwood cuttings or layering.

Management
Once Virginia creeper is well established, it grows quickly. It must often be pruned to prevent it from getting out of control. The species can handle periods of sparse rain fairly well; however, if a drought persists, water the vine every week soaking the soil at least six inches. Virginia creeper can be a rampant grower with a climbing height of over 60 feet and a spread of over 50 feet.

Pests and Potential Problems
No pests or diseases are of major concern, but mildews, leaf spots, canker and wilt are occasional problems. Virginia creeper is sometimes bothered by beetles, scale, leaf hoppers, caterpillars and other leaf eating insects. These pests cause the leaves to be ragged and tattered.

Some literature suggests that Virginia Creeper is not poisonous, but the sap of the plant contains oxalate crystals and can cause skin irritation and rashes in some people.

Ornamental: If you grow Virginia creeper on walls, make sure you want it as a permanent fixture. Once it is established, it is very difficult to remove. You could damage the wall trying to remove the species.

Environmental Concerns
Virginia creeper will grow up any tree and most shrubs. This species will slowly kill the host on which it is growing, because it prevents the host from receiving an adequate amount of sunlight. It can also crowd or choke other plants.

Control
Please contact your local agricultural extension specialist, or county weed specialist to learn what works best in your area. If chemicals are recommended be sure to read the label and follow all application and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective. Below is an internet site that contains control information for Virginia creeper:
North Carolina State University
http://ipm.ncsu.edu/apple/orchardguide/Herbicides.pdf

Cultivars, Improved, and Selected Materials (and area of origin)
The commercial nursery trade has developed three Virginia creeper cultivars:
'Engelmanii'-This has smaller leaves and better clinging characteristics than the species general population.
'Monham'-The leaves have white variegations.
'Variegata'-It is less vigorous than the species' general population, but the leaves are marked with yellow and white then develop a pink and red color in the fall.

Contact your local Natural Resources Conservation Service (formerly Soil Conservation Service) office for more information. Look in the phone book under "United States Government." The Natural Resources Conservation Service will be listed under the subheading "Department of Agriculture."

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Prepared By:
Kellie King and James Henson, USDA NRCS National Plant Data Center, Baton Rouge, Louisiana

Species Coordinator:
James Henson, USDA NRCS National Plant Data Center, Baton Rouge, Louisiana

Edited: 19sep05 jsp; 060802 jsp

For more information about this and other plants, please contact your local NRCS field office or Conservation District, and visit the PLANTS Web site<http://plants.usda.gov> or the Plant Materials Program Web site <http://Plant-Materials.nrcs.usda.gov>

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Great Trinity Forest Management Plan

UNDERSTORY PLANTS

Wild Onion

Allium canadense L.

Meadow garlic, Wild garlic, Wild onion

Liliaceae (Lily Family)

USDA Symbol: ALCA3

USDA Native Status: Native to U.S.

Meadow garlic or wild garlic's sparse cluster of grass-like leaves and its 8-12 in. flowering stalk grow from a bulb. From between narrow, grass-like leaves, which originate near its base, rises a stem topped by a dome-like cluster of star-shaped, pink or whitish flowers; plant has strong, onion-like odor.

This native perennial has a brown, fibrous skin on an edible bulb that tastes like onion. Field Garlic (*A. vineale*) is similar but has a strong garlic taste. It has greenish or purplish flowers, long-tailed bulblets, a single-parted spathe, and hollow cylindrical leaves. Introduced from Europe, it has become a problem weed occurring from New England south to Georgia and west to Arkansas, Kansas, and Minnesota. If these plants are too abundant in pastures or wheat fields they add an undesirable flavor to such products as milk, butter, or flour. Wild Leek (*A. ampeloprasum*), naturalized from Europe, is 3-4 1/2' (90-135 cm) tall with long flat leaves 1-2' (30-60 cm) long and a lavender flower cluster 2-2 1/2" (5-6.3 cm) wide; it is found from Virginia to Florida.

Plant Characteristics

Duration: Perennial
Habit: Grass/Grass-like
Leaf Complexity: Simple

Size Notes: 8-12"
Height (in feet): Less than 1

Bloom Information

Bloom Color: White, Pink
Bloom Time: May, Jun, Jul

Distribution

USA: AL, AR, CT, DE, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, MT, NE, NH, NJ, NY, NC, ND, OH, OK, PA, RI, SC, SD, TN, TX, VT, VA, WV, WI, DC
Canada: NB, QC
Native Distribution: N.B. to SD, s. to n. FL & TX
Native Habitat: Open woods; prairies

Growing Conditions

Water Use: Medium
Light Requirement: Sun
Soil Moisture: Moist
Soil Description: Moderately rich, neutral soils.
Conditions Comments: Some Allium species can become weedy in warmer climates. Tolerates all conditions well; very hearty plant. Make sure soil is well-drained, plants will rot in standing water. Generally free of pests and disease, although some people have had problems with slugs.

Benefit

Use Wildlife: Bulbs and leaves are eaten by wild turkeys.
Use Food: This native perennial has a brown, fibrous skin on an edible bulb that tastes like onion. (Niering)
Conspicuous Flowers: yes
nectar: yes
Deer Resistant: High

Propagation

Propagation Material: Seeds
Description: Best would be to salvage, or seed out in nursery bed and divide small bulbs several years later.
Seed Collection: Blooming in early spring, seeds ready to harvest soon after.
Seed Treatment: Easily propagated by untreated seed sown in warm location in late winter.
Commercially Availab: yes

Additional resources

USDA: Find *Allium canadense* in USDA Plants
FNA: Find *Allium canadense* in the Flora of North America (if available)
Google: Search Google for *Allium canadense*

Metadata

Record Modified: 2007-01-01
Research By: NPC, MWJ

Great Trinity Forest Management Plan

UNDERSTORY PLANTS

Canada Wildrye

(USDA NRCS Plant Fact Sheet)

United States Department of Agriculture
Natural Resources Conservation Service

Plant Fact Sheet

CANADA WILDRYE

Elymus canadensis L.

Plant Symbol = ELCA4

Contributed by: USDA NRCS Plant Materials Program

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Smithsonian Institute
@USDA NRCS PLANTS

Uses

Restoration: Canada wildrye is often an early successional component of prairie mixtures.

Livestock: Canada wildrye provides good forage quality during the early part of the grazing season but is generally considered an inferior forage after it matures. It is fairly palatable to most livestock, and is rated good in energy value but poor in protein value.

Wildlife: Canada wildrye has fair to good palatability as food for wildlife. It also provides nesting, brood, winter, and escape cover.

Erosion Control: Exceptional seedling vigor and rapid establishment make Canada wildrye an excellent species for use in erosion control seedings. Stands of Canada wildrye typically establish during the 1st year, reach peak production the 2nd or 3rd year, and then rapidly thin out. This species is sometimes used in seeding mixtures where quick development and stabilization is needed.

Status

Please consult the PLANTS Web site and your State Department of Natural Resources for this plant's current status (e.g. threatened or endangered species, state noxious status, and wetland indicator values).

Description

Canada wildrye is a native perennial bunchgrass that grows to 4 feet with erect or arching culms and flat, wide (up to 0.8 inches), waxy green, pointed leaves that grow from the base of the stem to the spike. Auricles are claw-like and clasping, arising from a broad, yellowish or light green collar. The thick and bristly spikelets can reach 10 inches in length, and are often 2 or 3 to a node. There are approximately 115,000 seeds per pound.

Adaptation and Distribution

Canada wildrye is a short-lived, cool-season grass found on sandy shores and dunes; wooded areas, especially along trails, rivers and streams; and other disturbed sites throughout much of the North America. Seedlings are vigorous and establish quickly, but are not highly competitive with other grasses. Growth begins later in the spring and lasts longer into the summer than growth of smooth brome. It is moderately drought tolerant and winter hardy. It has good tolerance to salinity and tolerates shade very well.

Canada wildrye is distributed throughout the northeast, north, and western United States. For a current distribution map, please consult the Plant Profile page for this species on the PLANTS Website.

Establishment

Canada wildrye is typically seeded in a mix with warm season and/or other cool season grasses. Native forbs can also be included to enhance the restoration benefits. Planting may be completed in the spring or late fall, or early fall if moisture conditions are satisfactory. The seedbed should be firm and weed problems eliminated prior to planting. Seeding rates will vary between 0.5 and 4.0 lbs./acre depending on the mix and site conditions. If planted alone, solid seed at 10 lbs./acre (for conservation use), or 5 lbs. acre in rows (for seed production).

Management

For good quality, nutritious hay Canada wildrye should be cut just as the heads are emerging from the boot. When used for pasture, grazing should be delayed until there is at least 5 inches of growth.

Canada wildrye generally decreases in response to grazing.

Because its crown has coarse stems and leaves, Canada wildrye is somewhat resistant to fire mortality. However, susceptibility increases when burns are conducted after the initiation of spring growth.

Pests and Potential Problems
Canada wildrye is susceptible to leaf and stem rust, and to ergot.

Cultivars, Improved, and Selected Materials (and area of origin)
'Mandan' (North Dakota) was released by ARS Northern Great Plains Research Laboratory for use in the northern Great Plains states.

Prepared By & Species Coordinator:
Tony Bush
USDA NRCS Rose Lake Plant Materials Center, East Lansing, Michigan

Edited: 01Feb2002 JLK; 05jun06 jsp

For more information about this and other plants, please contact your local NRCS field office or Conservation District, and visit the PLANTS Web site<http://plants.usda.gov> or the Plant Materials Program Web site <http://Plant-Materials.nrcs.usda.gov>

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