Carya illinoensis (Wangenh.) K. Koch

Pecan

Juglandaceae -- Walnut family

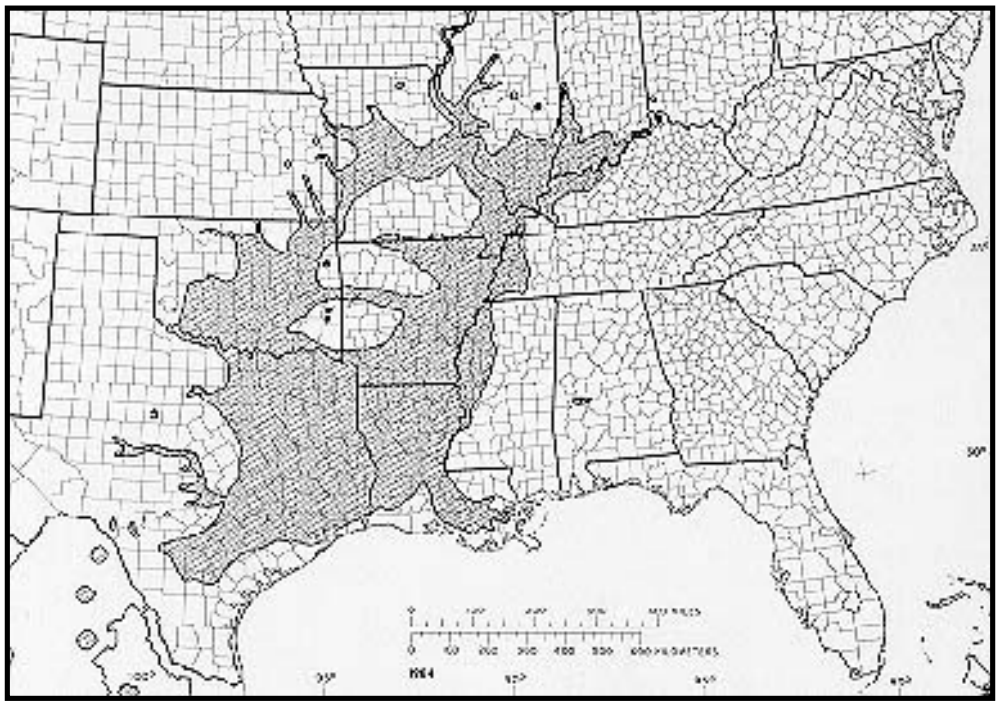
J. K. Peterson

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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