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Juglandaceae

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Introduction

The following sections characterize members of the walnut family (Juglandaceae) in relation to their taxonomy, distribution, ecology, and silviculture. Also included is information about their botanical importance as well as their significance in meeting human needs.

The walnut family contains tree species that produce some of the world's finest high-quality hardwood that is used to manufacture cabinets and fine furniture (walnut). Moreover, there are species in this family that are important sources of edible nuts (walnut and pecan). Members of the family are found in the north temperate and subtropical regions of the world, extending to India, Indochina, Malaysia, and Andean South America. The family is not present in Africa and Australia.

The walnut family originated during the Eocene epoch of the Tertiary period of geologic time about 65 to 55 million years ago. The climate of Eocene times was subtropical and moist throughout North America and Europe. Palm trees and alligators were found as far north as the Dakotas in the USA, while at high northern latitudes in Greenland and Siberia,

moist temperate zone forests were dominated by giant redwoods and deciduous trees such as beech, chestnut, and elm, while cycads, magnolias, and fig trees flourished in Alaska. The walnut family reached its greatest extent in numbers and distribution at that time after which it has steadily declined.

Taxonomy

The most recent taxonomic information indicates that the walnut family (Juglandaceae) comprises eight genera (*Alfaroa*, *Carya*, *Cyclocarya*, *Engelhardtia*, *Juglans*, *Oreomunnea*, *Platycarya*, and *Pterocarya*) with about 50 species (Table 1). However, some taxonomists report as few as seven genera (*Cyclocarya* omitted) and as many as nine genera (*Annamocarya* added) that include 60 species.

Members of the walnut family are mostly trees (often resinous), but a few are shrubs. All family members have more or less aromatic leaves which are mostly deciduous and consist of individual leaflets arranged like a feather with a central axis and lateral branches (pinnate) or arranged similar to pinnately compound leaves but leaflets are arranged groups of three (ternate). The leaves of the majority of the species are spirally arranged on twigs but they are oppositely arranged in two genera, *Alfaroa* and *Oreomunnea*. Superposed buds are common (bud found above lateral bud).

Male and female flowers are usually found on the same tree although occasionally sexes are found on separate trees. Flowers are wind pollinated and are mostly in the form of catkins.

Fruit is a nut encased within a husk (drupe-like) or a disk-winged nutlet. A drupe is usually a one-seeded fleshy fruit with the outer layer (husk) fleshy and the inner layer bony. Husks may split to release

Table 1 Distribution of the genera of the walnut family (Juglandaceae)

Genus	Number of species	Range
<i>Juglans</i>	20	North, Central, South America; Europe, and Asia
<i>Carya</i>	16	North America (13) and Asia (3)
<i>Platycarya</i>	1	China, Japan, Korea, and Vietnam
<i>Engelhardtia</i>	7	Southern and southeastern Asia, and northern India
<i>Cyclocarya</i>	1	China
<i>Pterocarya</i>	6	Eastern and southwestern Asia
<i>Alfaroa</i>	5	Central and South America
<i>Oreomunnea</i>	3	Mexico, Central and South America

the nut or may remain whole. The botanic characteristics of some of the more common genera are shown in Table 2.

There are about 20 species of walnut (*Juglans*) which are found mainly in the temperate and subtropical areas of the northern hemisphere. These species are distributed in North, Central, and South America, Eastern Europe, and Asia. Six species are native to the USA while three are native to Asia. The best-known is eastern black walnut (*Juglans nigra*), a native of eastern North America, for its use in the manufacture of fine furniture. The eastern European species, English or Persian walnut (*J. regia*), is important in the production of nuts for human consumption.

At one time, prior to glaciation, Europe, Asia, and North America were home to many species of hickories (*Carya*); however, many of them were driven to extinction by the advance of the glaciers, especially in Europe. Today about 16 species remain. Three are native to Asia while the rest are found in North America. One species is restricted to Mexico.

The hickories are subdivided into two groups: the true hickories and the pecan hickories. The true hickories are distinguished from the pecan hickories by differences in leaves, fruit husks, and bud scales. True hickories usually have seven or fewer leaflets per leaf while pecan hickories have more than seven leaflets. Fruit husks are unwinged (although they may have ribs) in the true hickories while the husks are broadly winged at the sutures in the pecan hickories. The buds of true hickories consist of more than six overlapping scales while the pecan hickories have buds that consists of from four to six scales that are valvate (non-overlapping).

The genus *Platycarya* consists of only one species (*P. strobilacea*) found in China, Japan, Korea, and Vietnam. There are about seven species in the genus *Engelhardtia* widely distributed in southern and southeastern Asia and northern India. There is one species in the genus (*Cyclocarya*, *C. paliurus*) and it

is found in China. The genus *Pterocarya* has six species distributed across eastern and southwestern Asia. Five species are listed for the genus *Alfaroa* located primarily in Central America. The members of this genus are unusual in the walnut family because the leaves are arranged oppositely on the stem. This leaf arrangement is also the case for the genus *Oreomunnea* which contains three species distributed through Mexico and Central America.

Ecology

Walnut (*Juglans*)

Black walnut (*J. nigra*) typically grows as scattered individual trees or in small groups throughout the central and eastern parts of the USA (Figure 1). Black walnut grows best on good sites in sheltered areas on well-drained bottomland sites in the Appalachians and the Midwest. Black walnut is sensitive to soil conditions and develops best on deep, well-drained, nearly neutral soils that are generally moist and fertile. Walnut grows best on sandy loam, loam, or silt loams. Walnut is common on limestone soils and grows especially well on deep loams, windblown soils, and fertile water deposited soils.

Black walnut grows in many of the mixed mesophytic forests but is seldom abundant. Usually it is found scattered among other trees and pure stands are rare, small, and usually located on the forest edge. An antagonism between black walnut and other plants growing within the root zone has been documented and attributed to juglone, a toxic substance found in the leaves, bark, nut husks, and roots of walnut trees. Some species are immune but others are not such as paper birch (*Betula papyrifera*), red pine (*Pinus resinosa*), eastern white pine (*P. strobus*), Scotch pine (*P. sylvestris*), and apple (*Malus pumila*). Tomato (*Lycopersicon esculenta*) plants are especially susceptible. Root system is deep and wide-spreading and black walnut is smoderately tolerant of flooding. However, it is intolerant of

Table 2 Summary of characteristics of the more common genera in the walnut family

Genus	Leaves	Twigs	Fruit
<i>Juglans</i> (walnut)	Deciduous, odd-pinnate, alternate	Pith chambered	Nut encased in husk which may or may not split
<i>Carya</i> (hickory)	Deciduous, odd-pinnate, alternate	Pith solid	Nut surrounded by husk most split on maturity
<i>Platycarya</i>	Deciduous, odd-pinnate, alternate	Pith solid	Small flattened narrowly two-winged nutlet
<i>Engelhardtia</i>	Deciduous, semievergreen or evergreen, even-pinnate, alternate	Pith solid	Three-winged nutlet
<i>Cyclocarya</i>	Deciduous, odd-pinnate, alternate	Pith chambered	Disk-winged nutlet
<i>Pterocarya</i>	Deciduous, odd or even pinnate, alternate	Pith chambered	Two-winged nutlet
<i>Alfaroa</i>	Opposite	Pith solid	Nut enclosed in husk
<i>Oreomunnea</i>	Opposite	Pith solid	Three-winged nutlet

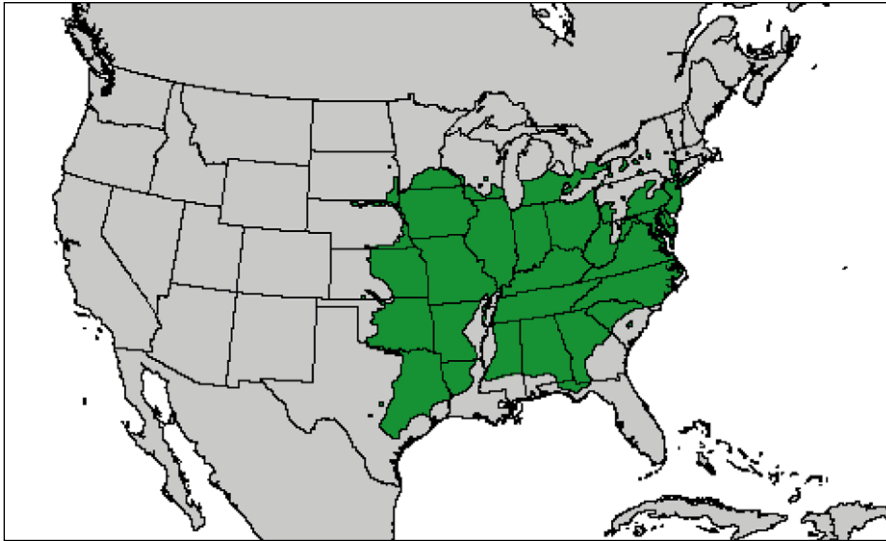


Figure 1 Range of black walnut (*Juglans nigra*). Adapted from Little EL, Jr (2003) *Digital Representations of Tree Species Range Maps. Atlas of United States Trees*. <http://climchange.cr.usgs.gov/data/atlas/little/>.

shade and in mixed species forests it must be in dominant or codominant canopy position if it is to survive.

Black walnut contains great genetic variation for growth and survival. More than 400 black walnut cultivars have been named and released over the last 100 years. However, hybridization is not common among species of walnuts. In fact, crossing between black walnut and butternut (*J. cinerea*) is difficult or impossible.

Ranging from cool temperate steppe to wet through subtropical thorn to moist forest life zones, English Walnut (*J. regia*) is reported to tolerate annual precipitation of 310–1470 mm, annual temperature of 7.0–21.1°C, and pH of 4.5–8.2. It thrives on rich, sandy loam, well-drained, slightly acid or neutral soils. English walnut responds well to cultivation and fertilization. In areas where hardiness is a problem, trees should not be forced into excessive vegetative growth and minimum temperature should not go below -29°C . If growth begins early in spring crop and foliage may be damaged by late frosts. When fully dormant, trees can withstand temperatures from -24°C to -27°C without serious damage.

Most true hickories are found on medium to dry sites and are often found in association with oaks (*Quercus* spp.). In fact, the largest forest region in the USA is situated in the eastern USA and is named the Oak–Hickory Forest because of the close association between the two genera. Most hickories are classed as moderately tolerant of shade and are considered to be relatively slow growing compared to its associates. There are exceptions however. Shellbark

hickory (*Carya laciniosa*) is very shade tolerant, exceeded only by sugar maple and beech.

The pecan hickories, on the other hand, are found on moist but well-drained ridge bottoms in river bottoms with other bottomland hardwoods. The exception is bitternut hickory (*C. cordiformis*) which is found on a wide variety of sites including dry, gravelly uplands. Pecan (*C. illinoensis*) is the largest of the hickories and attains a height of 35–40 m and a diameter (at breast height, dbh) of 60–120 cm or more.

The other six genera are typically found in semitropical forests characterized by mixed species forests in relatively high rainfall areas on mountain slopes and in valleys. Some, like *Oreomunnea*, are found in cloud forests. Cloud forests are usually found in humid areas 1000 m above sea level. In such forests, trees usually reach more than 20 m. Here the mean annual temperature varies from 12°C to 23°C and the annual mean precipitation is always higher than 1000 mm and sometimes exceeds 3000 mm. In many cases the forests are enshrouded in semipermanent mist, giving rise to the term cloud forest. Cloud forests harbor many species that can be found in the rain forests, but are typically rich in epiphytes, parasitic plants, bromeliads, vines, etc.

Silviculture

Walnuts are generally a minor tree species in most landscapes and as a consequence not cultured in a natural setting. If an individual tree is encountered in a forest stand its growing space requirements are assessed and the individual is released from

competition as required. Release is necessary in high-density stands because stem diameter growth of walnut is extremely sensitive to the degree of crowding in a stand. Trees have been mechanically pruned to increase stem quality. Research and experience has shown that with proper thinning and pruning it is possible to produce 40 cm saw logs in 30–35 years and veneer logs (50 cm) in 40–50 years. Given a silvicultural objective of veneer logs, the recommended stocking and spacing for an average stand diameter of 50 cm dbh should be 62 trees per hectare at a spacing of 13 m between trees.

Pecans should be grown on sites that have well-drained, deep soils (1.2–2 m) with moderate soil moisture holding capacity. Pecan trees are native to river valley soils and have a relatively high water requirement. They do best on sandy loam soils but also can be grown on heavier soils such as clay loams if the soils are well drained. In areas where the soil is lighter and relatively dry, irrigation is required. When pecan trees are fully mature, approximately 20 years after planting, tree spacing should be approximately 20–25 m between rows and also between trees within rows, or 15–22 trees per hectare.

Utilization

English walnut (*Juglans regia*) is native to the region in Eurasia extending from the Near East through to the Himalayas and on to Western China. This single species is known by various names: Persian, French, Turkish, Italian, Circassian, and Carpathian walnut. Walnuts must have been harvested from earliest times but the earliest records of growing of orchards of walnut trees go back to classical Greek and Roman times. Besides the nuts, trees are also a source of high-quality wood used for furniture and gunstocks. Growing of walnuts in Europe began in the 1500s; but by the 1600s walnut was replaced by mahogany as the wood most favored for furniture. They are now grown worldwide and the largest production is from California. Black walnut and other walnuts are used in much the same way as European walnut.

Hickories produce heavy, strong, shock-resistant wood with a high fuel value. These characteristics make hickory suitable for handles used in axes, hammers, and other striking instruments. Pecan is not only valuable as a fine furniture wood but the nut is prized for food. Species in the *Engelhardtia* and *Pterocarya* also produce fine cabinet woods.

See also: **Temperate and Mediterranean Forests:** Temperate Broadleaved Deciduous Forest. **Temperate**

Ecosystems: Fagaceae. **Tropical Forests:** Tropical Montane Forests.

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Pines

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Introduction

Pines clearly form the most ecologically and economically significant tree group in the world. The genus *Pinus* contains 110 species (Table 1), comprising more than half the species in the Pinaceae and almost 20% of all gymnosperm species. Ecologically, pines also influence the structure and function of many forest ecosystems. They affect biogeochemical processes, hydrological and fire regimes, and provide food and create habitats for animals. Pines are important, and very often dominant, components of the vegetation over large parts of the northern hemisphere (Figure 1). Economically, pines play a major role as sources of timber, pulp, resin, nuts, and other products. Pines have also been cultivated in many parts of the world, both within and well outside their natural range, and they form the foundation of exotic forestry enterprises in many southern hemisphere countries. Moreover, pines have featured in ancient myths and rituals throughout