Platanus occidentalis L. Sycamore

Platanaceae Sycamore family

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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 (fig. 1) 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.

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 m (1,000 ft) in the northern part and 762 m (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

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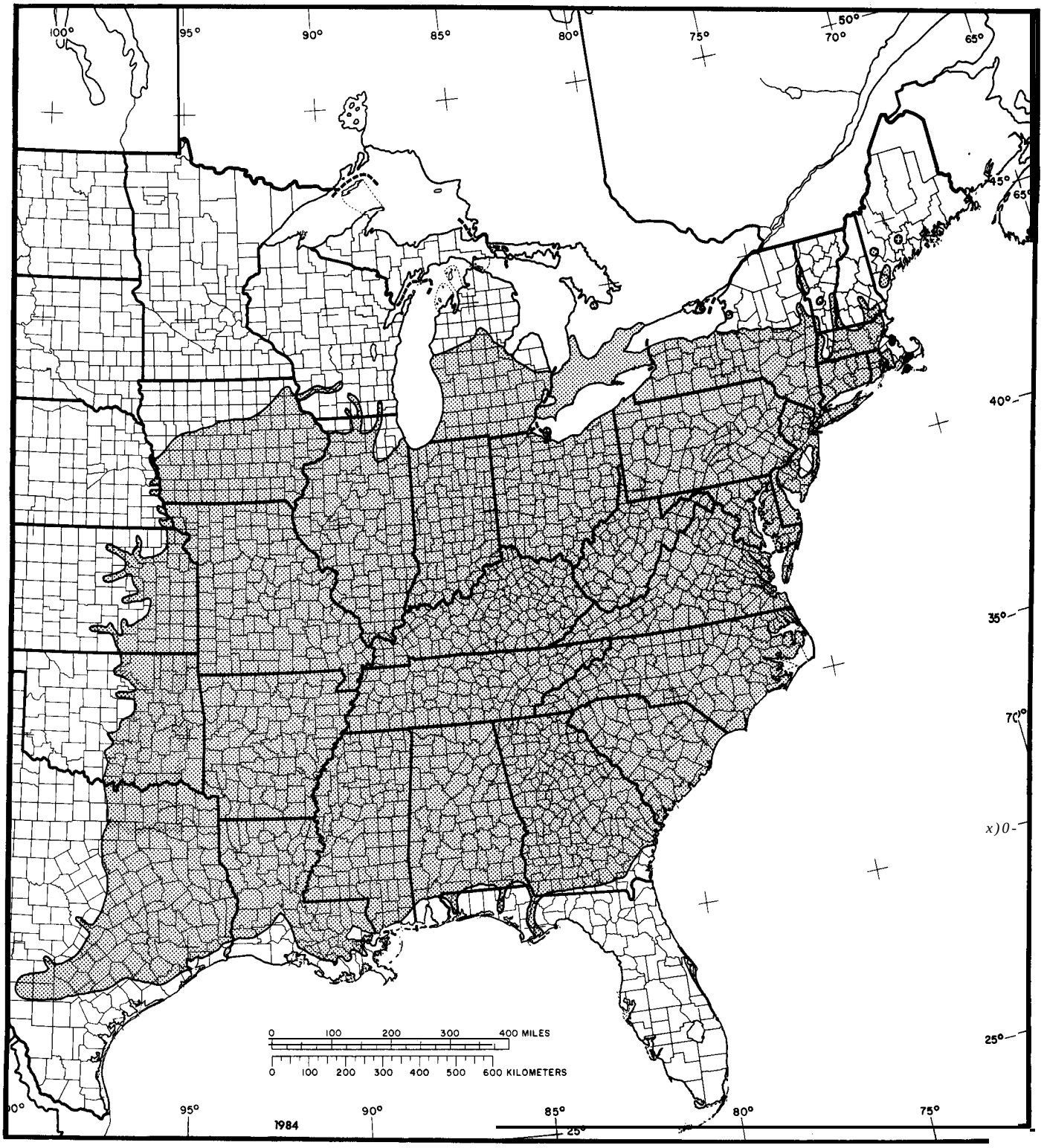

Figure *l-The native range of sycamore.*

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 rubum),* 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-Sweetgum-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 variant 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 81" 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 (fig. 2) 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

Figure *2-A 40- to 50-year-old* **sycamore.**

	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 m (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 m (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 m (140 ft) in height *(21)*. An individual tree in Indiana was 320 cm (126 in) in diameter at 1.2 m (4 ft) above the ground and 51 m (168 ft) tall *(21)*.

Open-grown sycamores have a large irregular crown that may spread to 30 m (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 ***(Jugluns** nigra)*, hackberry ***(Celtis occident&is),*** 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 ***(Corythucu** ciliata)*, the flathead sycamore-heartwood borer ***(Chulcophorellu** campestris)*, and the sycamore tussock moth *(Halisidota harrisii)*. Other insect enemies include leaf feeders and hoppers, periodical cicada ***(Mugicicudu septendecim),*** aphids, scales, crosswood borers, flatheaded borers, roundheaded borers, bark borers, darkling beetles ***(Tenebrionidue),*** ambrosia beetles, moths, and caterpillars, leaf rollers, and horntails ***(Siricoideu).*** 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 ***Cerutocystis fimbriata*** and ***Botryodiplodiu theobromue*** 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 ***Cerutocystis 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 ***(Phorudendron** 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 in-

jure 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 1500ha/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.

Figure *3-Sycamore seedlings in first growing season in Georgia* Coastal *Plain,* short-rotation *planting.* Spacing is *1.2 by 2.4 m (4 by 8 ft).*

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 (fig. 3). 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 *l? 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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