Populus deltoides Bartr. ex Marsh. Eastern Cottonwood

Salicaceae Willow family

P. deltoides Bartr. ex Marsh. var. deltoides Eastern Cottonwood (typical)

D. T. Cooper

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 (figs. 1, 2) 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 authors are Research Geneticist (retired), Southern Forest Experiment Station, New Orleans, LA, and Research Forester (retired), Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

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, well-drained, 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/cm^3 (0.8 oz/in^3), pH of 5.5 to 7.5, and greater than 2 percent organic matter *(1)*. Sites frequently meet the requirements

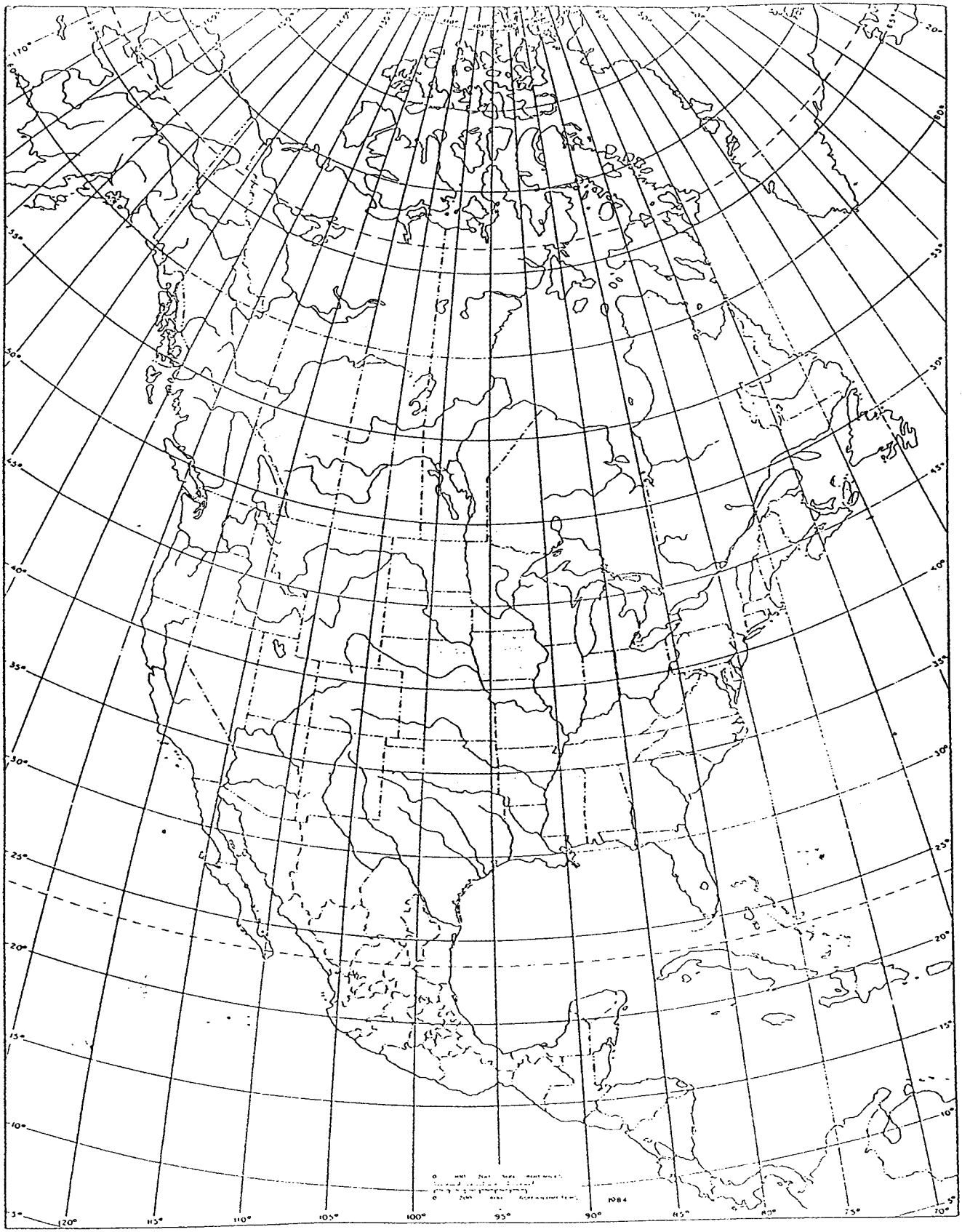

Figure 1—*The native range of eastern cottonwood.*

Figure 2—*Eastern cottonwood tree 20 m (65 ft) tall and 51 cm (20 in) in d.b.h.*

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 produc-

tion of a single open-grown tree have been as high as 48 million seeds *(3)*. Good seed crops are the rule. About 35 liters (1 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 m (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 m (43 ft) at age 3 and more than 30 m (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-producting 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 cu 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 × *acuminata* Rydb. *(P. angustifolia* × *deltoides)*

Populus × *bernardii* Boivin *(P. deltoides* × *tremuloides)*

Populus × *jackii* Sarg. *(P. balsamifera* × *deltoides)*

Populus × *polygonifolia* Bernard *(P. balsamifera* × *deltoides* × *tremuloides)*

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

Literature Cited

1. Baker, J. B., and W. M. Broadfoot. 1979. A practical field method of site evaluation for commercially important southern hardwoods. USDA Forest Service, General Technical Report SO–26. Southern Forest Experiment Station, New Orleans, LA. 51 p.
2. Baker, J. B., and B. G. Blackmon. 1977. Biomass and nutrient accumulation in a cottonwood plantation—the first growing season. Soil Science Society of America Journal 41:632–636.
3. Bessey, C. E. 1904. The number and weight of cottonwood seed. Science 20(499):118–119.
4. Brayshaw, T. C. 1966. Native poplars of southern Alberta and their hybrids. Canada Department of Forestry, Publication 1109. Ottawa, ON. 40 p.
5. Bull, H. 1945. Cottonwood—a promising tree for intensive management. Chemurgic Digest 4:53–55.
6. Eyre, F. H., ed. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC. 148 p.
7. FAO, International Poplar Commission. 1958. Poplars in forestry and land use. FAO, Forestry and Forest Products Studies 12. Rome, Italy. 511 p.
8. Farmer, Robert E., Jr. 1964. Sex ratios and sex-related characteristics in eastern cottonwood. Silvae Genetica 13:116–118.
9. Farmer, Robert E., Jr. 1966. Variation in time of flowering and seed dispersal of eastern cottonwood in the lower Mississippi Valley. Forest Science 12:343–347.
10. Johnson, R. L., and E. C. Burkhardt. 1976. Natural cotton wood stands—past management and implications for plantations. *In* Proceedings, Symposium on Eastern Cottonwood and Related Species. Sept. 28–Oct. 2, 1976, Greenville, MS. p. 20–29. Bart A. Thielges and Samuel B. Land, Jr., eds. Southern Forest Experiment Station, New Orleans, LA.
11. Krinard, R. M. 1979. Five years' growth of pruned and unpruned cottonwood planted at 40-by 40-foot spacing. USDA Forest Service, Research Note SO-252. Southern Forest Experiment Station, New Orleans, LA. 5 p.
12. Little, Elbert L., Jr. 1979. Checklist of United States trees (native and naturalized). U.S. Department of Agriculture, Agriculture Handbook 541. Washington, DC. 375 p.
13. McCracken, F. I. 1976. Etiology, epidemiology and control of decay of cottonwood. *In* Proceedings, Symposium on Eastern Cottonwood and Related Species. Sept. 28–Oct. 2, 1976, Greenville, MS. p. 222–225. Bart A. Thielges and Samuel B. Land, Jr., eds. Southern Forest Experiment Station, New Orleans, LA.
14. McKnight, J. S. 1950. Forest management by Old Man River. Southern Lumberman 181(2273):233–235.
15. McKnight, J. S. 1970. Planting cottonwood cuttings for timber production in the South. USDA Forest Service, Research Paper SO–60. Southern Forest Experiment Station, New Orleans, LA. 17 p.
16. Morris, R. C., T. H. Filer, J. D. Solomon, and others. 1975. Insects and diseases of cottonwood. USDA Forest Service, General Technical Report SO–8. Southern Forest Experiment Station, New Orleans, LA. 37 p.
17. Putnam, J. A., G. M. Furnival, and J. S. McKnight. 1960. Management and inventory of southern hardwoods. U.S. Department of Agriculture, Agriculture Handbook 181. Washington, DC. 102 p.
18. Schreiner, E. J. 1971. Genetics of eastern cottonwood. USDA Forest Service, Research Paper WO–11. USDA Forest Service in cooperation with Society of American Foresters, Washington, DC. 19 p.
19. Schreiner, E. J. 1974. *Populus* L. *In* Seeds of Woody Plants in the United States. p. 645–655. C. S. Schopmeyer, tech. coord. U.S. Department of Agriculture, Agriculture Handbook 450. Washington, DC.
20. Tauer, C. G. 1979. Seed tree, vacuum, and temperature effects on eastern cottonwood seed viability during extended storage. Forest Science 25:112–114.
21. USDA Forest Service. Data on file. Final Report FS–SO–1110–5.6. Forestry Sciences Laboratory, Starkville, MS.
22. Williamson, A. W. 1913. Cottonwood in the Mississippi Valley. U.S. Department of Agriculture, Bulletin 24. Washington, DC. 62 p.

23. Zsuffa, L. 1976. Vegetative propagation of cottonwood by rooting cuttings. *In* Proceedings, Symposium on Eastern Cottonwood and Related Species. Sept. 28–Oct. 2, 1976. Greenville, MS. p.99–108. Bart A. Thielges and Samuel B. Land, Jr., eds. Southern Forest Experiment Station, New Orleans, LA.