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PLANTING COTTONWOOD on BOTTOMLANDS



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SUMMARY OF PLANTING RECOMMENDATIONS

- (1) Plant only on bottomland sites that are neither extremely dry in the late summer and fall, nor deeply flooded in the winter and spring. Sites so sandy and dry, or so low and often flooded, that they support little or no natural vegetation are not suitable for cottonwood.
- (2) Plant at 6-foot intervals in plowed furrows 10 feet apart. If the planting site is densely covered with undesirable vegetation, burn or disk the area before plowing.
- (3) Plant during the winter, when cottonwood is dormant, preferably in February.
- (4) Plant 1- or 2-year-old cottonwood seedlings collected from natural stands or grown in nurseries. Trim the roots to a length of 15 inches or less (to a point where the taproot is stiff enough to insert in the planting hole), and the tops to 10 inches. Make 20-inch cuttings from the tops thus cut off.
- (5) Plant seedlings with a rod that makes a hole $\frac{1}{2}$ -inch in diameter and 15 inches deep. Plant cuttings to the same depth with a rod that makes a hole $\frac{1}{4}$ -inch in diameter, or if the ground is soft simply push them in.
- (6) Release the trees from the competition of other vegetation at least once and preferably twice during their first growing season by hoeing away all vegetation within about 18 inches of each tree before it is overtopped.
- (7) Protect the trees from fire and grazing.

PLANTING COTTONWOOD ON BOTTOMLANDS

Eastern cottonwood (*Populus deltoides virginiana*) is one of the fastest-growing trees of commercial importance native to this country. The wood is in demand for a great variety of uses and usually brings good stumpage prices. Rapid growth and relatively high value make cottonwood a very desirable tree to grow in plantations.

There are two principal reasons for interest in cottonwood propagation in the Yazoo-Mississippi Delta and similar bottomland regions where cottonwood grows naturally:

(1) Mature cottonwood invariably is replaced by other, generally less valuable, and slower-growing species after logging. This means that cottonwood must be planted if its present and former sites are to be kept fully and highly productive.

(2) The heavily cut-over and burned-over areas most in need of planting are usually covered with such a dense, rank growth of weeds, shrubs, vines, and clumps of sprouts that only a very fast-growing species like cottonwood is likely to be successful in overcoming the severe competition. Since cottonwood does not occur naturally on such areas, except as occasional widely scattered trees, it can be obtained in adequate numbers only by planting.

Cottonwood is especially suitable for planting on farms because in addition to the commercial value of its wood it is useful for fuel, for shade, and in windbreaks. Ditch banks, fence rows, and other relatively small unproductive farm areas can be made productive and useful by planting cottonwood. There may even be an advantage in planting small accessible areas because of the more intensive care and management that can be applied.

Relatively few attempts have been made in the Yazoo-Mississippi Delta and similar bottomland regions to plant cottonwood on forest land. There is, therefore, only a meager background of either experimental or practical experience. Beginning in 1940, however, research in cottonwood propagation has been conducted at Stoneville, Mississippi, as part of a cooperative Farm Forestry Research Project by the Southern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, and the Delta Experiment Station. This bulletin is based largely on the results to date of this investigation. Much more work remains to be done before many of the recommendations made here can be adequately checked, and the recommendations must accordingly be considered subject to later modification. It will be a relatively long time before all of the problems of cottonwood propagation are finally solved, however, and in the meanwhile it seems desirable to release the information obtained to date.

RANGE

Eastern cottonwood is found throughout the eastern half of the United States, and has been planted extensively in shelterbelts in the Plains States. It grows naturally on stream banks and other moist

sites, and makes its best growth in the lower Mississippi River valley where extensive pure stands are found on the islands and batture¹ lands of the Mississippi River. On such lands it is commonly found in mixture with willow in young stands, but the faster-growing cottonwood gradually assumes a dominant position and large cottonwood is generally found in pure stands. It also occurs as scattered individuals or in small groups in mixture with other hardwoods throughout the bottomlands.

USES

The wood is light in weight and color, comparatively uniform in texture, and generally straight-grained. These characteristics make it very desirable for industrial lumber, veneer, and excelsior. Most of the lumber is used in boxes and crates, for which it is especially well suited because of its light weight, lack of odor, ability to take nails without splitting, and good color for stenciling. Cottonwood yields an unusually high percentage of clear wide boards and is therefore much used as core stock in large panels and as wagon box boards. Cottonwood veneer is used principally in containers, but is used also in furniture and other products. Cottonwood is also suitable for pulping, and is used in the manufacture of paper and fiber board.

Annual production of cottonwood lumber in the South from 1931 to 1940 averaged about 60 million board feet, and most of this came from the Delta regions of Mississippi, Arkansas, and Louisiana. At the present time production is much greater because of demand created by the war. In 1939 cottonwood ranked fifth nationally among veneer woods in the amount consumed.

RATE OF GROWTH

Cottonwood is a relatively short-lived tree but grows so rapidly that it soon reaches a large size. In natural stands and plantations² on the better sites, cottonwood commonly increases $\frac{2}{3}$ to 1 inch in diameter and 5 feet in height annually up to 10 or 15 years of age, and grows at only a slightly slower rate up to 30 or 35 years. Well-stocked natural stands in the Mississippi Valley have been found to contain trees averaging 20 inches in diameter at breast height and 120 feet high when 35 years old. The growth rate starts to decrease sharply at about this age, however, so it is probably best to harvest the entire stand at about 35 years of age and replant. In well-stocked stands, cottonwood prunes itself very well, and produces a long, straight trunk that is generally clear of limbs for at least 50 feet when mature.

Fully stocked natural stands on good sites have been estimated to yield about 6 cords of pulpwood at 5 years, 24 cords at 10 years, and 50 cords at 15 years. The volume in board feet per acre, Doyle rule,

¹The unprotected area between the Mississippi River and its levees is known locally as batture or batture land.

²As used here and elsewhere in this bulletin, "plantation" refers merely to a group of planted trees, regardless of the area involved.

in similar stands has been estimated at 5,700 at 20 years, 10,700 at 25 years; 19,200 at 30 years; and 27,500 at 35 years. These impressive figures on yield show clearly the tremendous growth rate of cottonwood. Most natural stands, especially over large areas, are not fully stocked and therefore do not attain these yields. If survival is high, however, cottonwood planted at uniform spacing can be expected to equal the yield of fully stocked natural stands. Yields from well-stocked plantations that are thinned periodically will exceed the yields of unthinned natural stands on similar sites.

NATURAL REPRODUCTION

It is usually impossible to obtain adequate natural reproduction of cottonwood on most land from which mature cottonwood is cut. Cottonwood will seed itself only on bare soil that is saturated, but not covered, with water for long periods during seedfall. The site must remain moist and practically free of vegetation throughout the seedling's first year if good growth is to be obtained. The abundant moisture needed for seedling establishment cannot readily be supplied artificially on forest land in the Delta except perhaps on a small scale by irrigation. Receding flood waters or abundant rainfall are effective only if they keep the soil saturated for long periods during seedfall, and this condition is seldom obtained and obviously cannot be depended upon at any given time and place. Since the moisture requirements for natural reproduction are so exacting, cottonwood must be planted to insure its establishment.

PLANTING

Sites

Cottonwood makes its best growth on moist but well-drained sandy loam or silty soils in the batture, but growth is also very good on heavy clay soils along ditches, and on the gentle slopes bordering swamps and sloughs. Plantations made on such sites are most likely to be successful. Heavy clay "buckshot" soils that crack open as they dry out in the late summer and fall are unfavorable to the establishment of cottonwood, but it is thought that successful plantings may be made here with proper intensive care. Coarse sandy ridges or former sand bars, common in the batture, are unsuited to cottonwood. These sites are so sterile and dry that vegetation is sparse or lacking, and cottonwood plantings are almost certain to fail. A shallow water table or an unusually wet year may sometimes make cottonwood plantations possible on these sites, but they are factors that cannot be relied on. Low swampy sites, sloughs, or drains where planted trees may frequently be submerged for long periods are entirely unsuitable for cottonwood. Most bottomland sites that are neither extremely dry in the late summer and fall, nor deeply flooded in the winter and spring, seem satisfactory for cottonwood.

Site Preparation Before Planting

Preparing or treating the planting site before planting is necessary (1) if the site is so covered by vegetation that both planting and sub-

sequent release or cultivation of the planted stock are very difficult or impossible unless the site is at least partially cleared, or (2) if the site is so poor for cottonwood that planting in furrows and rather intensive subsequent cultivation are desirable. Burning is probably the cheapest effective method for clearing a planting site, but fire is a tool that must always be used with great care. Burning should be done only on sites where there are no trees (or only a negligible number) worth keeping, and where the fire can be kept from spreading to areas not scheduled for planting. In bottomlands, burning is usually practicable only in the fall. A heavy or clean burn is needed.

If for any reason burning cannot be done, a heavy disk plow pulled by a crawler-type tractor is suitable for preparing sites where there are not many large trees, stumps, or logs. Poor sites that will be cultivated rather intensively should be disked before planting in order to facilitate the later cultivation.

It is highly desirable but usually not essential to plow furrows in which to plant. A middle-buster plow is most suitable for this purpose. Furrows make planting easier and provide better alignment of rows, but their most useful function is to facilitate finding the planted trees when they need release from the competition of the surrounding vegetation. By cutting shallow roots and turning over several inches of soil, furrowing also retards the growth of competing vegetation and thereby both postpones the first release and makes a second release less likely to be needed. Finally, there is some evidence, especially on the drier sites, that trees planted in furrows survive and grow somewhat better than trees not planted in furrows. Good sites that are relatively free of vegetation, perhaps because of recent logging or recent abandonment from agricultural use, are least in need of plowed furrows.

Spacing

Until comprehensive information on the growth of cottonwood at different spacings can be obtained, the best spacing for plantations is debatable. Growth, however, is affected not merely by original spacing but also by the actual survival, which can only be estimated and may well be affected by various unpredictable factors. For this reason, the best spacing can never be rigidly defined but is actually rather flexible.

It is tentatively recommended that cottonwood be planted 6 feet apart in rows 10 feet apart. This spacing, providing for 726 trees per acre, seems most desirable from several standpoints. Because of the rapid growth and heavy natural thinning characteristic of cottonwood stands, 726 planted trees per acre are enough for a reasonably satisfactory stand even if the survival should be as low as 40 or 50 percent. Spacings closer than 6 by 10 feet seem likely to be unnecessarily close, and wider spacings may often result in understocked stands of very limby trees. For the same number of trees per acre, planting and subsequent release or cultivation are cheaper with rectangular spacing than with square spacing. If plowed furrows are

used, fewer furrows are needed. When rows are at least 10 feet apart, trucks may be driven between them to pick up material cut in thinnings.

It is thought that a 6- by 10-foot spacing is equally suitable for the production of sawlogs and pulpwood. Regardless of the product cut, however, frequent thinnings—starting at an early age—will be needed in order to obtain maximum yields and profit. The better the survival, the earlier the thinnings should be started and the better will be the ultimate total returns.

Planting Stock

Best results are obtained by using 1- or 2-year-old seedlings and cuttings taken from the tops of such seedlings. Cuttings taken from the crowns of older trees are not recommended; failures are too frequent to justify their use. Cuttings taken from 1- or 2-year-old sprout growth, especially from very young stock such as can be produced in a nursery, may also be suitable for planting, but have not yet been thoroughly tested. One-year-old seedlings or wildings about 2 to 5 feet tall from batture lands, borrow pits, or ditches are ideal. Nursery-grown seedlings of the same size are equally good. Seedlings are collected simply by pulling them out of the ground.

Before planting, the tops of seedlings should be cut back to a length of about 10 inches (see figure 1). Tall, uncut seedlings do not survive as well as those cut back, although 10 inches is a somewhat arbitrary choice. Seedlings cut back to 4 inches may survive and grow as well as those cut back to 10 inches, but they need to be released earlier and are more difficult to find. If planted in furrows some loss may also occur as a result of silting, which may cover the short tops with several inches of soil. The only disadvantage of lengths from 10 to 20 inches is that less top material can be utilized as cuttings. Lengths greater than 20 inches usually do not survive as well as shorter lengths and should be used only on low sites likely to be flooded deeply for a long period. Complete inundation of the trees for more than about a week during the growing season delays growth and may be fatal. Twenty-inch cuttings should be made from the pruned-off tops of seedlings; they survive and grow as well as the parent seedlings, and their use doubles or triples the amount of planting stock obtainable from a given number of seedlings.

Since cuttings from the top of a seedling are fully as satisfactory as the entire seedling or any part that includes the roots, wilding stock may be collected simply by taking cuttings in the field without pulling the seedlings. It is cheaper to collect in this way when wildings are plentiful or when the ground is hard and it is difficult to pull or lift the plants without digging. Cuttings also have the advantages of being easier to handle, prepare, and plant than rooted stock. When wilding stock is scarce, however, or when the plants are easily pulled, it is generally best to use both rooted stock and cuttings.

If seedlings are planted with a rod, as recommended below, the

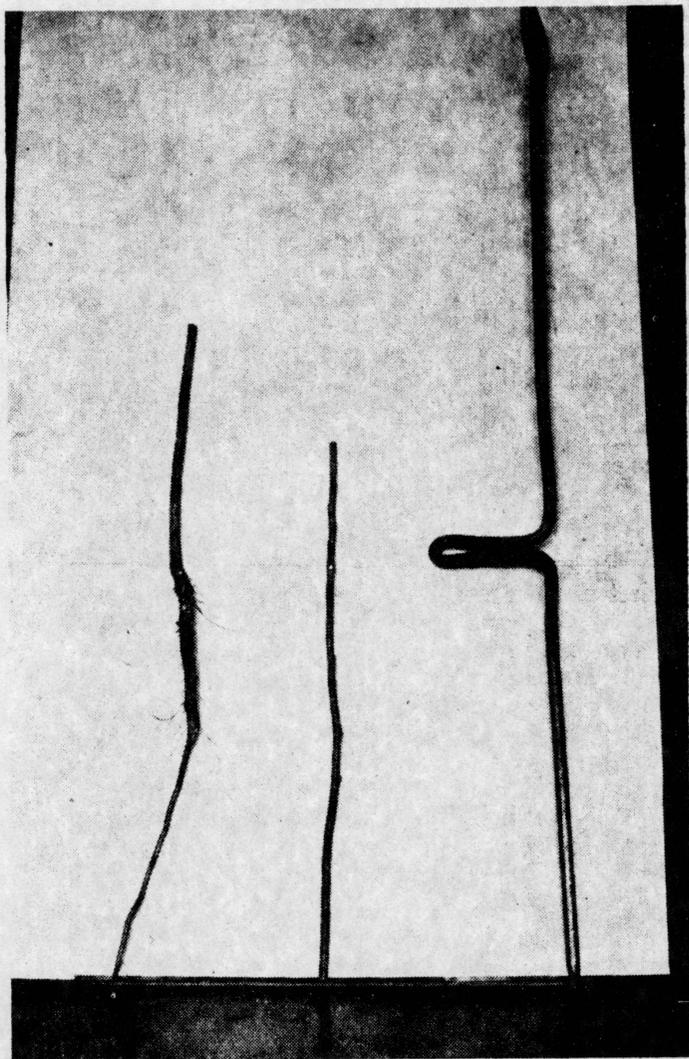


Figure 1. Cottonwood planting stock and planting rod. From left to right: 1-year-old wildling with top pruned to 10 inches and roots pruned to 15 inches; 20-inch cutting made from pruned-off top; and planting rod made for planting 15 inches deep.

taproots must be cut back to 15 inches or less, to a point where the taproot is stiff enough to insert in the planting hole, and the larger side roots must be pruned just enough to permit this insertion. Seedling roots must be kept moist at all times to prevent harmful drying. Less care is required for cuttings, but they should not be exposed to the sun or wind. Planting stock may be safely kept before planting by placing the roots of seedlings and the butt ends of cuttings in water (e.g., in ditches or stump holes), or by heeling-in in moist soil. Stock may be safely stored for long periods in moist cold storage at about 40° F., but this is recommended only if planting must be delayed until growth starts. It is best to place seedlings in cold storage in an uncut condition, cutting them back just before planting.

Method of Planting

A planting rod is recommended as the most suitable tool for planting because it is easy and cheap to make, quickest to use, and results in satisfactory survival. The rod should be made of rod iron, bent at 15 inches from one end to form a step that will be needed in hard ground. The upper end should be shaped to form a convenient handle, either T- or D-shaped, and the lower end should be pointed to aid penetration (see figure 1). The diameter of the rod should correspond to the diameter of the stock to be planted. A ½-inch rod is best for most seedlings and for most cuttings taken from sprouts, but a ¼-inch rod is best for most cuttings made from the tops of seedlings. It is important to get good contact in the hole between the planted tree and the soil, especially at the bottom of the hole. Cuttings should simply be pushed into the ground to the desired depth if the soil is soft enough.

Before planting with the rod, seedlings should be root-pruned sufficiently to allow insertion in the hole. The root length should not exceed the depth permitted by the step on the rod, preferably about 15 inches. If roots are shorter than this limit, a portion of the stem should be inserted in the hole to make up the deficiency. It is important to get good depth in planting: 10 inches should be the minimum on moist sites and 15 inches the minimum on dry sites.

Cottonwood seedlings may also be planted with the wedge-shaped bar commonly used for pine, or with a mattock, but these tools are much slower to use than a rod, especially in wet clay soils, and their use has not resulted in appreciably better survival or growth.

Planting is done most efficiently by a man who carries his stock either in a basket, tray, or cloth sack slit to permit hanging from the shoulder. Provision should be made for keeping the roots moist at all times.

The boundaries of a planting area or the ends of rows should be conspicuously marked to facilitate finding the trees when cultivation is needed. Stakes or bright cloths make good markers. Trees usually will be hard to find if they are not planted in plowed furrows, but it does not seem practicable to mark each tree separately.

Time of Planting

Cottonwood may be planted at any time during the dormant season, i.e., after the leaves have fallen in the autumn and before the buds open in the spring. In the Yazoo-Mississippi Delta, this season usually extends from late November or early December until early to late March. February is probably the best single month since it does not seem desirable to leave the dormant stock exposed to drying winds, floods in swamps, rabbits, or other injurious agencies for a long period. The ground is also likely to be most favorable for planting in this month. On the higher lands the soil is likely to be wetter in February than in the two preceding months. On the lower lands, if there is standing water, stock planted in February will not have long to remain in the water before growth starts, and the stock can be set with its tops above water with more assurance of retaining this position.

Cultivation

Cultivation or release of the planted trees from competing vegetation during the first year is essential. This is most simply done by cutting away all vegetation within a radius of about 18 inches from the tree with an ordinary cotton-chopping hoe. The time and frequency of release should be governed by the kind and density of competing vegetation, and its rate of growth compared with that of the cottonwood. In general, it is desirable to make a first release in early May, or not later than early June, and a second release late in June or in July. Each release should be made before the cottonwood is overtopped. When released early, the trees are more readily found and are likely to get off to a better start in growth. A disadvantage of early release is that it increases the need for a second release. Although one release may suffice if it is skillfully timed, it is usually better to make two releases. Plowed furrows will delay for several weeks the need for a first release, and thereby decrease the need for a second release. One man with a hoe can release from $\frac{1}{2}$ to 1 acre per day, depending upon the spacing, the amount of vegetation, and the ease with which the trees are found. Release is most rapid in plowed furrows. It will usually be unnecessary to make any release in the second year, although if vines are abundant it may be desirable to cut them to prevent serious damage to the form of the trees.

More intensive and probably more beneficial cultivation can be done with either machine or horse-drawn equipment. Only well-cleared sites or recently abandoned farm lands are suitable for such intensive cultivation, however, and they must be thoroughly disked or otherwise prepared for cultivation before planting. Even with machine cultivation, supplementary hand hoeing will be necessary in the first stages. Check plowing will minimize the need for supplementary hoeing, but perfect alignment of the trees is required for such work.

In a few instances, corn has been grown between rows of cottonwood and both plants have been intensively cultivated until the corn

was harvested. The cost of establishing a cottonwood plantation is greatly reduced by the returns obtained from the corn, and the cottonwood benefits greatly from the intensive cultivation that is required. This practice seems especially applicable to sites where cottonwood will not survive or grow well without intensive cultivation, but needs further testing before definite recommendations can be made. A site that is sufficiently cleared and cultivated, and permanently suitable for corn or some other agricultural crop, ordinarily should be devoted entirely to agricultural use and not planted with cottonwood. On the other hand, a site that is marginal or submarginal for agricultural use might well produce a good enough single crop of corn or cotton in a favorable year to defray most of the cost of establishing cottonwood.

Survival

Survival at the beginning of the second growing season in the field will probably range from about 30 to 90 percent, and the distribution of survivors is likely to be patchy or groupwise. Present experience is too limited to permit more specific estimates of survival for given sites or other conditions. It is also impossible at the present time to define the minimum survival that should be considered satisfactory. Whether or not a given plantation can be considered satisfactory, and whether or not it should be replanted or filled in, will depend on the suitability of the site, the normality of rainfall during the first growing season, the apparent causes of mortality, the distribution of surviving trees, the occurrence of desirable volunteer tree growth, and whether the principal objective is sawlogs or pulpwood. On a favorable site, with well-distributed survival, replanting the blanks will usually be inadvisable because of the likelihood that the replants will soon be suppressed. On medium or poor sites, however, or on good sites where survival is groupwise, it may well be advisable to fill in the blanks in the second year unless there is a good stand of desirable volunteer tree growth. Other things being equal, it is better to replant when low survival seems to be due to abnormal or subnormal rainfall than when low survival occurs with normal rainfall. Filling in blanks and later releasing the trees will be expensive, however, and the probable advantages should be carefully weighed against the estimated costs before replanting is undertaken.

In view of the present meager background of experience in planting cottonwood, it is best to begin planting on a relatively small scale on each different site or location. On sites where good results are obtained, the scale of planting can then be increased with some assurance of success. On sites where poor results are obtained, it is best to continue planting only on a small scale, modifying the technique as seems desirable, until either good results are obtained or it is decided that it is impossible to establish a good plantation.

GROWING NURSERY STOCK

Cottonwood planting stock may be successfully raised in a nursery, frequently for less than the cost of collecting wildings. A nursery also

has the advantage of providing a dependable source of supply. Accessible supplies of wildings are not always readily available when needed for planting. High water, not uncommon during the planting season, may make wilding collection extremely difficult or impossible. Wildings may also be scarce because of unfavorable conditions for establishment the previous spring.

Seed Collection

Cottonwood seed is usually mature early in May in the central portion of the Yazoo-Mississippi Delta. Seedfall generally occurs from about the first of May until July or August, with dissemination at its peak in late May. Seed may be safely collected after the first of May, and frequently collection is possible from a few late-maturing trees in June. A good rule to follow is to collect when the first pods begin to open; if collection is delayed too long, lower yields of seed per tree will be obtained.

The best seed-bearers are large, open-grown trees. Usually, little seed can be collected from trees less than 10 inches in diameter at breast height or less than 10 years old. Seed is borne only by female trees, and abundant crops are produced every year. Female trees bear yellow flowers, and male trees bear red flowers.

The green pods or capsules are most easily gathered from felled trees, but can be collected from standing trees by climbing or using a ladder. Logging operations are convenient places to collect seed. A large tree may yield over a bushel of seed pods, from which several pounds of seed can be extracted. A pound of seed, clean enough for sowing, contains about one-half million seeds.

If stored in bulk following collection, the pods will heat; they should therefore be spread out in thin layers to precure or dry at ordinary room temperature for 2 or 3 days before extracting the seed. Most of the pods will still be closed, but sufficiently dry to be easily opened by hand or mechanical maceration. The pods may be macerated immediately after picking, but seed extraction is more difficult at this time and the seed yield may be less. The pods may be air-dried for a week or more with little or no loss in seed viability, and even longer storage periods are possible in moist, cold storage at about 40° F.

Maceration releases the seed by crushing the pods, and to some extent loosens the seed from the cottony matrix which surrounds it. It is accomplished simply by rubbing or crushing the pods against a coarse screen by hand. If large quantities are to be handled, grain hammer-mills or other mechanical macerators can be used with greater efficiency. The seed is then separated from the "cotton" by rubbing over a screen wire of small mesh, such as a window screen. Only about 20 percent of the seed actually handled is readily extractable; beyond this point, further rubbing yields so little seed that it is probably unprofitable.

The seed should be sown immediately after extraction. Its viability is greatly reduced in a few days by dry, open storage, although it may be safely kept for a week or more in moist, cold storage.

Seed Sowing

The best nursery soil is a fertile sandy loam. Seedbeds 4 feet wide with shallow alleys or pathways 1 foot wide between beds are suitable. The beds are formed by breaking out the alley with a middle-buster, then leveling off the bed surface with either a rake or a drag.

The seed is sown on the surface of the bed by hand, either broadcast or in drills, 6 inches or more apart, and should not be covered. Broadcast beds are more easily sown and will produce more plantable trees per unit area owing to the better distribution of seed, but drilled beds are more easily weeded and may be cultivated. Cottonwood seed is so small that care is needed to obtain a uniform distribution of seed on the bed. Mixing the seed with a dry sandy soil will help. It is also desirable from this standpoint to sow unclean seed that is obtained by extraction through a large-mesh wire screen that allows portions of seed pods to fall through along with the seed.

Fresh seed is highly viable, with 80 to 90 percent germination. Actual tree percentage will of course be much lower, for the young seedlings are so fragile that the slightest adversity in field conditions causes considerable loss. It is therefore wise to sow heavily to insure a fully stocked stand, and thin later to the desired density if the stand is overstocked. A good stand can generally be produced from 1 ounce of clean seed per 100 square feet of seedbed, or about 300 seeds per square foot. If drill-sown, 100 seeds per linear foot are adequate if well distributed.

Constant, ample moisture is required for germination and initial establishment of the seedlings. If an overhead sprinkling system is available, the beds should be kept continually moist by frequent sprinkling. Equally good results may be obtained by irrigation, in which case the beds are first thoroughly soaked by flooding and then drained just enough to expose the surface on which the seeds are sown, preferably broadcast. Sufficient water is used to keep the alleys full, thus maintaining a saturated bed. This method is especially suitable for a small nursery, but requires a level site. The young seedlings should not be submerged, for development is then checked and some mortality will occur, especially on hot, sunny days.

The surface of the bed must be kept continually moist for at least 3 days after sowing. Germination occurs within 12 to 24 hours after sowing, when the radicle, surrounded by a tuft of fine white hairs, emerges from the embryo. With the hairs acting as an anchor, the cotyledons rise and open. This is followed by elongation of the root, which penetrates to a depth of about 1 inch by the fifth day. The seedling develops very slowly at first, but after about 3 weeks growth accelerates steadily and rapidly.

Shades or screens help to conserve and maintain uniform surface moisture, but are needed only if sufficient moisture cannot otherwise

be maintained. Half shade provided by a screen made of laths stapled with wire is suitable.

If the beds are overstocked, the seedlings should be thinned when about 4 weeks old to approximately 20 trees per square foot. Subsequent cultural care during the growing season is the same as for most other tree species. The beds will need weeding several times, especially when the seedlings are small. This involves hand-picking if the seed were broadcast, but may be done largely with a hoe if the seed were drill-sown. The trees should be watered generously during the summer, either by overhead sprinkling or by irrigation.

PROTECTION

Cottonwood plantations must be completely protected from both fire and grazing.

Small trees are very easily killed by fire, even light fires. Large trees may survive a light fire but are badly scarred by fire and soon develop serious butt rot that greatly reduces the amount of merchantable wood. Plantations should be protected from fire by a cleared and plowed fire-line about 15 feet wide.

Cattle and other livestock seriously damage small trees by browsing and trampling, especially if other forage is scarce. This not only directly kills many trees but also prevents the survivors from making the vigorous early growth that is essential for a successful plantation. If accessible to any livestock, plantations should be fenced before planting.

Rabbits gnaw the bark of small trees in winter, sometimes completely girdling them. Where rabbits are numerous, much damage may be done. In most cases of girdling, however, the tree sprouts again and there is little direct mortality. Spraying or painting the trees with rabbit repellent may give some measure of control, although generally it is not worth the added expense. An effective repellent is made by stirring 5 pounds of liquid asphalt paint into 3-1/3 quarts of water, adding 3-1/3 pounds of copper carbonate, and enough water to make up 4 gallons.

Poplar canker (*Cytospora* sp.) often kills unhealthy or weakened young trees, especially on adverse sites where growth is relatively poor. Mortality due to this canker seems to occur mostly in the late fall and early winter, when the trees often lack adequate moisture. The inner bark on the main stem is attacked and killed first, and dead or dying trees may have healthy looking tops for a month or more. The canker is very common, and lives on dead wood when injured or weakened live tissue is not available. The only remedy seems to be to promote vigorous growth in the first year by adequate release or cultivation.

Poplar leaf-beetles and caterpillars cause partial and sometimes complete defoliation of small trees both in plantations and in nursery beds. The insects may be found during most of the growing season,

but are likely to be most numerous and damaging in late summer. The damage usually is not serious, however, since even complete defoliation results only in slightly reduced growth. Control measures are not needed in plantations, but may sometimes be desirable in nurseries. Spraying with arsenate of lead is effective where control is needed.

Aphids or plant lice, cultivated by ants, often cause slight damage by retarding the growth of infested trees. Most harm is done to weak, slow-growing trees, so it is very desirable to promote vigorous early growth by cultivation or release. Spraying with 40 percent nicotine sulphate or a kerosene emulsion is an effective control measure, but usually is not necessary.

COSTS AND RETURNS

The cost of planting cottonwood will vary according to (1) the condition of the planting site and the intensity of site preparation, (2) the availability of planting stock, (3) the need for release and cultivation, (4) the spacing, and (5) the cost of labor. The following itemized estimate is thought to represent the average cost per acre of planting cottonwood 6 by 10 feet on cut-over land, with farm labor at \$2 per day:

Ground preparation	\$ 3.00
Plowing furrows	3.00
Planting stock	2.00
Planting	2.00
Release or cultivation (twice in the first year)	5.00
Total cost	\$15.00

Since there are no mature cottonwood plantations in the Yazoo-Mississippi Delta, returns must be estimated from the best available information. Net returns will of course vary widely according to the value of the land, the tax rate, the cost of planting, the value of stumpage, the volume of timber produced, and even the manner in which net returns are computed. There is, therefore, no possibility of a simple, precise answer to the question of net returns, but conservative estimates should show whether or not there is a sufficiently large margin for profit to make the investment attractive.

It is thought that the greatest average annual growth in board feet is attained at about 35 years, when the yield in fully stocked stands is estimated to be 27,500 board feet per acre, Doyle rule. At \$8 per M board feet for stumpage, this amounts to \$220 per acre. The 3 percent severance tax in Mississippi reduces this to \$213.40 per acre. The per-acre expenditures made in order to obtain this return are estimated as follows:

Planting	\$15 90
Taxes on land	
50c annually for 35 years for land protected by the levee	17.50
or 5c annually for 35 years for unprotected land	1.75
Protection from fire and grazing	
An average of 5c annually for 35 years	1.75

Cash expenditures of \$34.25 per acre on land protected by the levee, of \$18.50 per acre on batture land, are therefore estimated to result in a return of \$213.40 after 35 years. The net returns are \$179.25 and \$194.90 per acre, respectively. These figures are deliberately conservative since they ignore additional returns from pulpwood, both in thinnings during the 35-year period and in the final harvest from the tops of sawlog trees and from trees too small for sawlogs. Thinnings alone will probably yield at least 30 cords of pulpwood worth \$1 per cord, and the first thinning will be needed when the plantation is only about 10 years old.

These calculations, like those for most farm enterprises, do not take into account compound interest. It is customary, however, in calculating probable returns from forest plantations to carry all expenditures at a rate of compound interest that it is expected could be obtained from relatively long-term investments. If a plantation can show a substantial net return after computing the costs on such a basis, it is considered a good investment. This method is used in the following table, which again is conservative in ignoring all yields of pulpwood:

TABLE I. ESTIMATED COSTS AND RETURNS PER ACRE
FROM COTTONWOOD PLANTATIONS HARVESTED AT 35 YEARS

Item	Land protected by the levee	Unprotected batture land
Interest on cost of land	4% on \$15.00.....\$44.19	4% on \$5.00.....\$14.73
Cost of planting	\$15.00 carried at 4%..... 59.19	\$15.00 carried at 4%..... 59.19
Taxes on land	\$ 0.50 annually carried at 4%..... 36.82	\$ 0.05 annually carried at 4% 3.68
Cost of administration and fire protection	\$ 0.05 annually car- ried at 4%..... 3.68	\$ 0.05 annually carried at 4% 3.68
Total cost	143.88	81.28
Gross return from stumpage	27½ M bd. ft. at \$8.00 per M..... 220.00	27½ M bd. ft. at \$8.00 per M..... 220.00
Mississippi severance tax	3% of gross return.... 6.60	3% of gross return.. 6.60
Net return from stumpage	213.40	213.40
Net profit	69.52	132.12
Average annual net profit after carrying all costs at 4% compounded	1.99	3.77

These computations indicate that well-stocked cottonwood plantations should prove very profitable. Under intensive management, with frequent thinnings, cottonwood plantations will probably be profitable even on rather costly and heavily taxed land. Cottonwood plantations on cheap, cut-over batture lands offer the greatest promise, however, since plantations on these lands should yield an excellent profit where otherwise little or nothing of value would be produced for a long period.