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Early Pruning Affects 15-Year Growth of Cottonwood Planted at 40- by 40-Foot Spacing

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Abstract

We compared the growth of eastern cottonwood (*Populus deltoides* Bartr. ex Marsh.) trees planted at 40- by 40-foot spacing and subjected to four pruning treatments from the 2nd through the 8th year of growth. Treatments were (1) no pruning, (2) prune to one-third of total height annually, (3) prune to one-half of total height annually, and (4) prune to 17 feet when diameter at breast height (d.b.h.) exceeded 8.5 inches, which occurred in the 4th year. Diameter and height measurements were taken annually for 15 years. By age 15, average diameters differed significantly among all four treatments and ranged from 16.8 inches (half-height pruning) to 19.8 inches (no pruning). Pruning had no effect on total height, which averaged 110 feet across all treatments. Total sawtimber volume differed significantly among treatments and ranged from 3,921 board feet (Doyle) per acre (half-height pruning) to 6,919 board feet (Doyle) per acre (no pruning). In widely spaced cottonwood plantations, pruning is not recommended if pulpwood production is the sole objective of management, but is necessary if quality sawtimber production is the primary objective of management. The mean d.b.h. of unpruned trees planted at 40- by 40-foot spacing represents the maximum potential diameter achievable for cottonwood and can serve as a benchmark for comparison to diameters observed at narrower spacings.

Keywords: Bole quality, eastern cottonwood, growth, plantation management, pruning, wide spacing.

INTRODUCTION

Diameter growth of eastern cottonwood (*Populus deltoides* Bartr. ex Marsh.) in plantations is restricted by competition from other cottonwood trees. The age at which competition begins and the intensity of competition depend on the initial spacing of the plantation, site characteristics, moisture availability, and the genetics of the planting stock. At initial spacings ranging from 4 by 9 feet to 16 by 18 feet, maximum diameter growth of cottonwood occurred in the first 4 years after plantation establishment (Krinard and Johnson 1975). Initial spacing is thus an important consideration in plantation management of cottonwood because it ultimately influences both tree size and rotation length, whether pulpwood or sawtimber production is desired.

However, the influence of competition on crown development and diameter growth of cottonwood established at a very wide spacing may be minimal. Diameter growth under conditions of minimal competition may identify the maximum potential diameter increment achievable for cottonwood and could serve as an upper limit for comparison to diameter growth observed at other spacings. A very wide initial spacing also may identify the minimum rotation length required for production of sawtimber or veneer logs, or both. Widely planted cottonwood trees would need to be pruned, however, to maintain clear boles and improve stem quality.

This study was initiated to compare growth of cottonwood trees planted at 40- by 40-foot spacing and to evaluate the effects of different pruning treatments on growth. Early results were reported by Krinard (1979, 1985).

METHODS

The study was established on batture land (unprotected by levees) at Huntington Point in western Bolivar County, MS. The land is within the floodplain of the Mississippi River and was owned by Chicago Mill and Lumber Company at the time of plantation establishment. Soil type is Commerce silt loam (fine-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquept). Site index for cottonwood was estimated to range from 105 to 125 feet at 30 years (Broadfoot 1976).

The 9-acre study site was cleared in 1971, fallowed in 1972, and planted in 1973. However, the Mississippi River flood of 1973 destroyed the plantation and it was replanted in January 1974. A matrix of 16 rows by 16 columns provided 256 planting spots. Spacing between planting spots was 40 by 40 feet. Three 18-inch cuttings of select Stoneville clone 66 (Land 1974) were planted at each spot and thinned to one tree per spot in June 1974.

Study design was a randomized complete block with four replications of four treatments. Each treatment plot per replication consisted of 4 rows by 4 columns, for a total of 16 trees. This 16-tree plot (0.588 acres) was considered to be the experimental unit.

Disking was performed several times each year to control weeds during the first five growing seasons. The site was tilled in July of the sixth growing season to help eliminate ruts. Annual weed control thereafter was by mowing.

Pruning treatments were applied from the 2nd through the 8th years: (1) no pruning (control), (2) prune to one-third of total height annually (third-height pruning), (3) prune to one-half of total height annually (half-height pruning), and (4) prune to 17 feet when diameter at breast height (d.b.h.) exceeded 8.5 inches, which first occurred in the 4th year (17-foot pruning).

Trees were pruned by hand from a boom-mounted ladder attached to a small bulldozer. Pruning was completed during the dormant season after the 2nd through the 5th years, delayed until early July due to flooding after the 6th year, and completed in early May after the 7th and 8th years. Epicormic sprouts were removed monthly from the 2nd through the 5th years, but were removed only at the time of pruning in subsequent years.

Total height and d.b.h. of each tree were measured annually for 15 years. Maximum crown diameter in the north-south and east-west directions for all trees and diameters outside bark at 9, 13, and 17 feet on four trees per treatment plot were measured after the 5th and 10th years. Crown diameter and upper-stem diameter data were reported by Krinard (1985).

Board-foot volume estimations were obtained from dendrometer measurements taken on two trees per treatment plot during the 9th growing season and after the 14th growing season. Data were combined to produce the following volume equation for trees ≥ 12.5 inches d.b.h. to a minimum top diameter of 10 inches:

$$V_{DOYLE} = -85.1 + 0.008090D^2H \qquad r^2 = 0.98 \qquad s_{y,x} = 11.9$$

where

V_{DOYLE} = volume, in board feet (Doyle scale)

D = d.b.h., in inches

H = total height, in feet

Analysis of variance for a randomized complete block design was used to detect differences among treatments in d.b.h., annual diameter increment, total height, and annual height increment for each of the 15 years of the study. Sawtimber volume and annual sawtimber volume increment were analyzed for the 10th through the 15th years only. Significance tests were conducted at the 0.05 level of probability. Treatment effects were considered fixed; block effects were considered random. Duncan's New Multiple Range Test was used to separate treatment means. Plot averages used in the analyses included all trees except 4 trees that were replanted after the 1st year and 22 trees that suffered broken tops during the first 6 years.

RESULTS AND DISCUSSION

Effects of Pruning on Growth

Mean d.b.h. was significantly affected by pruning treatments from the 3rd through the 15th years (table 1). Throughout most of this period, all treatments were significantly different from each other. Significant differences among pruning treatments in mean annual diameter increment actually began in the 2nd year and continued through the 6th year, with significant differences also found in the 8th and 15th years (table 2). These early reductions in diameter growth as a result of pruning were maintained throughout the remainder of the study (fig. 1). Annual diameter increment generally declined from the 2nd and 3rd years through the 8th year, but was nearly constant thereafter (fig. 2). Mean annual diameter increment of unpruned trees (control) and trees not yet pruned (17-foot pruning) peaked during the 3rd year, whereas mean annual diameter increment of trees pruned at the end of the 2nd year (third-height

Table 1—Mean d.b.h., by year and pruning treatment, of cottonwood planted at 40- by 40-foot spacing; means within a column followed by the same letter are not significantly different at the 0.05 level of probability

	Year														
Pruning treatment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
								inches							
Control	1.1 a	4.0 a	7.2 a	9.6 a	11.4 a	13.0 a	14.0 a	14.8 a	15.5 a	16.4 a	17.1 a	17.8 a	18.4 a	18.9 a	19.8 a
Third-height pruning	1.1 a	4.1 a	6.9 b	8.9 b	10.3 c	11.6 c	12.5 c	13.2 c	13.9 c	14.7 c	15.4 c	16.0 c	16.5 c	17.2 b	17.9 c
Half-height pruning	1.1 a	3.8 a	6.3 c	8.1 c	9.2 d	10.4 d	11.4 d	12.0 d	12.6 d	13.4 d	14.2 d	14.8 d	15.4 d	16.1 c	16.8 d
17-foot pruning	1.1 a	4.1 a	7.3 a	9.6 a	10.9 b	12.2 b	13.2 b	14.0 b	14.7 b	15.5 b	16.3 b	17.0 b	17.6 b	18.2 a	18.9 b
Overall average	1.1	4.0	6.9	9.1	10.5	11.8	12.8	13.5	14.2	15.0	15.7	16.4	17.0	17.6	18.4

Table 2—Mean annual diameter increment, by year and pruning treatment, of cottonwood planted at 40- by 40-foot spacing; means within a column followed by the same letter are not significantly different at the 0.05 level of probability

	Year													
Pruning treatment	2	3	4	5	6	7	8	9	10	11	12	13	14	15
							inches							
Control	2.9 a	3.2 a	2.4 a	1.7 a	1.5 a	1.0 a	0.9 a	0.7 a	0.8 a	0.7 a	0.7 a	0.6 a	0.6 a	0.9 a
Third-height pruning	3.0 a	2.8 b	2.0 b	1.4 b	1.2 b	0.9 a	0.7 b	0.7 a	0.8 a	0.7 a	0.6 a	0.6 a	0.6 a	0.8 b
Half-height pruning	2.7 b	2.4 c	1.8 b	1.1 d	1.2 b	0.9 a	0.6 b	0.6 a	0.8 a	0.8 a	0.7 a	0.6 a	0.7 a	0.7 b
17-foot pruning	3.0 a	3.2 a	2.4 a	1.3 c	1.2 b	1.0 a	0.8 a	0.7 a	0.8 a	0.8 a	0.7 a	0.6 a	0.6 a	0.8 b
Overall average	2.9	2.9	2.2	1.4	1.3	1.0	0.8	0.7	0.8	0.7	0.7	0.6	0.6	0.8

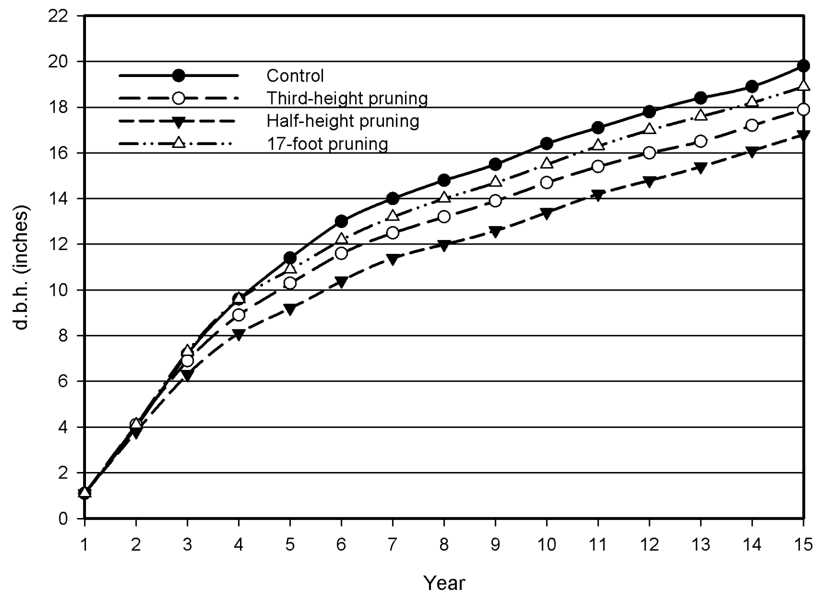

Figure 1—Mean d.b.h., by year and pruning treatment, of cottonwood planted at 40- by 40-foot spacing.

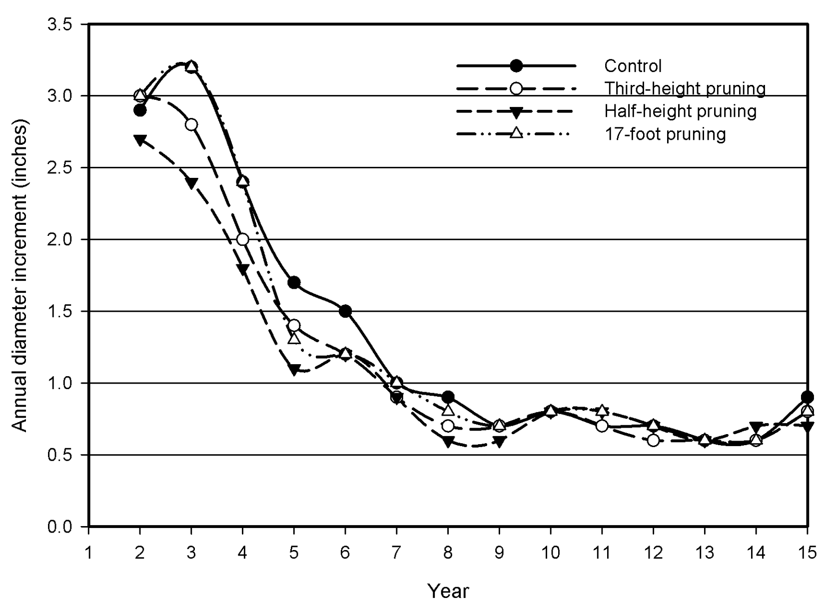

Figure 2—Mean annual diameter increment, by year and pruning treatment, of cottonwood planted at 40- by 40-foot spacing.

pruning and half-height pruning) peaked during the 2nd year and declined thereafter.

Pruning had no effect on either total height (table 3) or mean annual height increment (table 4) at any time during the course of the study. Consequently, data for both variables were averaged across all treatments. Height growth was very rapid and mean total height reached 100 feet by age 11 (fig. 3). Mean annual height increment actually peaked in the 4th year, but remained high through the 5th year (fig. 4). It gradually declined from the 5th through the 12th years and was nearly constant thereafter.

Sawtimber volume differed significantly among treatments from the 10th through the 15th years (table 5). Early differences among treatments in diameter growth as a result of pruning eventually translated into differences in sawtimber volume, and these differences were maintained through later years (fig. 5). Mean annual sawtimber volume increment also differed significantly among treatments in most years (table 6). Annual volume growth fluctuated from year to year and among treatments, but generally averaged from 500 to 900 board feet (Doyle) per acre (fig. 6).

The cottonwood clone used in this study was classified as a select clone primarily because of rapid early growth when planted at close spacings (Mohn and others 1970). Other cottonwood clones with different rates of growth and crown development may respond differently at wide spacings, but similar data for other clones are not available.

During the period of maximum diameter growth (within the first 5 years), pruning treatments had a negative effect on diameter growth. Because pruning reduced the length of the crown and therefore reduced the amount of foliage on the tree, total photosynthate production by the tree also was reduced and diameter growth was diminished. When pruning was discontinued, mean annual diameter increment recovered, but the early effects of pruning on tree diameter persisted for the remainder of the study. In other words, trees that had smaller diameters as a result of early pruning continued to have smaller diameters many years after pruning was discontinued, even though mean annual diameter increment no longer was affected.

Unpruned cottonwood trees in this study were larger and contained more sawtimber volume than pruned trees, but logs in the unpruned trees exhibited very low quality because of the large number of limbs retained on the bole. In fact, logs in the unpruned trees likely will be marketed as pulpwood rather than as sawtimber due to the large number of defects on the bole.

The decision to prune or to not prune cottonwood trees planted at very wide spacings depends on the goals of management. If the sole objective of management is pulpwood production, pruning is not recommended. The unpruned trees in this study were significantly larger and contained more volume than the pruned trees. Thus, pruning is not necessary to achieve the management objective of maximum fiber production in the shortest period of time. However, if the primary objective of management is sawtimber production, pruning of trees planted at very wide spacings is necessary to produce quality sawlogs.

However, annual pruning over several years probably is not economically feasible. In this study, a one-time pruning to a height of 17 feet when d.b.h. exceeded 8.5 inches

Table 3—Mean total height, by year and pruning treatment, of cottonwood planted at 40- by 40-foot spacing; means within a column followed by the same letter are not significantly different at the 0.05 level of probability

	Year														
Pruning treatment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
								feet							
Control	10 a	24 a	37 a	50 a	62 a	72 a	81 a	84 a	91 a	95 a	101 a	103 a	105 a	107 a	109 a
Third-height pruning	11 a	24 a	36 a	50 a	62 a	72 a	80 a	84 a	92 a	96 a	102 a	104 a	106 a	110 a	112 a
Half-height pruning	11 a	23 a	35 a	48 a	60 a	67 a	77 a	81 a	88 a	92 a	99 a	100 a	102 a	106 a	108 a
17-foot pruning	11 a	24 a	36 a	50 a	62 a	70 a	80 a	82 a	91 a	96 a	102 a	104 a	106 a	108 a	111 a
Overall average	11	24	36	50	62	70	80	83	90	94	101	103	105	108	110

Table 4—Mean annual height increment, by year and pruning treatment, of cottonwood planted at 40- by 40-foot spacing; means within a column followed by the same letter are not significantly different at the 0.05 level of probability

	Year													
Pruning treatment	2	3	4	5	6	7	8	9	10	11	12	13	14	15
							feet							
Control	13.2 a	13.2 a	12.8 a	12.6 a	9.1 a	9.4 a	3.0 a	7.0 a	4.0 a	6.1 a	2.0 a	2.0 a	2.0 a	2.1 a
Third-height pruning	12.9 a	12.4 a	13.9 a	12.3 a	9.4 a	8.8 a	3.9 a	7.7 a	3.6 a	6.3 a	2.0 a	2.1 a	3.5 a	2.0 a
Half-height pruning	12.4 a	11.8 a	13.3 a	11.6 a	7.6 a	9.6 a	3.8 a	7.4 a	3.7 a	6.9 a	1.7 a	2.0 a	4.0 a	1.9 a
17-foot pruning	13.4 a	12.2 a	13.3 a	12.4 a	8.2 a	9.7 a	3.0 a	7.9 a	4.5 a	6.4 a	1.8 a	2.3 a	2.3 a	2.3 a
Overall average	13.0	12.4	13.3	12.2	8.6	9.4	3.4	7.5	4.0	6.4	1.9	2.1	3.0	2.1

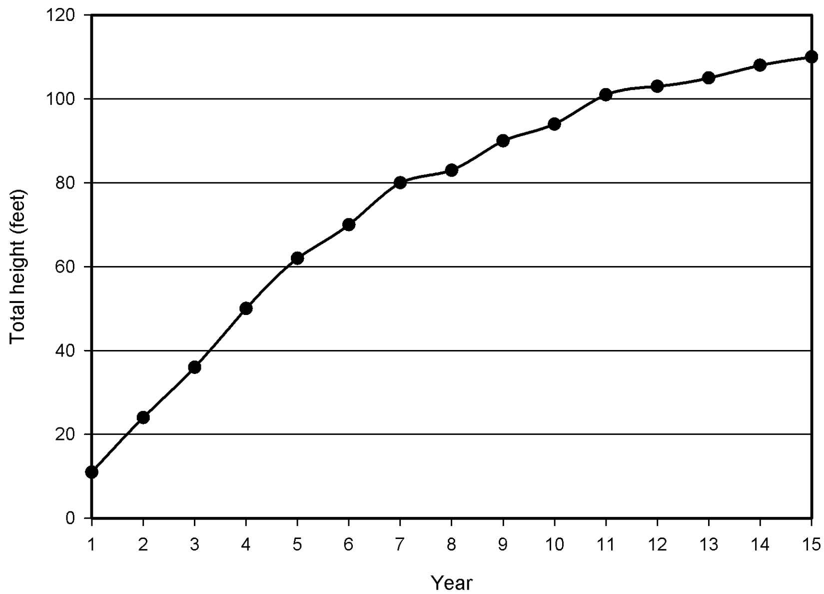

Figure 3—Mean total height, by year, of cottonwood planted at 40- by 40-foot spacing.

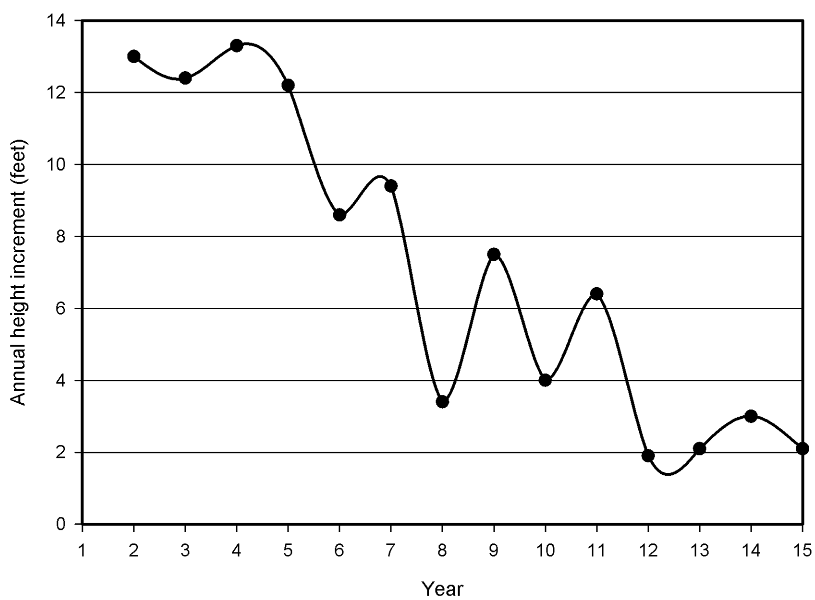

Figure 4—Mean annual height increment, by year, of cottonwood planted at 40- by 40-foot spacing.

Table 5—Mean sawtimber volume, in board feet (Doyle) per acre, for the 10th through the 15th years, by pruning treatment, of cottonwood trees ≥12.5 inches d.b.h. to a 10-inch top; means within a column followed by the same letter are not significantly different at the 0.05 level of probability

	Year					
Pruning treatment	10	11	12	13	14	15
Control	3172 a	4048 a	4744 a	5338 a	5970 a	6919 a
Third-height pruning	2142 b	2915 b	3450 b	3990 b	4686 b	5406 b
Half-height pruning	1075 c	1736 c	2192 c	2749 c	3426 c	3921 c
17-foot pruning	2716 ab	3632 ab	4241 ab	4840 ab	5554 ab	6362 ab
Overall average	2276	3083	3657	4229	4909	5652

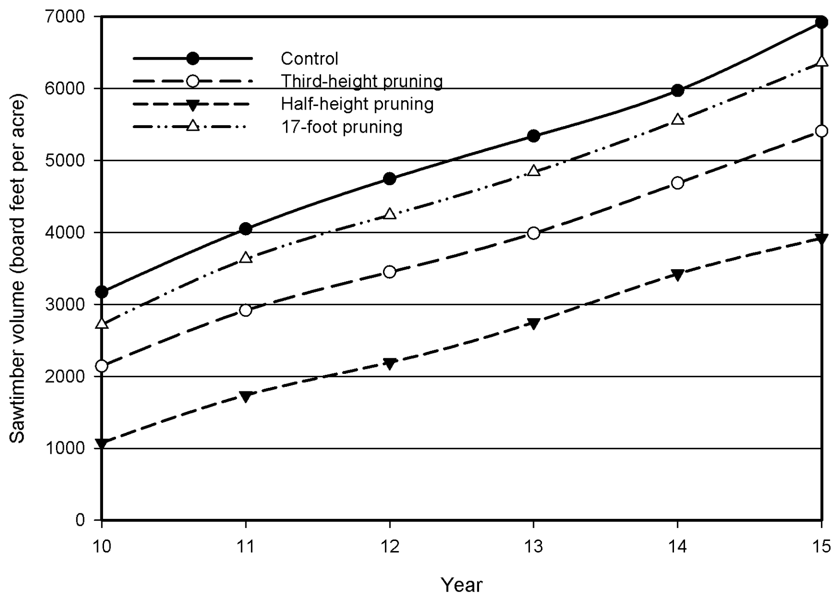

Figure 5—Mean sawtimber volume (Doyle) for the 10th through the 15th years, by pruning treatment, of cottonwood planted at 40- by 40-foot spacing.

(which occurred during the 4th year) resulted in the least adverse effect on mean d.b.h. by age 15 years. This pruning treatment did not significantly reduce mean sawtimber volume per acre, when compared to the unpruned control. However, numerous epicormic branches were produced along the lower bole of trees subjected to this one-time pruning at the end of the 4th year. Because the spacing between trees was very wide, most of the epicormic branches persisted and were still on the lower bole at the end of the 15th year. Consequently, the quality of the butt log on trees that received this pruning treatment was low. Additional pruning operations subsequent to the one performed at the end of the 4th year would be necessary to maintain a clear butt log.

A potentially attractive silvicultural option to optimize diameter growth, sawtimber volume growth, and the production of clear sawlogs may be to prescribe a series of two or more pruning operations designed to produce a clear bole to a height of 33 feet at the end of the second pruning. The first operation prunes the lower 17 feet of the bole when mean d.b.h. of the trees exceeds 8.5 inches. In our study, this threshold was reached by the end of the 4th year. Pruning to a height of 17 feet created a clear bole length that accounted for 34 percent of total tree height. The second operation prunes the lower 33 feet of the bole when the proportion of clear bole length to total tree height again would be about 35 percent after pruning. In our study, this threshold would have been reached by the end of the 10th year. At this point, total tree height averaged 94 feet. Pruning to a height of 33 feet would create a clear bole length that accounts for 35 percent of total tree height. A third pruning operation to remove epicormic branches produced on the lower 33 feet of the bole may or may not be necessary.

Maximum Potential Diameter and its Relation to Other Initial Spacings

A second objective of this study was to identify the maximum potential diameter achievable for cottonwood on a good site under conditions of minimal competition. The

Table 6—Mean annual sawtimber volume increment, in board feet (Doyle) per acre, for the 10th through the 15th years, by pruning treatment, of cottonwood trees ≥12.5 inches d.b.h. to a 10-inch top; means within a column followed by the same letter are not significantly different at the 0.05 level of probability

	Year					
Pruning treatment	10	11	12	13	14	15
Control	759 a	876 a	696 a	594 a	632 a	949 a
Third-height pruning	620 b	773 b	535 b	540 a	696 a	720 b
Half-height pruning	559 b	661 c	456 c	557 a	677 a	495 c
17-foot pruning	718 a	916 a	609 ab	599 a	714 a	808 ab
Overall average	664	806	574	572	680	743

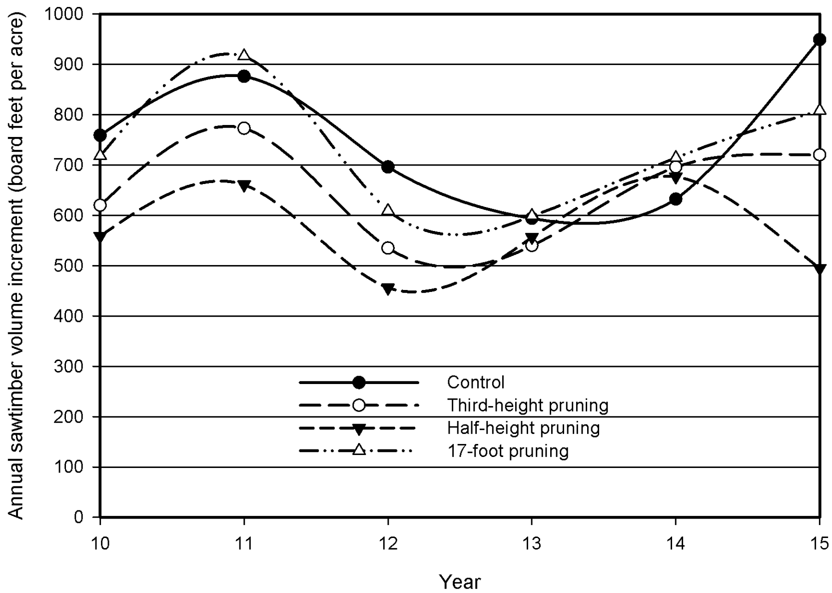

Figure 6—Mean annual sawtimber volume (Doyle) increment for the 10th through the 15th years, by pruning treatment, of cottonwood planted at 40- by 40-foot spacing.

cottonwood trees established at the 40- by 40-foot spacing experienced little competition from adjacent trees, such that crown development and diameter growth essentially were unimpeded over the course of the first 15 years after plantation establishment. In this sense, the mean d.b.h. of the unpruned trees in this study represents the maximum potential diameter achievable for cottonwood on similar sites, and can serve as a benchmark for comparison to diameters observed at narrower spacings.

Krinard and Johnson (1984) compared diameter growth over a 20-year period of cottonwood trees planted at four different initial spacings: 4 by 9 feet, 8 by 9 feet, 12 by 12 feet, and 16 by 18 feet. The plantation was established on a bottomland site on Commerce silt loam soil (the same soil series found in our study) near Fitler in Issaquena County, MS. Although site index was not measured directly in our study or in the Krinard and Johnson (1984) study, Broadfoot (1976) estimated site index for cottonwood on Commerce silt loam to range from 105 to 125 feet at 30 years. Because Commerce silt loam is the dominant soil series at both locations, we believe that the two sites are similar in site quality for cottonwood.

We used data from the unthinned plots in the Krinard and Johnson (1984) study to calculate mean d.b.h. of the cottonwood trees planted at each of the four initial spacings at the end of the 4th through the 15th years after plantation establishment. The mean d.b.h. values for each of the four initial spacings in that study then were compared to the mean d.b.h. values observed for the unpruned cottonwood trees at corresponding ages in our study. These comparisons are expressed as percentages of the maximum potential diameters achievable for cottonwood at ages 4 through 15 years and are presented in figure 7.

Initial spacing clearly has a strong and persistent effect on growth and development of cottonwood plantations on good sites (fig. 7), a consequence that has been reported many times for a wide variety of species (Clark and others 2010, DeBell and Harrington 2002, Kennedy 1993, Reukema and Smith 1987). Our intention, however, was not only to verify this effect, but also to quantify the degree to which initial spacing limits growth and development of cottonwood plantations. We express the influence of initial spacing as the percentage of maximum potential diameter achieved by cottonwood planted at the four initial spacings reported by Krinard and Johnson (1984). To illustrate, mean d.b.h. of cottonwood trees planted at the two narrow spacings (4 by 9 feet and 8 by 9 feet) ranges from 31 to 37 percent and from 41 to 46 percent, respectively, of the maximum potential diameter achievable for cottonwood at ages 4 through 15 years on good sites (fig. 7). Development of these cottonwood plantations is limited greatly by the narrow initial spacings. The influence of initial spacing on plantation development is somewhat less severe for cottonwood trees planted at the two wider spacings (12 by 12 feet and 16 by 18 feet), where mean d.b.h. ranges from 51 to 55 percent and from 58 to 63 percent, respectively, of maximum potential diameter (fig. 7).

The extent to which initial spacing limits growth and development of cottonwood plantations established at the four spacings evaluated by Krinard and Johnson (1984) remains relatively constant over time, at least through the first 15 years after plantation establishment (fig. 7). The lack of fluctuation within each of the lines depicted in figure 7 gives the illusion that plantation development is a stable and steady process. On the contrary, plantation development is a very dynamic and volatile process that results in many changes in stand density and structure over time.

The rapidity of these changes is especially pronounced in young cottonwood plantations. Because cottonwood is an inherently fast-growing species (Putnam and others 1960), individual trees in a plantation, except those established at very wide spacings, begin to experience severe competition from adjacent trees during the early stages of plantation development. Because cottonwood is a very shade-intolerant species (Baker 1949), individual cottonwood trees are not able to withstand severe competition for a long period of time. In general, small trees succumb quickly to severe competition and die in a short period of time. As severe competition becomes more widespread across the plantation, more and more trees die and the mortality rate increases sharply. When the majority of the trees that die have diameters smaller than the mean d.b.h. of the plantation as a whole, there is an immediate jump in the mean d.b.h. of the surviving trees. This process of self-thinning and the associated jump in mean d.b.h. likely contribute to the apparent ability of a cottonwood plantation to maintain a relatively stable relationship over time between its mean d.b.h. and the maximum potential diameter.

The onset of severe competition in cottonwood plantations established at narrow initial spacings occurs at a younger age and has a more detrimental effect than in plantations established at wide initial spacings. For example, the cottonwood plantation established at an initial spacing of 4 by 9 feet in the Krinard and Johnson (1984) study experienced a sharp increase in mortality rate during the 7th year and exceeded 50 percent cumulative mortality during the 11th year. By the end of the 15th year after establishment, cumulative mortality was 75 percent, mean d.b.h. of the plantation was 7.4 inches, and mean sawtimber volume was only 890 board feet (Doyle) per acre. In contrast, the cottonwood plantation established at an initial spacing of 16 by 18 feet in the Krinard and Johnson (1984) study did not

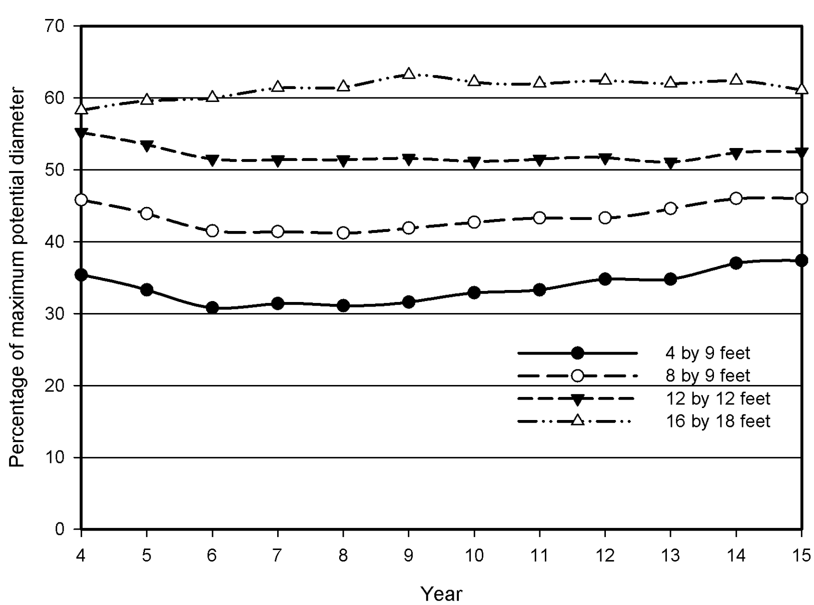

Figure 7—Percentage of maximum potential diameter, by year, achieved by cottonwood planted at four different initial spacings. (Spacing data source: Krinard and Johnson 1984)

suffer a large increase in mortality rate until the 14th year. By the end of the 15th year, cumulative mortality was only 24 percent, mean d.b.h. was 12.1 inches, and mean sawtimber volume was 5,534 board feet (Doyle) per acre. If we use the unpruned portion of our cottonwood plantation established at an initial spacing of 40 by 40 feet as a benchmark for maximum production of cottonwood plantations on good sites, then maximum potential diameter at age 15 years is 19.8 inches and maximum potential sawtimber volume at the same age is 6,919 board feet (Doyle) per acre. Clearly, selection of the most appropriate initial spacing for management objectives is one of the most important decisions to be made prior to plantation establishment.

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LITERATURE CITED

Baker, F.S. 1949. A revised tolerance table. Journal of Forestry. 47(3): 179-181.

Broadfoot, W.M. 1976. Hardwood suitability for and properties of important Midsouth soils. Res. Pap. SO-127. New Orleans: U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station. 84 p.

Clark, A., III; Daniels, R.F.; Jordan, L.; Schimleck, L. 2010. Impact of initial spacing on yield per acre and wood quality of unthinned loblolly pine at age 21. In: Stanturf, J.A., ed. Proceedings of the 14th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-121. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 333-337.

DeBell, D.S.; Harrington, C.A. 2002. Density and rectangularity of planting influence 20-year growth and development of red alder. Canadian Journal of Forest Research. 32(7): 1244-1253.

Kennedy, H.E., Jr. 1993. Effects of crown position and initial spacing on foliar nutrient composition of seven bottomland hardwoods. Res. Note SO-371. New Orleans: U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station. 6 p.

Krinard, R.M. 1979. Five years' growth of pruned and unpruned cottonwood planted at 40- by 40-foot spacing. Res. Note SO-252. New Orleans: U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station. 5 p.

Krinard, R.M. 1985. Ten years' growth of pruned and unpruned cottonwood planted at 40- by 40-foot spacing. Res. Note SO-316. New Orleans: U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station. 5 p.

Krinard, R.M.; Johnson, R.L. 1975. Ten-year results in a cottonwood plantation spacing study. Res. Pap. SO-106. New Orleans: U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station. 10 p.

Krinard, R.M.; Johnson, R.L. 1984. Cottonwood plantation growth through 20 years. Res. Pap. SO-212. New Orleans: U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station. 11 p.

Land, S.B., Jr. 1974. Forest tree improvement: Mississippi certifies nation's first "blue tag." Journal of Forestry. 72(6): 353.

Mohn, C.A.; Randall, W.K.; McKnight, J.S. 1970. Fourteen cottonwood clones selected for Midsouth timber production. Res. Pap. SO-62. New Orleans: U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station. 17 p.

Putnam, J.A.; Furnival, G.M.; McKnight, J.S. 1960. Management and inventory of southern hardwoods. Agric. Handb. 181. Washington, DC: U.S. Department of Agriculture. 102 p.

Reukema, D.L.; Smith, J.H.G. 1987. Development over 25 years of Douglas-fir, western hemlock, and western redcedar planted at various spacings on a very good site in British Columbia. Res. Pap. PNW-RP-381. Portland, OR: U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station. 46 p.

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Meadows, James S.; Krinard, Roger M. 2013. Early pruning affects 15-year growth of cottonwood planted at 40- by 40-foot spacing. Res. Pap. SRS–53. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 9 p.

We compared the growth of eastern cottonwood (*Populus deltoides* Bartr. ex Marsh.) trees planted at 40- by 40-foot spacing and subjected to four pruning treatments from the 2nd through the 8th year of growth. Treatments were (1) no pruning, (2) prune to one-third of total height annually, (3) prune to one-half of total height annually, and (4) prune to 17 feet when diameter at breast height (d.b.h.) exceeded 8.5 inches, which occurred in the 4th year. Diameter and height measurements were taken annually for 15 years. By age 15, average diameters differed significantly among all four treatments and ranged from 16.8 inches (half-height pruning) to 19.8 inches (no pruning). Pruning had no effect on total height, which averaged 110 feet across all treatments. Total sawtimber volume differed significantly among treatments and ranged from 3,921 board feet (Doyle) per acre (half-height pruning) to 6,919 board feet (Doyle) per acre (no pruning). In widely spaced cottonwood plantations, pruning is not recommended if pulpwood production is the sole objective of management, but is necessary if quality sawtimber production is the primary objective of management. The mean d.b.h. of unpruned trees planted at 40- by 40-foot spacing represents the maximum potential diameter achievable for cottonwood and can serve as a benchmark for comparison to diameters observed at narrower spacings.

Keywords: Bole quality, eastern cottonwood, growth, plantation management, pruning, wide spacing.

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