SOUTHERN FOREST EXPERIMENT STATION

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BENEFITS FROM THINNING BLACK WILLOW

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SOUTHERN FOREST EXPERIMENT STATION

Black willow stands 18 and 24 years old were cut from about 130 square feet of basal area per acre to near 95, 75, and 55 square feet. Growth was best on plots thinned to 55 square feet in the 24-year-old stand and to 95 square feet in the 18-year-old stand. The stands were along the Mississippi River.

One of the common tree species in the lower Mississippi Valley is black willow *(Salix nigra* Marsh.). It is concentrated in dense, even-aged stands along the river and its tributaries, often in association with cottonwood *(3)*. Black willow grows rapidly and usually matures in about 55 years *(1)*. The wood is used for factory lumber, commercial and package veneer, and pulpwood.

High density of stands often results in heavy mortality. If left alone, the trees tend to stagnate. Maisenhelder and Heavrin *(2)* contended that thinning would increase yields. The research reported here supports their contention.

THE STUDY

Two pole-sized stands along the Mississippi River batture were studied. The first, within a mile of Arkansas City, Arkansas, was 24 years old when treated in 1954 (fig. 1). Soil is Sharkey clay. Trees averaged 13.5 inches d.b.h. and were up to 115 feet tall. Basal area per acre averaged about 130 square feet, and total volume, about 3,700 cubic feet. There were 131 trees 5.1 inches d.b.h. and larger.

The second stand, about 10 miles south of Arkansas City, was treated in 1958 at age 18. Trees averaged 12.4 inches d.b.h.; dominants were up to 110 feet tall. The stand was on a Mhoon silty clay soil. A sand layer about 3 to 4 feet beneath the surface of two-thirds of the study area joined a nearby lake and probably held water throughout most of the growing season. Best growth occurred on this portion of the area. The stand averaged about 130 square feet of basal area and 3,700 cubic feet in 158 trees per acre 5.1 inches d.b.h. and larger.

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Figure 1.—*Twenty-four-year-old black willow stand thinned from approximately 130 to 75 square feet basal area per acre.*

Four thinning treatments were tested on both areas:

Check. No thinning.

Light thinning. To about 95 square feet of basal area per acre.

Medium. To about 75 square feet.

Heavy. To about 55 square feet.

In addition, two diameter-limit cuts were made on the 24-year-old stand:

Large-tree removal. All trees larger than 14.9 inches d.b.h. were cut.

Small-tree removal. All trees smaller than 13 inches d.b.h. were cut.

Each treatment was replicated three times in a randomized block design. Plots comprised 1 acre in the older stand and ½ acre in the younger.

All trees were tagged after treatment. Diameters of living trees were measured every 2 years until 1964. Local volume tables were made from direct measurement of cut trees and Abney-level measurement of standing trees. Cubic-foot volumes were computed for merchantable wood up to a 4-inch d.i.b. top, board-foot volumes (Doyle) to a 12 inch d.i.b. top.

Differences due to treatment were evaluated at the 95-percent level of probability by Duncan's multiple-range test.

RESULTS

Results are presented separately by stand. They are for a 10-year period in the older stand and a 6-year period in the younger.

Older Stand

After treatment, stocking ranged from 51 trees per acre on heavily thinned plots to 131 trees on the check plots (table 1). In general, the higher the stocking, the greater the mortality. In 10 years, mortality on the check plots

Table 1.—*Data summary for the 24-year-old stand*

Treatment and measurement year	Trees	Basal area	Volume	
			Cordwood [1]	Saw logs [2]
	No.	*Sq. ft.*	*Cu. ft.*	*Bd. ft.*
Check				
1954	131	128.3	3,715	4,391
1964	73	114.9	3,597	10,066
Annual change	−5.8	−1.3	−12	568
Light thinning				
1954	98	93.9	2,690	2,216
1964	64	99.8	3,111	8,058
Annual change	−3.4	0.6	42	584
Medium thinning				
1954	76	79.0	2,303	2,583
1964	60	101.1	3,190	9,440
Annual change	−1.6	2.2	89	686
Heavy thinning				
1954	51	58.2	1,716	2,153
1964	47	87.8	2,821	9,544
Annual change	−0.4	3.0	110	739
Small tree removal				
1954	62	79.3	2,384	3,588
1964	45	86.7	2,797	9,916
Annual change	−1.7	0.7	41	633
Large tree removal				
1954	92	72.0	1,984	0
1964	64	90.7	2,780	6,143
Annual change	−2.8	1.9	80	614

[1] Based on trees 5.0 inches d.b.h. and larger.
[2] Based on trees 15.0 inches d.b.h. and larger.

was 44 percent, as compared to 8 percent on heavily thinned plots.

A diameter growth rate of less than 2 inches in 10 years may be considered slow for black willow, 2 to 5 inches medium, and more than 5 inches fast. A majority of the trees grew at the medium rate. But fast growers were from four to six times more numerous in the thinned plots than in the unthinned. Large-tree removal produced more fast growers than all other treatments and a higher proportion than all except heavy thinning. Best growth of any tree was 7½ inches.

Stand growth was defined as the total 10-year change in volume or basal area of the residual trees. Volumes and basal areas of trees that died during the period were not included in the totals for 1964. Cull trees were measured and included, but trees growing into merchantable size (5.1 inches d.b.h.) were not.

Relation between growth and residual basal area was linear—the lower the beginning basal area, the better was the growth. The range in growth was from minus 1.3 square feet per acre annually on the check plots to 3 square feet on the heavily thinned plots.

Volume growth also was best on heavily thinned plots—110 cubic feet or about 1.4 cords annually (allowing 80 cubic feet to the cord). Check plots lost volume (table 1) (fig. 2). Cubic-foot growth was significantly lower on the check plots than on those given heavy and medium thinnings and on those from which large trees were removed.

Sawtimber growth ranged from about 740 board feet per acre per year on heavily thinned plots to about 570 board feet on check plots. Ingrowth accounted for 37 to 56 percent of the total, depending on treatment.

Growth per tree increased as degree of thinning increased. Trees on heavily thinned plots grew about 1.5 times more basal area and cubic-foot volumes than those on check plots and 1.2 times more than those in each of the other treatments. Growth per tree was significantly higher after heavy thinning than after large-tree removal, light thinning, and no thinning. Small-tree removal and medium thinning also resulted in significantly higher individual-tree growth rates than no treatment.

Trees growing into pulpwood size (5.1 inches d.b.h.) during the decade were largely hack-

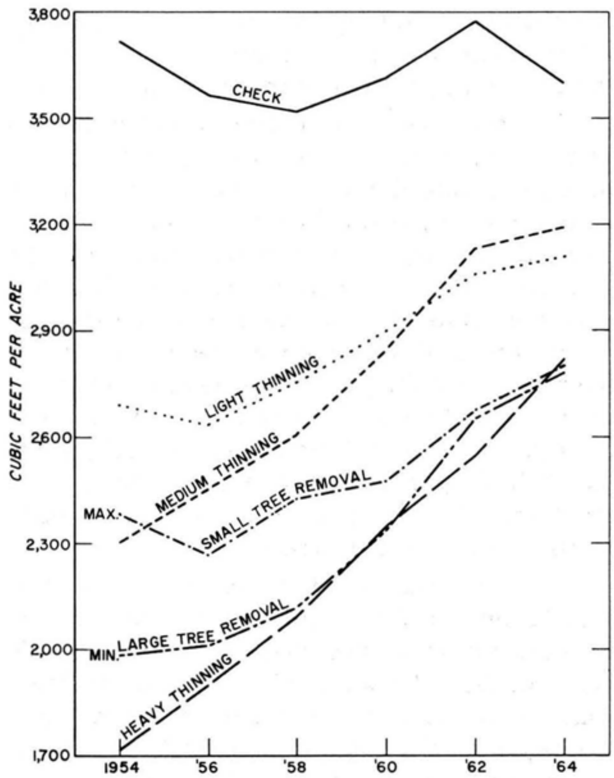

Figure 2.—*Cubic feet per acre for the 24-year-old stand.*

berry, privet, and pecan. Most were short and poorly formed. In 10 years, these trees added about 18 square feet of basal area per acre to the small-tree removal plots and about 5 square feet to the heavily thinned plots.

Younger Stand

In the younger stand, mortality from 1958 to 1964 reduced stocking of unthinned plots by about one-third, or 6 percent annually—more than twice the loss from mortality in thinned plots.

Fifty to 60 percent of the trees in the check and lightly thinned plots grew at the medium rate, whereas 60 to 80 percent of those on medium and heavily thinned plots grew fast (more than ½ inch per year). Percentage of fast growers rose as degree of thinning increased. Best growth of any tree, when projected on a 10-year basis, was 11½ inches.

Basal area growth was highest on the lightly thinned plots—4.3 square feet per acre. Plots given a medium and heavy thinning had a basal area growth of 4.0 and 3.9 square feet. Check plots lost growth. Two plots of each treatment were underlain with the sand layer mentioned earlier. Depending on treatment, these plots annually grew 1.9 to 6.1 square feet of basal area per acre more than corresponding plots without the sand layer.

Cubic-foot growth followed the same pattern as basal area. It reached a high of 164 feet, or over 2 cords per acre per year, in the light thinning treatment that started with about 2,900 cubic feet (fig. 3). The two lightly thinned plots with the sand layer grew 2.9 cords annually. Cubic-foot growth was significantly lower on the check than in each of the thinning treatments.

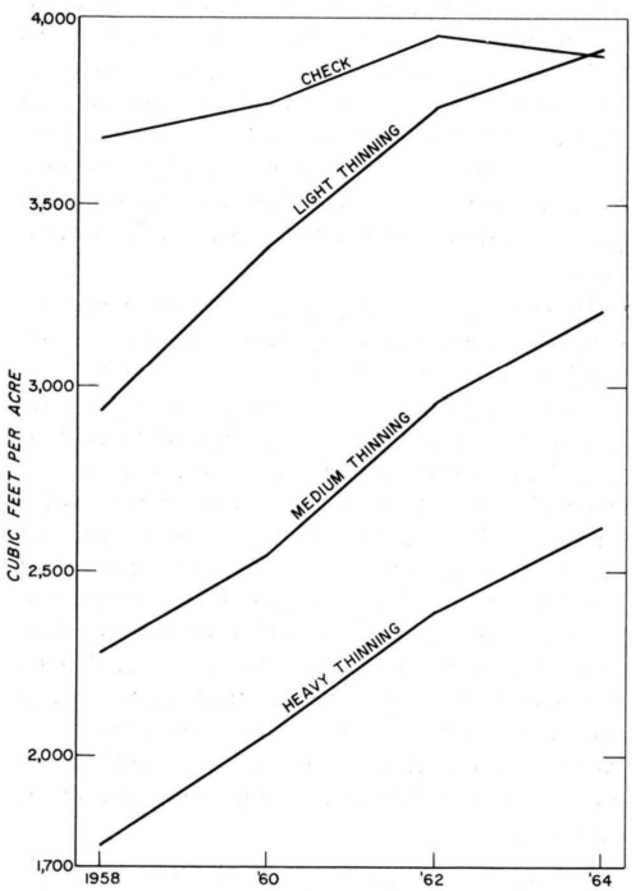

Figure 3.—*Cubic feet per acre for the 18-year-old stand.*

Sawtimber growth was good in all treatments, ranging from 803 board feet per acre annually on check plots to 1,152 board feet on lightly thinned plots (table 2). Ingrowth accounted for one-half to two-thirds of total growth, depending on treatment.

Table 2.—*Data summary for the 18-year-old stand*

Treatment and measurement year	Trees	Basal area	Volume	
			Cordwood [1]	Saw logs [2]
	No.	*Sq. ft.*	*Cu. ft.*	*Bd. ft.*
Check				
1958	158	131.3	3,676	1,922
1964	105	129.9	3,903	6,739
Annual change	−8.8	−0.3	38	803
Light thinning				
1958	90	99.9	2,932	3,457
1964	81	125.6	3,918	10,366
Annual change	−1.5	4.3	164	1,152
Medium thinning				
1958	80	79.2	2,274	1,409
1964	68	103.5	3,212	8,133
Annual change	−2.0	4.0	157	1,121
Heavy thinning				
1958	50	59.2	1,752	2,198
1964	46	82.4	2,625	8,045
Annual change	−0.7	3.9	146	975

[1] Based on trees 5.0 inches d.b.h. and larger.
[2] Based on trees 15.0 inches d.b.h. and larger.

As with the older stand, average growth of live trees increased as the degree of thinning increased. Compared with average basal area growth in heavily thinned plots, trees grew 84 percent as much after the medium thinning, 75 percent after light thinning, and 52 percent on check plots. The difference in individual-tree growths between heavily thinned and check plots was statistically significant.

Nonwillow species, primarily hackberry, invaded all plots and added about 3 square feet of basal area per acre to the medium and heavily thinned plots, 2 square feet to those lightly thinned, and less than 1 square foot to check plots.

Comparison of Stands

Even before treatment, differences between upper levels of stocking indicated that the site of the younger stand was superior to that of the older one. The younger stand contained 150 to 160 square feet of basal area as compared to 130 to 140 square feet in the older. At comparable basal areas, growth was considerably better in the younger stand. To simplify comparison between stands and treatments, average annual change in cubic-foot volume was expressed as a percentage of the volume after treatment:

Treatment	Younger stand	Older stand
	– Percent –	
Unthinned	1.0	0
Light thinning	5.6	1.6
Medium thinning	6.9	3.9
Heavy thinning	8.3	6.4
Small-tree removal	...	1.7
Large-tree removal	...	4.0

Mortality did not differ greatly between study areas for the same treatment. Therefore, site potential is indicated by excluding mortality and basing growth only on trees that survived. For example, surviving trees in all treatments added between 3½ and 4 square feet of basal area and about 130 cubic feet annually on the poorer site, and between 5½ and 6 square feet and about 200 cubic feet on the better site. The better site supported more surviving trees and about 1/3 more growth per tree.

Survivor growth reveals another aspect to the thinning treatments. On both sites growth was about the same in all treatments, although the beginning levels of stocking were quite different (fig. 4). The only exception was heavy thinning on the better site, where the lower growth may have been the result of inadequate stocking.

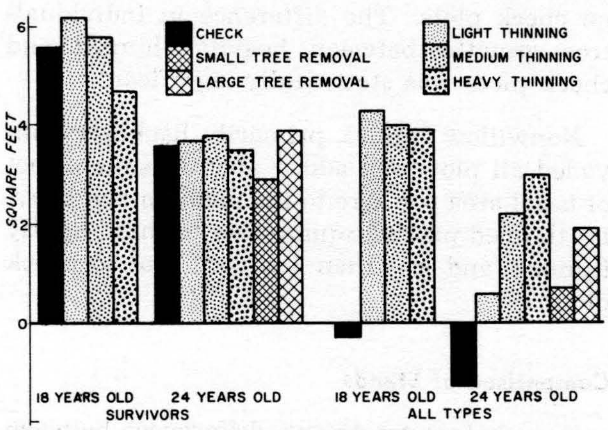

Figure 4.—*Annual basal area growth per acre.*

CONCLUSIONS

A major benefit to be derived from thinning willow is utilization of trees that would otherwise die. In this test selective thinning made available 2/3 to 2½ more cords per acre annually than could be obtained from unthinned stands.

Thinning also stimulates diameter growth of residuals. Survivor growth in this study was about the same whether spread over 47 or 73 trees on the poorer site and 68 or 105 on the better site. Growth was reduced on the better site when only 46 trees were left after thinning.

The best thinning in terms of subsequent growth depends on site. As indicated by the check plots, growth curves had probably flattened before thinning in both stands. But growth on the better site appeared to level off at about 130 square feet of basal area per acre and on the poorer site at about 90 square feet. On the good site then, a thinning interval of 6 years may be required to maintain the stand between 90 (the best base for growth) and 130 (where growth falls off) square feet. A cut every 10 years on the poorer site should confine the stand between 60 (minimum basal area for full site utilization) and 95 square feet. If site quality is unknown, thinning to about 70 square feet is probably the best compromise.

In this study, cutting the larger trees resulted in better growth than removal of the smaller trees. This finding is contradictory to what most foresters would expect. It can be partly explained by close scrutiny of individual plot data. After treatment, all three plots cut from above had basal areas and growth rates only slightly less than those of plots thinned at the medium rate. Two of the three plots cut from below had residual basal areas and growth rates close to those of lightly thinned plots; the third plot was nearer in basal area and subsequent growth to that after heavy thinning. Thus, growth rates after cutting of large or small trees were more a function of the residual basal area than the method of thinning.

It appears that either type of diameter-limit cutting may result in only slightly less growth than selective thinning if residual basal areas are equal. In the study, however, it was very difficult to control basal area in diameter-limit cuts. Other disadvantages are that spacing between trees cannot be manipulated nor can high-quality trees be favored.

Thinning was obviously beneficial in the black willow stands that were studied. In most stands in the lower Mississippi Valley, precommercial thinning is probably desirable when dominant trees average 3 to 4 inches d.b.h. About 350 trees per acre should be left.

The responses to thinning reported in this paper should help forest managers to choose an appropriate density for the residual stand. A reasonable rule-of-thumb to follow in commercial thinnings is to remove trees until the average spacing, in feet, is 1.75 times the average tree diameter. For example, if the average d.b.h. is 10 inches, spacing between trees should average 17.5 feet. The resulting stand contains about 142 trees and 77 square feet of basal area per acre. Any time the factor falls below 1.5, thinning is probably needed, even on a good site. The site is probably not being fully utilized if the factor exceeds 2.0.

Where managers cannot follow the recommendations of this paper, a minimum of two commercial thinnings may be an acceptable compromise. General observations indicate that the first should take place when dominants average about 10 inches d.b.h., and the second, when they are about 16 inches d.b.h.

The final harvest should usually take place when dominants average about 20 to 24 inches d.b.h. If the stand is allowed to develop further, it may break up quickly, particularly if a drought occurs.

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