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Small Hardwoods Reduce Growth of Pine Overstory

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Dense understory hardwoods materially decreased the growth of a 53-year-old and a 47-year-old stand of loblolly and shortleaf pines. Over a 14-year period, hardwood eradication with chemicals increased average annual ***yield*** from ***the 53-year-old stand by 14.3 cubic*** feet, ***or 123 board-feet per acre. In the 47-year-old stand the average annual treatment advantage was 32.6 cubic feet, or 342 board feet per acre, over an 11 -year period.***

Sawtimber stands of loblolly and shortleaf pine (*Pinus taeda* L. and *P. echinata* Mill.) frequently have dense understories of small hardwoods. In uplands in the South, soil moisture is seldom sufficient throughout the growing season for maximum pine growth, and understory hardwoods compete significantly for the limited amount of soil moisture. In midsummer in southern Arkansas, water was lost about 25 percent faster on plots with hardwoods left in place than on those with hardwoods removed (6).

Should these understories be eradicated or should they be ignored? To make the correct decision, the land manager must know to what extent they impair the growth of the pines above. Experiments to measure growth effects, however, have produced contradictory results. Eradication of understory hardwoods by burning had no effect on the diameter growth of 60-year-old loblolly pine in South Carolina (2). In Tennessee, Russell found that control of understory hardwoods failed to speed the growth of pole-size loblolly (4). Likewise, in South Carolina, McClay reported no improvement in diameter growth of l&inch loblolly pine after 5 years of hardwood control (3). He cautioned that conclusive comparisons could not be made until after several years of low rainfall. On the other hand, in the Ouachita Mountains of Arkansas, Bower and Ferguson showed that the removal of 33 square feet of hardwood understory basal area increased the growth of a shortleaf pine overstory by 31 percent (1). The improvement in overstory growth was smaller when only part of the understory was removed.

This paper presents the results of two long-term studies in stands of loblolly and shortleaf pine sawtimber. One study, in Bradley County, Arkansas, was continued for 14 years. The other, near Crossett, Arkansas, was started 4 years before the Bradley test. Two plots were destroyed by a tornado soon after establish-

ment, but four remaining plots were remeasured for 11 years. The weather conditions in 18 calendar years are represented by the two studies combined.

METHODS

The Bradley study was established in a 53-year-old pine stand in 1955.[1] The stand was even-aged and well-stocked. Loblolly pine accounted for 88 percent of the pine stems. Soil is Beauregard, a forested coastal-plain series. Because of gently rolling topography, all the experimental plots have good surface drainage. Site index ranges from 74 to 78 (at age 50). When the study was started a dense under-story of small hardwoods on all plots averaged about 9,000 plants per acre (fig. 1). Southern red oak (*Quercus falcata* Michx.) and sweetgum (*Liquidambar styraciflua* L.) made up 38 percent of the understory by number. The remainder consisted of blackgum (*Nyssa sylvatica* Marsh.), sumac (*Rhus* spp.), elm (*Ulmus* spp.), red maple (*Acer rubrum* Le.), dogwood (*Cornus* spp..), miscellaneous oaks (*Quercus* spp.), haw (*Crataegus* spp.), hickories (*Carya* spp.) , and various shrubs.

[1]The study was established in cooperation with and on land owned by the Bradley-Southern Division of Potlatch Forests. Inc.

Figure 1.—*Loblolly-shortleaf pine stand with dense understory of small hardwoods (background) and understory eradicated chemically (foreground).*

There were two treatments. In one, all hardwoods and shrubs were eradicated. In the other, all understory vegetation was left in place. Each treatment was replicated three times in a randomized block design. Plots were 1/4 acre in size. Each was surrounded by a 0.5-chain isolation strip that was treated in the same way as the plot.

Hardwoods and other broad-leafed vegetation were removed by cutting all that were over head high and wetting the top and sides of the stumps with a 5-percent oil solution of 2,4,5-T. Those under head high were given a foliar spray of a 2-percent water emulsion of 2,4,5-T applied with a hand sprayer. Today, cheaper and more efficient methods of chemical control are available.

To keep hardwoods from resprouting, plots were resprayed every 2 or 3 years with the water emlusion (fig. 1). Hardwoods on the three control plots were left undisturbed and were inventoried at 5-year intervals. At the start, all plots were thinned to a residual overstory basal area of 75 square feet and to a volume of approximately 2,330 cubic feet per acre. An average of 87 pines per acre was left on the control plots and 90 on the treated plots.

The pines were measured yearly to determine changes in basal area and board-foot volume. The study was extended for 14 years to measure responses to a wide range of rainfall patterns and totals. Water deficiencies during the growing season (May through October) were computed, because they have been shown to relate more meaningfully to growth than does total annual rainfall (5) .

The Crossett study was identical to the Bradley study with respect to objectives, treatment, pine species, understory hardwood species, plot size, and number of replications. It differed in time of initiation, location, site quality, stand age, and pine stocking.

It was established in 1951 by the USDA Forest Service in cooperation with the Crossett Company on land now owned by the Georgia-Pacific Corporation. The plots were located in Ashley County, Arkansas, 27 miles southeast of the Bradley area. Soil is Lexington silt loam. Site index is 88 (at age 50). When the study was established the even-aged loblolly-shortleaf pine stand was 47 years old and had a per-acre stocking of 132 trees, 103 square feet of basal area, and 3,218 cubic feet of wood volume. In the understory a thick cover of small hardwoods and woody shrubs averaged 5,590 plants per acre. The hardwoods and shrubs were completely eradicated on three plots, but were left intact on three control plots.

RESULTS

In the Bradley study hardwood numbers per acre on control plots decreased from 8,777 to 5,222 (fig. 2). Hardwood density increased, however, because average stem diameters increased from 0.6 inch in 1955 to 1.1 inches in 1968. Understory basal area increased from 18.4 square feet per acre in 1955 to 32.7 square feet in 1968. It seems safe to assume, therefore, that the demand of understory hardwoods for soil moisture did not diminish during the study.

From the start, the average periodic cubic growth per year was greater on the treated plots, but not always to a significant degree (fig. 3). In 1964, the periodic cubic-foot growth of the plots without hardwoods proved to be significantly greater than the control yields, starting a firm trend that continued un-

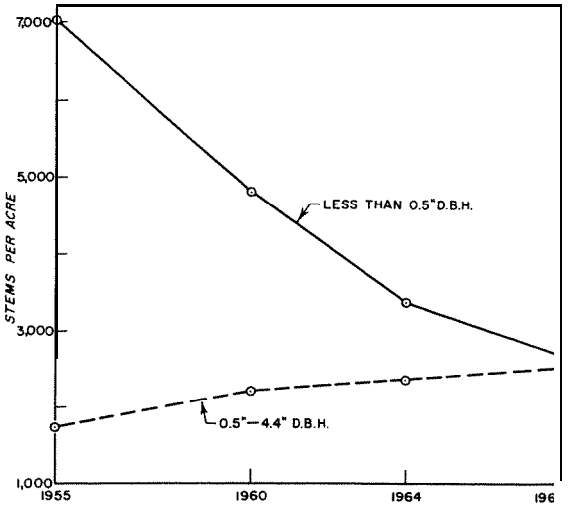

Figure 2.—*Changes* in numbers of hardwoods per acre on control plots.

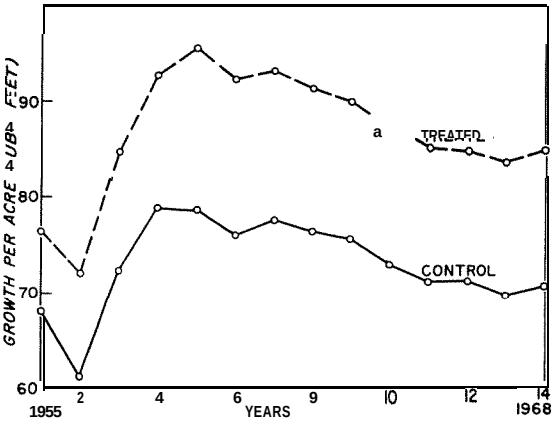

Figure 3.—*Periodic annual cubic growth per acre.*

diminished to the termination of the study in 1968. Periodic annual board-foot and basal area growth differences were also significantly higher on treated than on untreated plots from 1964 onward.

At the start of the study both treatments were similar in basal area and cubic volume. The cumulative growth trend lines diverged early, indicating a rapid response to hardwood removal. The advantage of treatment increased continuously to the close of the study (figs. 4 and 5). In the beginning the treated plots had a small ad-

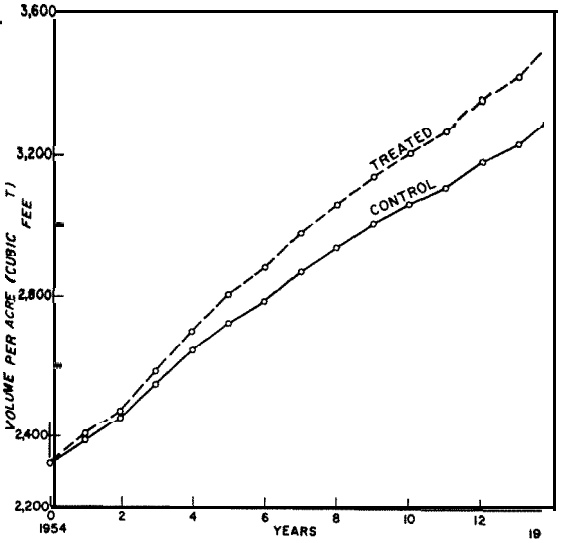

Figure 4.—*Stand* in cubic feet *per acre at end of each growing season.*

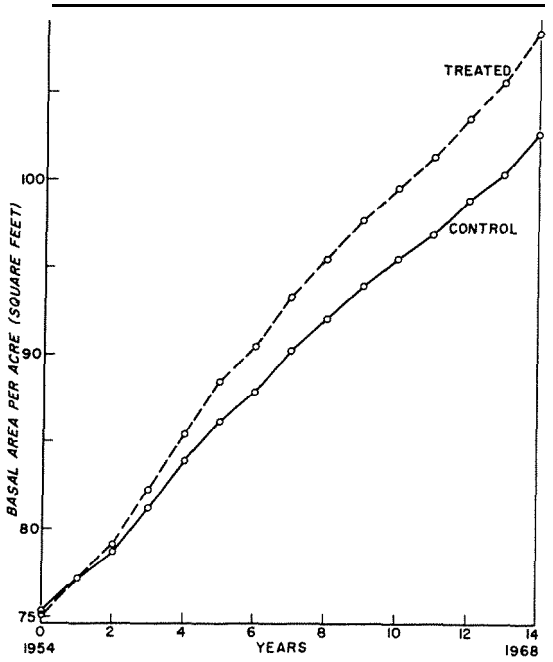

Figure 5.—*Stand* in basal area *per acre at end of each growing season.*

vantage over the controls in board-foot stocking. The response to hardwood removal, however, more than quadrupled the initial advantage in favor of the treated areas (fig. 6).

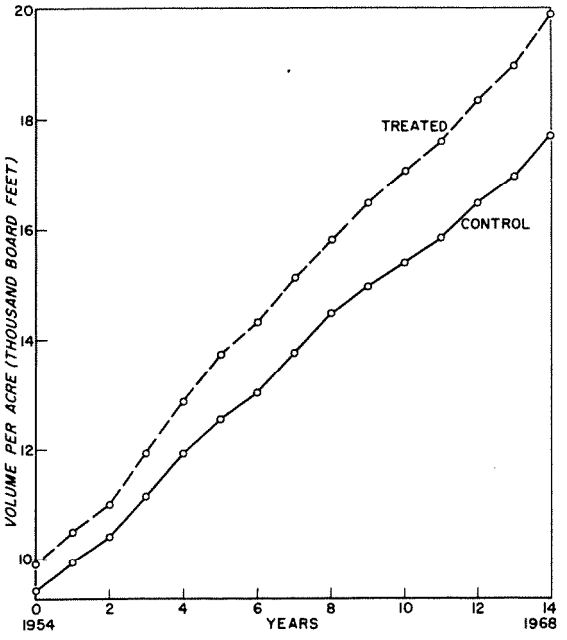

Figure 6.-Stand *in* board *feet per acre at* end of each growing season.

Average annual growth per acre during the study was:

Treatment	Cubic feet[1]	Board feet[2]	Square feet of basal area
Hardwoods removed	84.9	713	2.4
Hardwoods left	70.6	590	2.0
Difference	14.3	123	.4

[1]All trees included.
[2]International ¼ -inch rule. Trees 9 ½ inches d.b.h. and larger.

In 14 years the total growth advantage per acre attributable to understory hardwood removal amounted to 200 cubic feet or 1,720 board feet. These differences were obtained in stands well stocked to begin with and heavily stocked when the test ended. When the study began the treated plots had an average basal area of 75.1 square feet and a volume of 2,328 cubic feet, or 9,908 board feet per acre. At the close of the test these averages had increased to 108.3 square feet, 3,517 cubic feet, and 19,891 board feet. By contrast, the beginning and ending per-acre stockings for the controls were 75.3 and 102.6 square feet, 2,330 and 3,319 cubic feet, and 9,431 and 17,687 board feet.

In general, current annual cubic-foot growth varied inversely with growing-season water deficiency (fig. 7). Without exception, the trees on plots cleared of hardwoods outgrew those on the control plots. Contrary to expectations, growth differences between treatments were not greatest when seasonal water deficiencies were most acute.

In December 1953, 33 months after the Crossett study was established, a severe tornado totally destroyed one treated and one control out of the original six plots. Annual remeasurements were continued on the four surviving plots until 1961 to salvage as much information as possible.

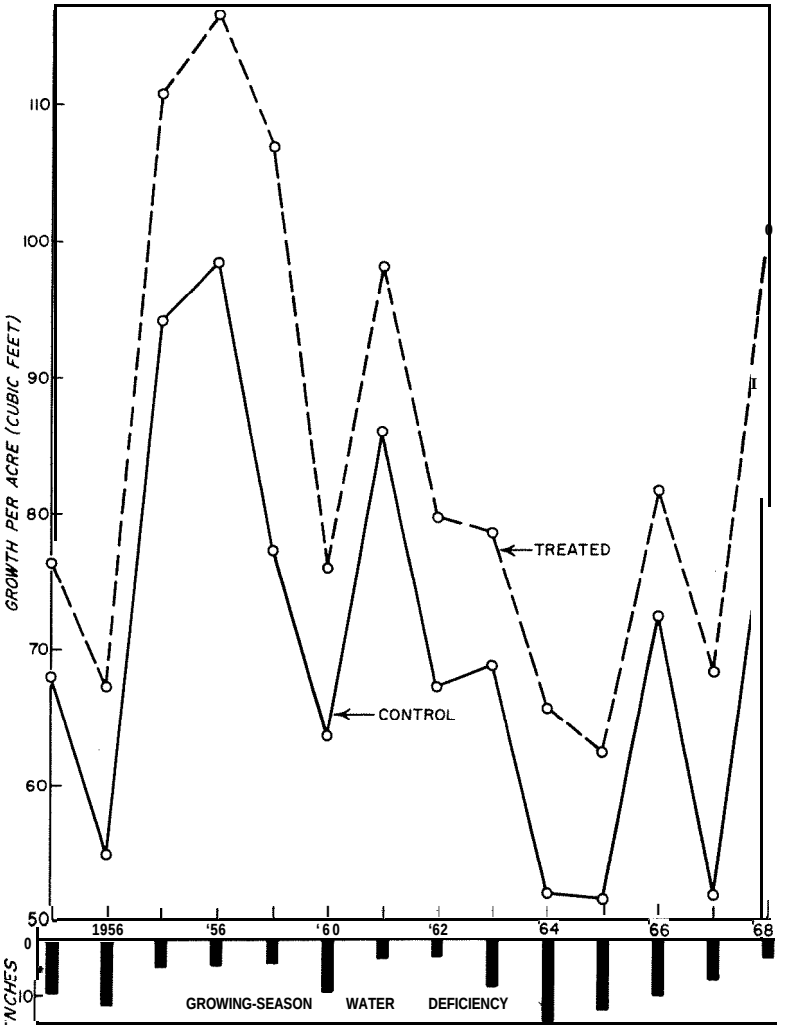

Figure 7.—*Current annual cubic growth per acre.*

Average annual growth on all plots was very high; in 1955 it was 1,293 board feet and 154.8 cubic feet per acre on one plot. Treated plots consistently outperformed the controls :

Treatment	Cubic feet[1]	Board feet[2]	Square feet of basal area
Hardwoods removed	108.2	926	3.0
Hardwoods left	75.6	584	2.1
Difference	32.6	342	.9

[1]All trees included.
[2]International ¼-inch rule. Trees 9 ½ inches d.b.h. and larger.

The periodic annual growth differences for the entire study were significant at the 5 percent level despite the insensitivity resulting from having only two treatment replications. The total per-acre growth advantage resulting from understory eradication amounted to 359 cubic feet, 3,760 board feet, and 9.9 square feet of basal area.

SUMMARY AND CONCLUSIONS

The two tests show that dense understory hardwoods significantly reduce growth of mixed stands of loblolly and shortleaf pine. Total 14-year growth differences in favor of hardwood-free plots amounted to 200 cubic feet, or 1,720 board feet per acre. In the ll-year-study, gross differences were even more pronounced, totaling 359 cubic feet, or 3,760 board feet per acre.

Regardless of moisture conditions during the growing season, pines on plots divested of understory hardwoods consistently outgrew those on control plots. Contrary to expectation, growth differences were not greater when moisture was deficient than under favorable conditions.

From evidence provided by these two studies and other supporting data, it is clear that dense understories of hardwoods materially lessen the average annual growth of even-aged loblolly-shortleaf pine stands on upland sites. Yields can be meaningfully increased by removing these understories.

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