Southern Forest Experiment Station

Research Note

SO-243

1978

Fertilization Increases Growth of Thinned and Nonthinned Upland Oak Stands in the Boston Mountains of Arkansas

D. L. GRANEY AND P. E. POPE

SUMMARY

Thinning and fertilization tests with pole-sized red oaks (northern red oak *Quercus rubra* L. and black oak *Q. velutina* Lam.) and white oak (*Q. alba* L.) were begun in the Boston Mountains of Arkansas in the spring of 1975. Fertilizer treatments of either (1) no fertilization, (2) 200 lbs N + 45 lbs P per acre, or (3) 400 lbs N + 45 lbs P per acre were applied to 288 red and white oaks that had received thinning or nonthinning treatments. Two-year diameter growth response for thinned red-oaks increased by 52 percent for the 200-lb treatment and by 97 percent for the 400-lb treatment. Increases for nonthinned red oaks averaged 40 and 58 percent for the 200- and 400-lb treatments.

Diameter growth for thinned white oaks increased by 95 percent for the 200-lb treatment and by 86 percent for the 400-lb treatment. Increases for nonthinned white oaks averaged 48 and 74 percent for the 200- and 400-lb treatments: Thinning did not significantly increase response to fertilization for either red or white oaks.

HELPING ACCELERATE GROWTH OF HARDWOOD STANDS

Over 200,000 acres of forest land in the Boston Mountains of Arkansas support overstocked, even-aged, pole-sized stands of oaks and associated species. Although many stands are on medium to good sites (height of 60 to 70 ft at 50 years), diameter growth averages only about 1 inch in 10 years. A lack of outlets for small diameter hardwoods has prevented intermediate cutting in these stands. But, because demands for sawtimber are increasing and inventories of large hardwood poletimber and immature sawtimber are small, some land managers have begun non commercial thinning programs to accelerate growth in the slow-growing hardwood stands. Fertilization may further stimulate growth of crop trees. Positive growth responses of oaks and other upland hardwoods to fertilization have been demonstrated (Mitchell and Chandler 1939, Farmer and others 1970, Ward and Bowersox 1970, Karnig 1972, Watt 1974). Generally, the greatest response of hardwoods has been associated with nitrogen (N) and to a lesser degree phosphorus (P) when applied with N.

PROCEDURES

Study Area

The Boston Mountains are the highest and southernmost member of the Ozark Plateaus physiographic province (fig. 1). They form a band 30 to 40 miles wide and 200 miles long from north central Arkansas westward into eastern Oklahoma. Elevations range from about 900 ft in the valley bottoms to 2500 ft at the highest point. The plateau is sharply dissected, and most ridges and spurs are flat to

Southern Forest Experiment Station/T-l0210 U.S. Postal Services Bldg., 701 Loyola Avenue, New Orleans, La, 70113
Forest Service, U.S. Department of Agriculture.
Serving Alabama, Arkansas, Louisiana, Mississippi, Eastern Oklahoma, Tennessee, Eastern Texas.

gently roiling and generally less than one-half mile wide. Mountain slopes consist of an alternating series of steep simple slopes and gently sloping benches.

Rocks in the area are sedimentary and predominantly of Pennsylvanian age; they consist of alternate horizontal beds of shales and resistant sandstones.

Annual precipitation averages 46 to 48 inches in the 2.2 million acre portion within Arkansas. March, April, and May are the wettest months. Extended summer dry periods are common, and autumn is usually dry. The frostfree period is normally 180 to **200** days long.

Three study areas were selected from overstocked stands on mountain benches that range from 2 to 3 chains wide and are typified by deep, well-drained soils of the **Nella** or **Leesburg** series (Typic Paleudults). These soils were formed from sandstone and shale colluvium and are among the most productive upland soils in the mountains.

Sample Trees

In each study area, 48 red oak and 48 white oak trees were selected for the thinning and fertilizer treatments. The trees from each species were arranged into 16 sets of 3 trees each. Individual members of each three-tree set were uniform in diameter, crown size, and height, and were located on essentially the same site conditions. Consecutive three-tree sets were randomly assigned the thin or nonthin treatments, and three fertilizer treatments were randomly assigned each three-tree thinned or nonthinned set. Thus, 144 red oaks and 144 white oaks at three locations were used to determine the effects of thinning and fertilization on diameter growth.

Tree Measurements

For each sample tree, diameter at breast height (d.b.h.) was measured to the nearest 0.01 inch. The diameter measurement point was identified by a painted band on each tree. Increment cores were

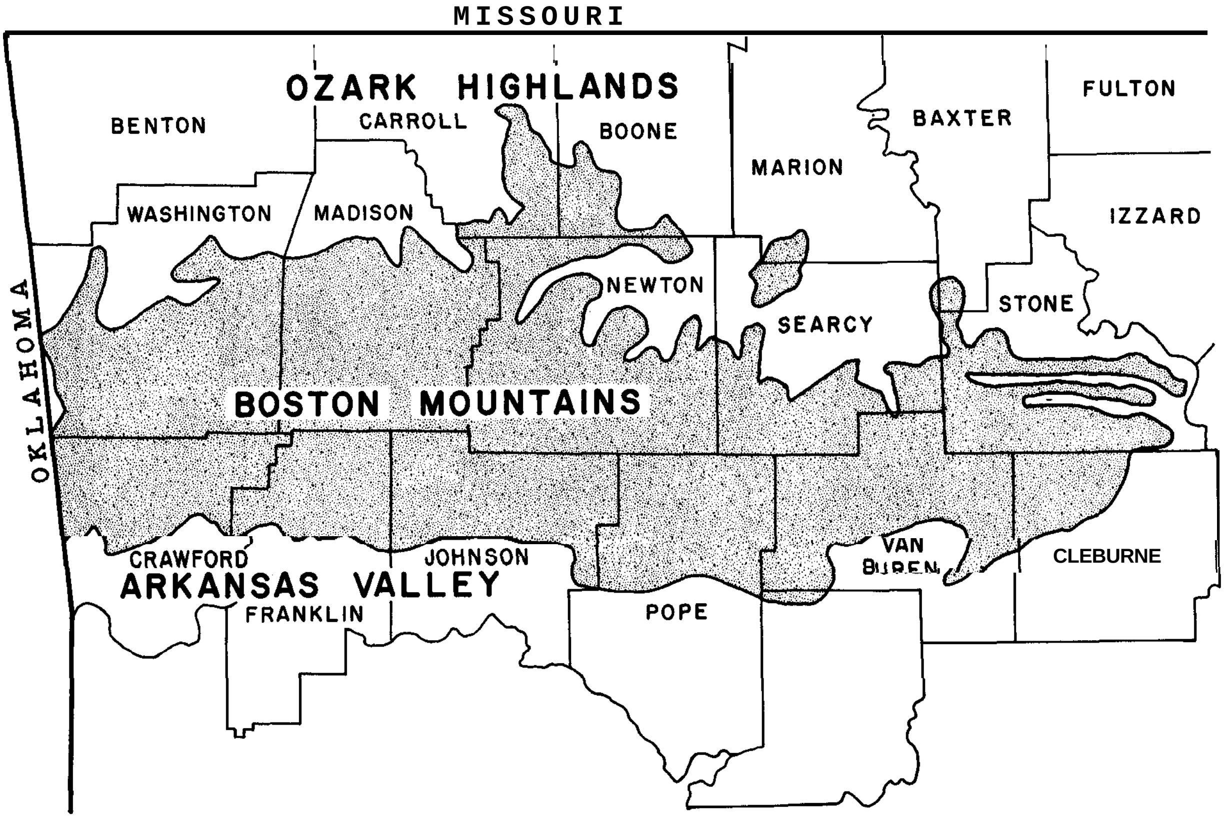

Figure 1.—*The Boston Mountains in Arkansas.*

D. L. Graney is Silviculturist, Southern Forest Experiment Station, Forest Service - USDA, Fayetteville, Ark. P. E. Pope is Assistant Professor, Department of Forestry and Natural Resources, Purdue University, West Lafayette, Indiana. Study was initiated while Pope was Assistant Professor, Department of Horticulture and Forestry, University of Arkansas, Fayetteville.

extracted from the north, east, south, and west sides of each tree and were used to determine tree age and to obtain a measure of past growth, which served as a covariate in the data analysis. After extraction, cores for each tree were sealed in plastic soda straws. For each core, a binocular microscope was used to measure annual radial growth to the nearest 0.01 inch. Total height was also recorded for each sample tree.

Thinning Treatments

Basal area near each sample tree was determined with a prism. From this initial value, the basal area was reduced by removing two major competitors and several smaller trees until an area of about 70 ft^2 per acre was attained. Thinning treatments were completed in March 1975. Average stand and tree characteristics for red and white oak thinned and nonthinned treatments are shown in table 1.

Table 1.—*Average stand and tree characteristics for red and white oak plots.*

Treatment	Age	Site index	Initial diameter	Basal area
	(years)	*(feet)*	*(inches)*	*(W/acre)*
		RED OAKS		
Thinned	50	62	8.18	68
Nonthinned	50	62	8.48	120
		WHITE OAK		
Thinned	52	59	8.26	66
Nonthinned	52	59	7.89	123

Fertilizer treatments

Fertilizers used were ammonium nitrate (34-O-O) and diammonium phosphate (18-46-O). Fertilizer treatments were: (i) no fertilizer (control), (ii) 200 Ibs N + 45 Ibs P per acre (200 lb treatment), (iii) 400 Ibs N + 45 Ibs P per acre (400 lb treatment). Fertilizers were surface broadcast on a 0.01 acre circular plot surrounding each tree. Fertilizer was applied in late April 1975 about 1 week after trees leafed out.

RESULTS AND DISCUSSION

Response to Thinning

After two growing seasons neither the red oaks nor white oak had responded to thinning (table 2). Diameter growth of thinned and nonthinned white oak control trees averaged about 0.12 inch per year for the 1975-76 growing seasons. Nonthinned red oak controls averaged 0.13 inch per year while thinned trees averaged about 0.12 inch. But, as indicated in figure 2, the nonthinned trees had indicated a slightly higher growth rate before thinning.

Response to Fertilization

Fertilization significantly increased growth of both red and white oaks (table 2). Mean annual diameter growth for red oak was 0.18 and 0.23 inch for the thinned 200- and 400-lb treatments, 52 and 97 percent increases over growth of controls. Response of red oak nonthinned trees was not as dramatic but averaged 40 and 58 percent greater than the controls for the 200- and 400-lb treatments.

Our results for fertilized and thinned red oaks compare favorably with the initial response of red oaks to fertilization in New York (Mitchell and Chandler 1939, Karnig 1972), but are greater than responses of black oak in the Missouri Ozarks (Watt 1974) and red oaks in West Virginia (Auchmoody and Smith 1977) and the Tennessee Valley (Farmer and others 1970). Response for fertilized but nonthinned red oak trees was fairly close to that found by Farmer and others (1970) for red oaks in the Tennessee Valley.

The significant growth response of red oaks to increasing levels of nitrogen was essentially linear over the range of 0 to 400 lbs per acre. Watt (1974), working with thinned black oak in the Missouri Ozarks, also reported a linear diameter growth response to increasing levels of N fertilization up to 900 Ibs per acre.

Diameter growth of thinned white oaks was not significantly different for the 200- and 400-lb treatments but was 95 and 86 percent greater than growth of nonfertilized trees. Response for thinned white oaks was greater than responses to fertilization reported elsewhere (Mitchell and Chandler 1939, Farmer and others 1970, Ward and Bowersox 1970). Mean annual diameter growth for nonthinned white oaks was 48 percent greater than controls for the 200-lb treatment and 74 percent greater for the

Table P.-*Mean annual diameter growth response to fertilization for thinned and nonthinned red and white oaks.*

Fertilizer treatment	Thinned Growth	Thinned Response'	Nonthinned Growth	Nonthinned Response'
	(inches)	*(%)*	*(inches)*	*(%)*
		RED OAKS		
Control	.118	—	.129	—
200 lb	.180	52	.180	40
400 lb	.233	97	.204	58
		WHITE OAK		
Control	.117	—	.119	—
200 lb.	.228	95	.176	48
400 lb.	.218	86	.207	74

'Percent increase over control.

400-lb treatment. Response of nonthinned white oak was similar to that of white oak in the Tennessee Valley (Farmer and others 1970).

Unlike red oaks, white oak did not respond significantly to increasing levels of N. Ward and Bowersox (1970) reported no significant increases in white oak diameter growth between N applications of 60 and 180 lbs per acre but did observe an increase in 5-year gross volume growth between lower and higher N levels when N was combined with lime.

In the Boston Mountains of Arkansas, differences between red oaks and white oak in response to fertilization are probably due to inherent differences in site requirements. A recent site quality investigation for upland oaks in the Boston Mountains (Graney 1977) found that red oaks were highly sensitive to changes in site and soil characteristics. White oak, however, had similar site indices over a wide range of site and soil conditions. Although response for both red and white oaks to fertilization indicates that N (and possibly P) limits growth in this area, requirements for white oak are apparently satisfied with lower levels of fertilization than are those of red oaks.

Before thinning and fertilization, patterns of both red and white oak diameter growth (after the wet growing seasons of 1967 and 1968) reflected increasing crown and root competition in the overstocked stands (figs. 2 and 3). With few exceptions, crowns of sample trees were small and by remeasurement in 1976 had not begun to expand much. Red oak diameter growth declined from a maximum of about 0.22 inch in 1968 to about 0.12 inch in 1974 (fig. 2). White oak diameter growth declined from a high of about 0.18 inch in 1968 to about 0.11 inch before thinning and fertilization (fig. 3). The slight increase in control diameter growth for red oaks and white oak in the 1975-76 growing seasons probably reflected the wet 1975 growing season.

Among fertilized red and white oaks, thinned trees had slightly higher diameter growth rates than nonthinned trees, but differences were not significant. Our results are only for 2 years, and effects of thinning on fertilized trees may become more apparent in later remeasurements.

Two-year results of this study indicate that growth of pole-sized red and white oaks in overstocked stands can be significantly increased by fertilization. Studies in other areas have indicated the maximum response of upland oaks to fertilization occurs within the first 3 years and then declines over a period of years. We will continue to monitor diameter growth in this study for a minimum of 5 years or until no further response is observed.

LITERATURE CITED

Auchmoody, L. R., and H. Clay Smith.
1977. Response of yellow-poplar and red oak to fertilization in West Virginia. Soil Sci. Soc. Am. J. 41: 803-807.

Farmer, R. E., Jr., G. W. Bengtson, and J. W. Curlin.
1970. Response of pine and mixed hardwood stands in the Tennessee Valley to nitrogen and phosphorus fertilization. For. Sci. 16: 130-136.

Graney, D. L.
1977. Site index predictions for red oaks and white oak in the Boston Mountains of Arkansas. U.S. Dep. Agric. For. Serv. Res. Pap. SO-139, 9 p. South. For. Exp. Stn., New Orleans, La.

Karnig, Jack J.
1972. Nitrogen fertilizer increasesdiametergrowth of northern red oak. J. For. 70: 629.

Mitchell, Harold L., and Robert F. Chandler, Jr.
1939. The nitrogen nutrition and growth of certain deciduous trees of northeastern United Staes. Black Rock For. Bull. 11, 94 p.

Ward, W. W., and T. W. Bowersox.
1970. Upland oak response to fertilization with nitrogen, phosphorus, and calcium. For. Sci. 16: 113-120.

Watt, Richard F.
1974. Response to fertilization of oaks in the Missouri Ozarks. Agron. Abst., Amer. Soc. Agron.,p. 179.

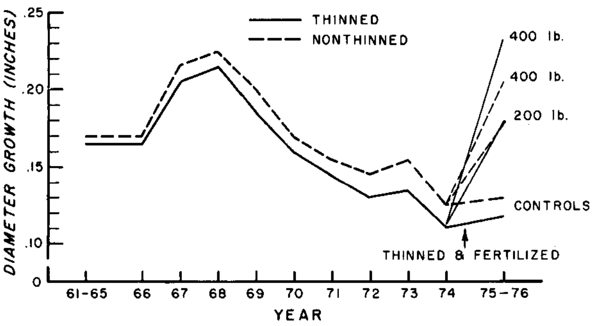

Figure 2.—*Mean annual diameter growth 1961-74 and response to fertilization for thinned and nonthinned red oaks.*

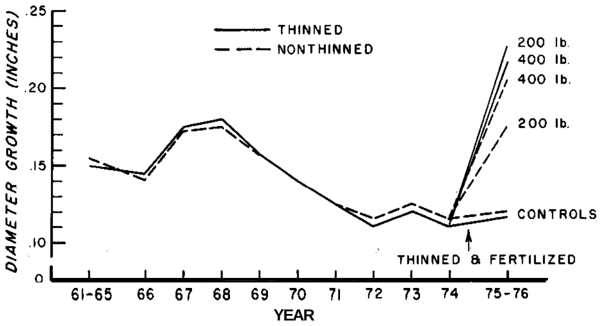

Figure 3.—*Mean annual diameter growth 1961-74 and response to fertilization for thinned and nonthinned white oak.*

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—672-040