RESPONSE OF RED OAKS AND WHITE OAK TO THINNING AND FERTILIZATION IN THE BOSTON MOUNTAINS OF ARKANSAS

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ABSTRACT

Thinning and fertilization tests with poletimber-size 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 applications of N and P were broadcast at either 200 lbs N + 45 lbs P per acre or 400 lbs N + 45 lbs P per acre to individual red and white oaks that had received a thinning treatment 0, 1, 2, 3 or 4 years before fertilization.

For the 1975 and 1976 growing seasons diameter growth response for red oaks was 45 percent greater than controls for the 200 lb treatment and 69 percent greater for the 400 lb treatment. Response for white oak was about the same for both fertilizer treatments with 61 and 64 percent increases over the controls for the 200 and 400 lb treatments. The time interval between thinning and fertilizer application (0-4 years) did not significantly affect the diameter growth response to fertilization.

[1/]Study was initiated while P. E. Pope was Assistant Professor, Department of Horticulture and Forestry, University of Arkansas, Fayetteville.

Large acreages in northern Arkansas now support even-aged, overstocked poletimber size stands of oaks and associated hardwoods. Most stands are from 40 to 60 years old, and diameter growth averages about 1 inch in 10 years. Lack of markets for small diameter hardwoods has prevented intermediate cutting in these stands at younger ages. Increasing demands for hardwood sawtimber and small inventories of large-poletimber and small sawtimber size classes have encouraged many land managers to start a noncommercial thinning program to reduce competition and accelerate growth of potential crop trees (in overstocked stands) if necessary. Further stimulating growth of crop trees by fertilization is also possible. Oaks and other upland hardwoods responded well to fertilization in a number of earlier tests (Mitchell and Chandler 1939, Farmer et al. 1970, Ward and Bowersox 1970, Karnig 1972, Watt 1974). Generally, the greatest growth response with hardwoods has been associated with applications of nitrogen (N) and, to a lesser degree, phosphorus (P) and N applied together.

This study summarizes 2-year growth responses of red oaks (northern red oak *Quercus rubra* L. and black oak *Q. velutina* Lam.) and white oak (*Q. alba* L.) to fertilization in the Boston Mountains of Arkansas. The major objectives were to determine how fertilizer application affected diameter growth of red and white oaks in previously thinned stands and to determine the importance of time since thinning on diameter growth response to fertilization.

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 feet in the valley bottoms to 2500 feet at the highest point. The plateau is sharply dissected, and most ridges and spurs are flat to gently rolling and 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.

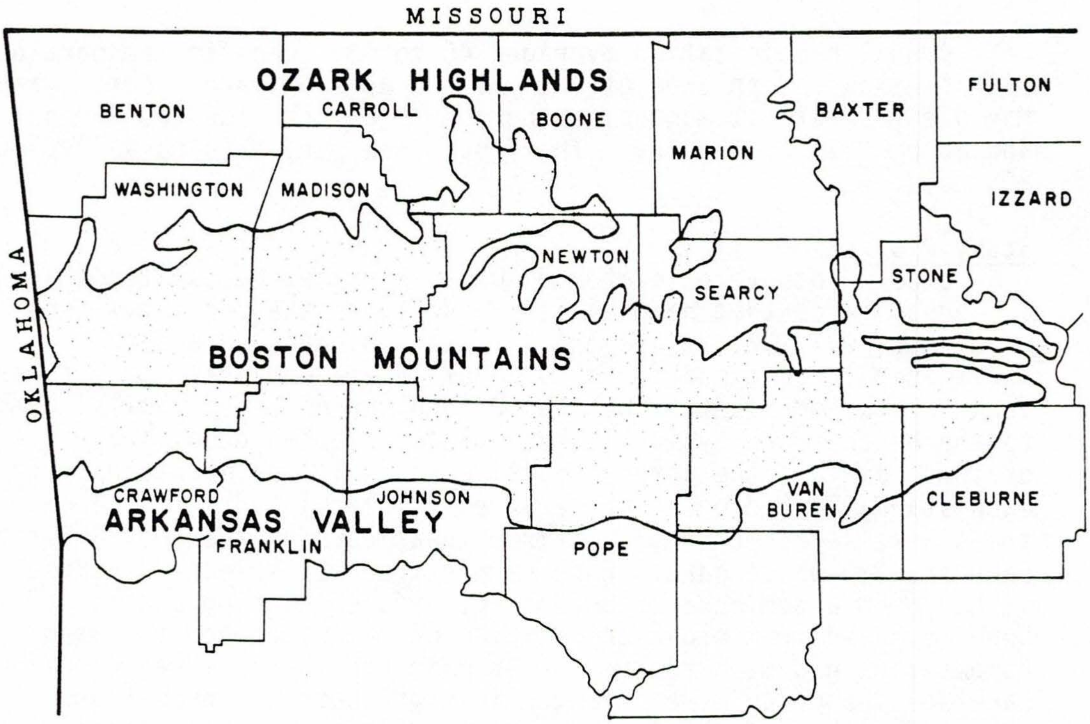

Figure 1.--The Boston Mountains in Arkansas.

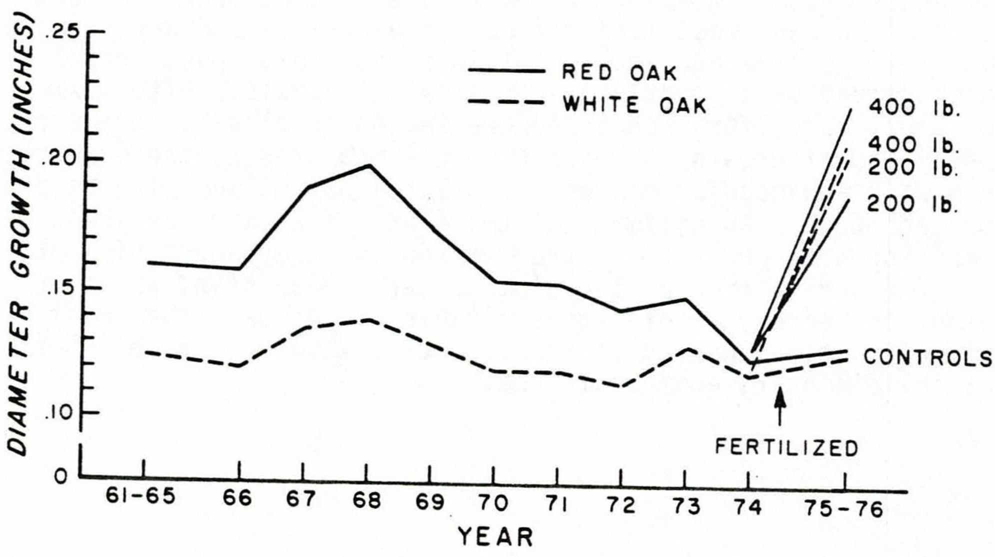

Figure 2.--Mean annual diameter growth 1961-1974 and response of red and white oaks to fertilization (combined data).

Annual precipitation averages 46 to 48 inches in the portion within Arkansas, an area of 2.2 million acres. March, April, and May are the wettest months. Long summer dry periods are common, and autumn is usually dry. The frost-free period is normally 180 to 200 days.

Study Plots

Study plots were located on Ozark National Forest lands and included stands that had been thinned before the growing season of either 1971, 72, 73, 74 or 75. Each thinning date was replicated three times for a total of 15 stands. All study trees were located on mountain benches 2 to 3 chains wide. Soils common to the benches are typically more than 60 inches deep, are well-drained, and are the more productive soils in the mountains. In each stand, 24 red oak (northern red or black) and 24 white oak trees were selected for fertilizer treatments; a total of 360 red oaks and 360 white oaks. Each sample tree was selected because it had been a dominant or codominant before thinning and it had been released from crown competition on two sides (or two major competitors had been removed). In each stand, trees representing each species group were arranged in eight sets of three trees each. The three trees in each set were located on essentially the same soil and slope condition, and were selected for uniformity in height, diameter, crown size, and degree of release.

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 to ensure accurate location for remeasurements. Increment cores were extracted from the north, east, south, and west facing sides of each tree and were used both to determine tree age and to obtain a measure of past growth, which served as a covariate in the data analysis. After extraction, increment cores for each tree were sealed in plastic soda straws. Annual radial growth for each core was measured to the nearest 0.01 inch with a binocular microscope. Total height was also recorded for each tree. An estimate of the stand basal area of trees competing with each sample tree was obtained by means of a prism with the sample tree as the plot center. Mean stand and tree values for each year of release (table 1) indicate that most sample locations were uniform with respect to age, site index, initial diameter, and basal area.

Table 1. Stand and tree characteristics for red and white oak plots.

Year thinned	Age [mean (range)] (years)	Site index [mean (range)] (feet)	Initial diameter [mean (range)] (inches)	Stand basal area [mean (range)] (sq.ft./acre)
		Red Oak		
1971	49 (48-51)	63 (61-65)	9.21 (8.60-9.66)	70 (68-72)
1972	61 (55-68)	62 (60-65)	11.35 (9.43-12.86)	78 (73-81)
1973	58 (56-65)	63 (60-65)	10.36 (9.83-12.15)	78 (70-34)
1974	53 (49-58)	65 (62-70)	8.75 (8.06-9.44)	80 (75-86)
1975	50 (47-55)	62 (61-63)	8.18 (7.22-9.35)	70 (65-74)
		White Oak		
1971	53 (51-57)	57 (55-62)	8.56 (8.01-8.91)	70 (68-72)
1972	65 (56-72)	56 (55-57)	10.06 (8.66-11.47)	78 (73-81)
1973	62 (60-68)	58 (57-58)	9.76 (9.45-9.93)	78 (70-84)
1974	56 (52-62)	59 (55-62)	7.98 (7.04-9.13)	80 (75-86)
1975	52 (49-54)	59 (57-61)	8.26 (7.35-8.89)	70 (65-74)

Fertilizer Treatments

Fertilizers used were ammonium nitrate (34-0-0) and diammonium phosphate (18-46-0). Fertilizer treatments were: (a) no fertilizer (control), (b) 200 lbs N + 45 lbs P per acre (200 lb treatment), (c) 400 lbs N + 45 lbs P per acre (400 lb treatment). Fertilizers were surface broadcast on a 0.01 acre circular plot surrounding each tree. The fertilizer was applied in late April, 1975 about 1 week after trees leafed out.

RESULTS AND DISCUSSION

Fertilization significantly increased diameter growth of dominant and codominant red oaks and white oak, but time since thinning and the time x fertilizer interaction did not significantly affect diameter growth of either species group (table 2).

Two-year diameter growth response to fertilization of red and white oak trees in previously thinned stands was quite similar (fig. 2). The red oaks were more responsive to varying levels of N with over-all increases over controls of 45 and 69% for the 200 and 400 lb treatments respectively. Response for white oak was nearly the same for both fertilizer treatments; 61% for the 200 lb treatment and 64% for the 400 lb treatment. Although N limits growth in this region for both red oaks and white oak, requirements for white oak are apparently satisfied by lower levels of fertilization than are those of red oaks. A recent site quality investigation for upland oaks on similar soils in the area (Graney 1977), also indicated that white oak was less sensitive than red oaks to changes in site and soil characteristics.

Overall diameter growth response to fertilization for red oaks was slightly lower than 1- and 2-year responses reported for red oaks in New York (Mitchell and Chandler 1939, Karnig 1972) and slightly greater than observed for red oaks in the Tennessee Valley (Farmer et al. 1970) and West Virginia (Auchmoody and Smith 1974) and for black oak in the Missouri Ozarks (Watt 1974). White oak produced an overall response of slightly over 60% which is slightly higher than response of white oak in Pennsylvania (Ward and Bowersox 1970) and about the same as response reported in New York (Mitchell and Chandler 1939) and the Tennessee Valley (Farmer et al. 1970).

For both red oaks and white oak, major differences in response to fertilization occurred among the 15 test locations. Growth response varied from 0.02 to 0.16 inch for individual red oaks and from 0.02 to 0.15 for white oaks. Also for both red oaks and white oak, trees thinned in 1974 and 75 responded better to fertilization than those thinned in 1971, 72, and 73, although the differences were not significant.

Table 2. Mean annual diameter growth of thinned and fertilized red and white oak trees.

Year thinned	Control growth (in.)	Fertilizer Treatment 200 lb. Growth (in.)	200 lb. Response 1/ (%)	400 lb. Growth (in.)	400 lb. Response 1/ (%)
		RED OAK			
1971	.175	.210	20	.255	46
1972	.142	.200	40	.251	77
1973	.126	.182	44	.200	59
1974	.093	.179	92	.178	91
1975	.118	.180	52	.233	97
Mean	.131	.188	45	.220	69
		WHITE OAK			
1971	.170	.251	48	.276	62
1972	.126	.195	55	.174	38
1973	.124	.175	41	.179	44
1974	.099	.169	71	.193	95
1975	.117	.228	95	.218	86
Mean	.127	.204	61	.208	64

1/ Percent increase over controls.

Perhaps the most perplexing result of this study has been the absence of a significant growth response to thinning. In a separate thinning-fertilization study[2], Graney and Pope observed a consistently larger but statistically nonsignificant diameter growth response to fertilization for trees receiving a thinning treatment, and, in this study, time since thinning (0 to 4 years before fertilization) also produced no significant effect on response to fertilization. That the response to thinning (particularly for the red oaks) is rather slow to develop can be illustrated for the 72 red and white oaks in stands thinned before the 1971 growing season (fig. 3). The diameter growth indicated is confounded somewhat by an alternating series of dry and wet growing seasons but even after six growing seasons the red oaks are indicating no obvious trend toward an increasing rate of diameter growth. The same trend held for all red oak thinning treatments.

White oak thinned in 1971, however, indicated an immediate though not significant response to thinning, and rate of diameter growth has continued to increase through the 1976 growing season (fig. 3). The trend in white oak response to thinning also held for the 1972 thinning treatment. The 1973 and 1974 thinning treatments were confounded with very wet and very dry growing seasons, and no trend in diameter growth response to thinning could be detected.

Before fertilization, diameter growth of all red and white oak sample trees was strongly influenced by growing season rainfall and increasing crown and root competition in the overstocked stands (fig. 2). In other than the wet 1967-68 growing seasons, red oaks were averaging about 0.15 to 0.16 inches per year up to the very dry 1974 growing season where growth was more than 0.02 inch below previous years.

Effects of high stand density and increased competition on diameter growth of red oaks is quite apparent in the stands thinned in 1974 (fig. 4). Diameter growth rates declined from 0.20 inches during the wet growing season of 1968 to 0.09 inches in 1974. Before fertilization, white oaks had a lower but more consistent annual diameter growth rate (about 0.12 inches) than did the red oaks (fig. 2). White oak also did not indicate a major decline in growth during 1974 growing season.

2/ Graney, D. L. and P. E. Pope. Effects of thinning and fertilization on diameter growth of red oaks and white oak in the Boston Mountains of Arkansas. (Unpublished manuscript).

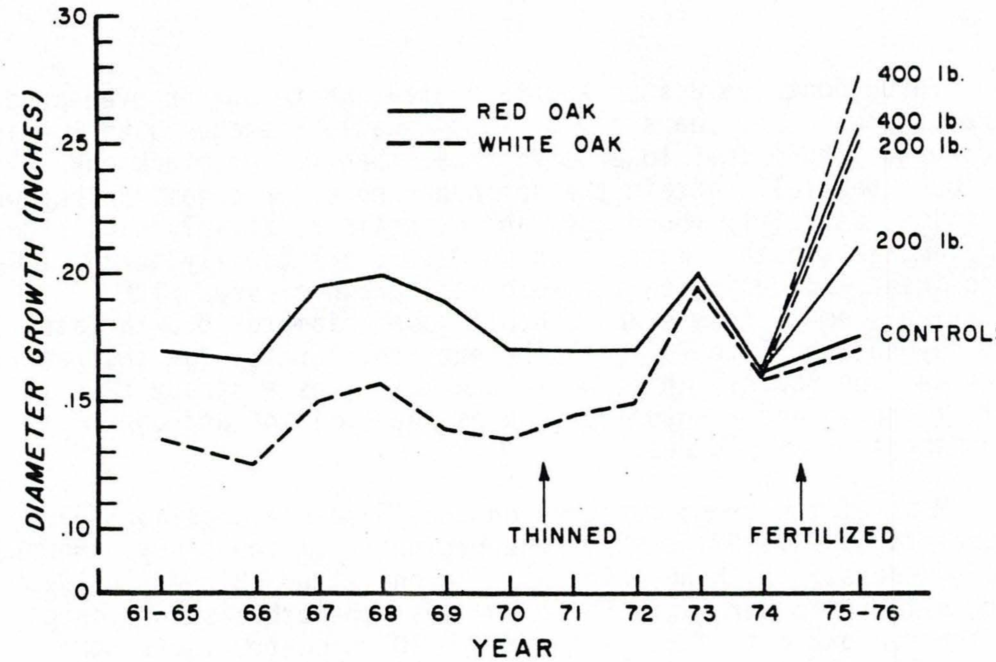

Figure 3.--Mean annual diameter growth 1961-1974 and response of red and white oaks to thinning and fertilization (1971-thinned stands).

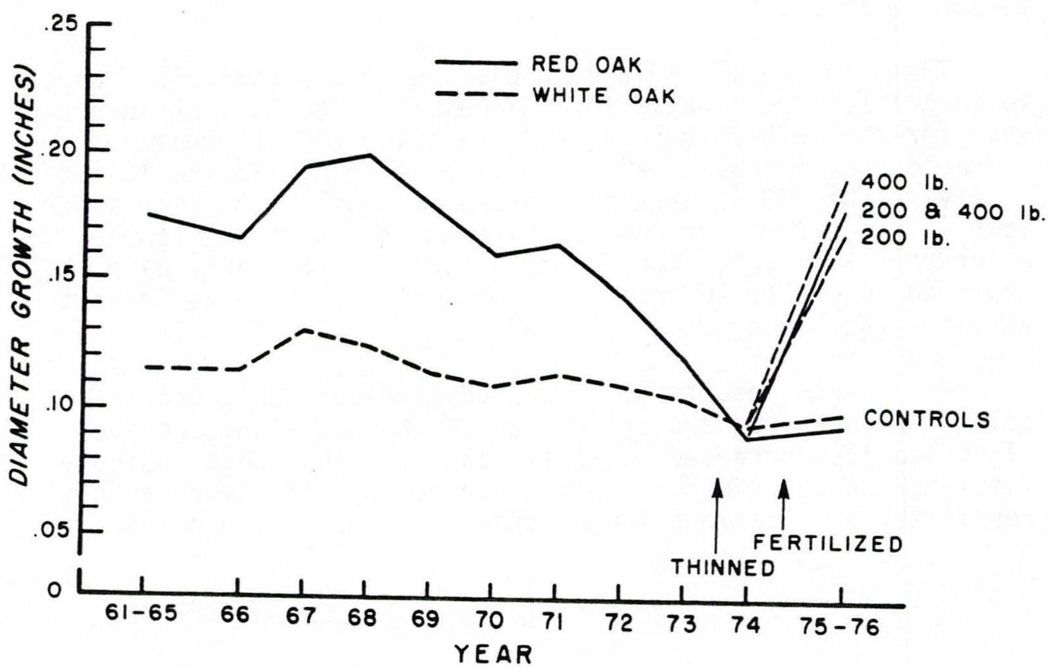

Figure 4.--Mean annual diameter growth 1961-1974 and response of red and white oaks to fertilization (1974-thinned stands).

Throughout the Boston Mountain area, white oak in even-aged mixed stands of 60 years old or less usually averages 3 to 5 years older and 3 to 5 feet lower site index than red or black oaks. Red oaks generally attain the dominant and upper codominant crown positions at fairly young ages and maintain relatively high rates of diameter growth. White oaks, however, are usually in the lower codominant (bordering on intermediate) crown classes with relatively small crowns and exhibit lower diameter growth rates. But beyond age 60 to 70 years, height growth rates for the red oaks decline rapidly while white oak maintains a steady rate of height growth and eventually reaches the dominant and upper codominant crown classes.

Most of the trees measured on the 15 sample locations had diameters of 7 to 9 inches at the beginning of the study. However, two of the stands thinned in 1972 and one stand thinned in 1973 were slightly older (ages 65 to 70) than the other stands sampled. In the red oak data for these stands, 10 three-tree-sets were dominant, larger crowned trees in the 11 to 13 inch (small sawtimber) diameter classes. The past growth of these larger trees and the indicated response to fertilization (fig. 5) give some indication of what could occur on the medium sites. Apparently, diameter growth of the older dominants in a rather uncrowded condition will average about 0.20 inches per year with fairly significant fluctuations caused by variations in growing season rainfall.

Trees in the 11 to 13 inch diameter group will also respond to fertilization. The 10 controls averaged about 0.22 inches per year for the 1975-76 growing seasons. The 200 lb treatment averaged 0.26 inches (a 20 percent increase) while the 10 red oaks receiving the 400 lb treatment averaged nearly 0.32 inches per year (a 46 percent increase). Although not a strong sample, the observed response for the 30 trees compared favorably with that observed for 12 to 16 inch diameter northern red oaks in West Virginia (Auchmoody and Smith 1977).

The 2-year results of this study indicate that growth of poletimber size red and white oaks in thinned stands can be significantly increased by fertilization. They also indicate that little or no additional response can be expected by delaying fertilizer applications longer than 1 year after thinning.

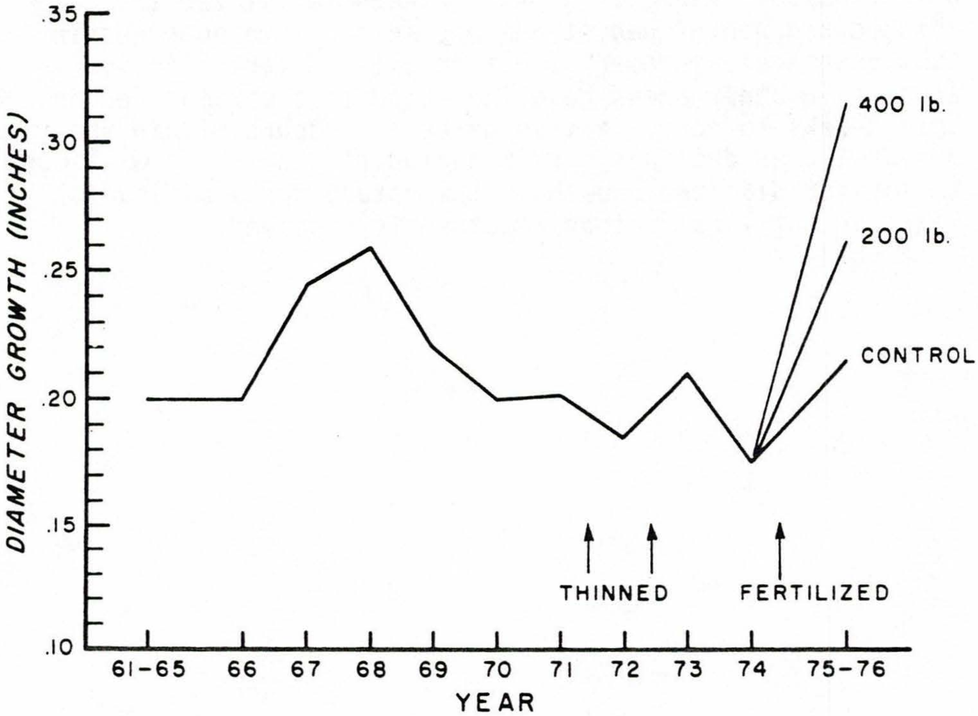

Figure 5.--Mean annual diameter growth 1961-1974 and response of 30 small sawtimber-size (11 to 13 inch d.b.h.) red oaks to fertilization.

Results of a companion study[2/] indicated that significant diameter growth response to fertilization can be obtained in overstocked stands without thinning. Combining thinning with fertilization increased the response over nonreleased trees but the differences were not significant for the 2-year results. Differences in diameter growth between fertilized trees in thinned and nonthinned stands may become more apparent in subsequent remeasurements, but results of fertilization studies in other areas have indicated that maximum response of upland oaks to fertilization generally occurs within the first 3 years, 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.

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