GROWTH OF A 30-YEAR CHERRYBARK OAK PLANTATION 6 YEARS AFTER THINNING

Wayne K. Clatterbuck[1]

Abstract—A 24-year cherrybark oak (*Quercus falcata* var. *pagodifolia*) plantation in the Coastal Plain of west Tennessee was thinned during the winter of 1994-1995. Growth in the plantation was severely stagnated. Trees were planted at a 9 by 9-foot spacing and survival was 69 percent after 24 years after decreasing from 88 percent at age 15. The plantation should have been thinned earlier to avoid the onset of stagnation and the resulting decline in rate of diameter and volume growth. Approximately 50 percent of the stems and 35 percent of the basal area were cut during the row thinning, taking every second row. Results six growing seasons after thinning indicate that the remaining residual trees are increasing in diameter at an annual rate greater than the 9 years prior to the thinning. The plantation volume cut during the thinning operation was replaced by growth on the remaining trees within six years. The volume is accumulating on a fewer number of trees yielding larger diameter trees and increased value over a shorter period of time. A second thinning is projected by age 35. These trends can be used by practitioners as preliminary information on the growth and development of a 30-year-old cherrybark oak plantation before and after thinning.

INTRODUCTION

Thinning is the one operation where merchantable value can be easily increased through regulating stand density and augmenting the diameter growth of residual trees (Hopper and others 1995). Its primary purpose is to salvage trees in immature stands that would normally be lost due to natural stand mortality. Thinning affects merchantable yield by distributing volume growth on fewer, larger trees (Smith 1962).

Although there is a wealth of information about thinning in southern pine stands (Moehring and others 1980), there is a conspicuous absence of thinning information in natural hardwood stands and even less in planted hardwood stands. Meadows and Goelz (2001) recently reviewed the literature on thinning in natural hardwood stands and planted stands.

This research capitalizes on a study for genetic improvement of cherrybark oak. The plantation has been closely monitored and measured periodically for 30 years. This article presents the growth and development of the plantation for the first 24 years before thinning, then the growth results 6 years after thinning. Although this is an unreplicated case study, the 30-year data will give practitioners some long-term information on growth and development of cherrybark oak in plantations before and after thinning.

STUDY AREA

The 1.8-acre cherrybark oak plantation is located on Natchez Trace State Forest (NTSF) in Henderson County, TN, located approximately 10 miles northeast of Lexington, TN near the confluence of Scarce Creek and the Big Sandy River. The forest is managed by the Tennessee Department of Agriculture, Forestry Division (TDA-FD). The plantation is in a second bottom with moderately well-drained, Udifluvent soils (Collins and Iuka series) formed in young alluvium washed from loessal and sandy Coastal Plain materials (Smalley 1991). The area is occasionally flooded during the late winter and early spring by streams or by runoff from higher lying areas, however the duration is only for a few days. Using Smalley's (1991) landscape classification, the study site is landtype #23: narrow moist bottoms. Annual precipitation averages 51 inches, with July through September as the driest months and late winter to early spring as the wettest. Average site index (base age 50) is estimated to be 100-110 feet for cherrybark oak. (Clatterbuck 1987, Smalley 1991).

The NTSF was part of the federal Resettlement Administration purchase of land during the mid-1930's. Before the purchase, the area consisted of marginal and submarginal farms. Most of the cleared land had sustained severe sheet and gully erosion. After the federal government bought the property, many families leased their homes and land and some remained for more than 20 years. By 1959, all families had relocated; their homes and outbuildings were sold, moved or demolished.

The study area is adjacent to Dry Branch, a tributary of Scarce Creek, was cultivated through the mid-1950's and then abandoned. Sediment was deposited from the uplands on this second bottom area until the active erosion was controlled. A variety of soil textures occur because of mixing during transport, active erosion and differential rates of deposition. The field was then maintained in pasture or hay until planting.

The field was planted with 1-0 cherrybark oak in January of 1969 at 9 by 9-foot spacing as part of a tree improvement

[1]Associate Professor, Dept. of Forestry, Wildlife & Fisheries, The University of Tennessee, Knoxville 37901-1071

Citation for proceedings: Outcalt, Kenneth W., ed. 2002. Proceedings of the eleventh biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–48. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 622 p.

study initiated by the USDA Forest Service, Southern Research Station and TDA-FD to develop a source of genetically improved cherrybark oak for planting in west Tennessee. The planting design was a randomized complete block with 4-tree family plots, 18 families from a Warren County, MS seed source, and 10 replications with 72 trees per replicate.

The planting site was an old field that was heavy in Johnson grass, tall fescue and vetch. Disking was used to prepare the site for planting. Disking and mowing after planting was done at least twice a year for the first four years. Height measurements were taken at age 4 (1973) and age 7 (1976); height and diameter measurements at age 10 (1979), age 15 (1984), and age 24 (1993). The plantation was thinned during the spring of 1994 and the remeasurement was at age 30 (1999).

METHODS

The plantation was measured at age 24 (1993) before thinning. Basal area in 1993 was 103 square feet per acre. Superior phenotypes based on height, diameter and volume were identified. A thinning regime was formulated with the retention of these phenotypes to continue the genetic objectives of the study, namely creation of a cherrybark oak seed production area. The thinning can best be described as a row thinning where every second row was harvested. Selected phenotypes within the harvested rows were retained and one tree on each side of retained phenotypic trees within leave rows was cut. No attempt was made to select inferior trees during the thinning. The goal was to thin approximately 50 percent of the trees resulting in a reduction of 40 percent of the basal area.

RESULTS

Plantation Development after Planting and before Thinning

Very little height growth occurred during the first four growing seasons (table 1), but the rate of height growth increased until the 15-year measurement, then the rate decreased afterward (table 2). Slow initial height growth is characteristic of oak (McGee and Loftis 1986), and may have been further retarded by severe grass and herbaceous competition. The site received at least two mowings per year for the first four growing seasons, which permitted considerable competition from herbaceous vegetation. Grass is perhaps the greatest competitor of planted seedlings (Ford 1999). However, survival rates indicate that cherrybark oak can tolerate such competition in the seedling stage and eventually overtop it, although the growth rate during this period is small. Once established, growth rate increases considerably (table 2) and continues to the 15-year measurement.

Survival was between 88 and 93 percent through age 15, then dropped to 69 percent at age 24. The decrease in survival suggests that trees were exceeding the amount of growing space. The presence of many dead trees scattered throughout the plantation and the presence of epicormic branches along the boles of many trees indicated that the plantation was approaching stagnation. Diameter growth rate was decreasing (tables 1 and 2), another indication that stagnation was taking place. Field observations indicate that adjacent crowns were overlapping and the crowns of many of the subordinate, less vigorous trees were spindly, dying back or dead. From age 15 through age 24 the number of trees per acre decreased from 473 to 372, a mortality rate of 21 percent. Clearly, the plantation should have been thinned at an earlier age to maintain or increase tree growth and development.

Plantation Development after Thinning

Prior to thinning (age 24), the plantation averaged 372 trees per acre (69 percent survival), average basal area of 103 square feet per acre with an average total height of 63 feet and a mean diameter of 6.9 inches. Total stand volume was 2,243 square feet per acre. These data are from all trees regardless of crown class.

Approximately 35 percent of the basal area, 50 percent of the stems and 45 percent of the volume were cut per acre during the thinning. Leaving some of the best phenotypes in the cut rows resulted in more basal area and volume being left than anticipated.

Six years after the thinning, total height continues to increase but at a decreasing rate (table 2). The rate of

Table 1—Changes at different ages, before and after thinning, in mean height, diameter, and volume of trees in a cherrybark oak plantation with associated changes in survival, basal areas and total volume for the plantation

	Individual Tree			Plantation			
Age (yrs)	Mean Height (ft)	Mean Diameter (in)	Mean Volume (cubic ft)	Survival (pct.)	Trees/Acre (#)	Basal Area (sq ft/ac)	Total Volume (cubic ft/ac)
4	2.3	—-	—	93	500	—-	—-
7	9.9	—-	—-	92	495	—-	—-
10	19.3	2.6	—-	91	490	18.1	—-
15	37.3	4.5	1.76	88	473	52.2	832.5
24	61.4	6.9	6.03	69	372	102.6	2,243.2
thinned at age 24							
30	75.6	8.8	12.21	-	190	81	2,139.9

Table 2—Average annual height, diameter and volume growth rates in a 30-year-old cherrybark oak plantation in west Tennessee

Age Interval (yrs)	Height growth rate (ft)	Diameter Growth Rate (in)	Volume Growth Rate (cubic ft)
0 – 4	0.6	—-	—-
5 – 7	2.5	—-	—-
8 – 10	3.1	—-	—-
11 – 15	3.6	0.38	—-
16 – 24	2.7	0.26	0.47
thinned at age 24			
25 – 30	2.4	0.31	1.03

annual diameter growth has increased to 3.1 inches per decade from 2.6 inches before thinning. Diameter growth rates were declining from ages 16-24 because of the onset of stagnation and then began to increase from ages 25-30 after thinning when more growing space was available for crown expansion (table 2).

Since thinning, basal area has increased from 65 to 81 square feet per acre in 6 years or 2.6 square feet per acre annually. If these rates of basal area growth continue, we expect another thinning will be necessary in four to six years.

Average volume per tree doubled in the six years following thinning from an average of 6 to 12 cubic feet per tree, an average annual growth per tree of 1.0 cubic feet per year. Even though approximately 50 percent (1,082 cubic feet per acre) of total volume was harvested during the thinning, total volume of the plantation increased from 1,161 to 2,320 cubic feet per acre or an average volume growth rate of 193 cubic feet per acre per year the following six years. The total amount of volume six years after thinning was essentially the same as the amount of volume before the cut (table 1). The volume is accumulating on a fewer number of trees yielding larger diameter trees and increased value over a shorter period of time.

Trees, particularly oaks, which have been repressed and are under stress have a tendency to develop epicormic branches (Clatterbuck 1993). Although the degree of epicormic branching was not quantitatively assessed in this study, we observed that the number of epicormic branches was greater in the intermediate and suppressed crown classes than the dominant and codominant classes before thinning. Meadows and Goelz (2001) reported similar findings with stressed water oak (*Q. nigra*) plantations. After thinning, epicormic branches remained and were more numerous on trees in subordinate crown classes. On the larger and more vigorous dominant and co-dominant cherrybark oak trees, there were fewer epicormic branches, some of these branches died and were shed and others remained becoming larger in diameter. Without base data for comparison, these trends are not quantifiable, but the thinned plantation does contain high-quality sawtimber trees with few if any epicormic branches.

The diameter distribution of the plantation before thinning resembled a bell-shaped curve with trees being the most abundant in the 8-inch diameter class (figure 1). Six years after thinning where nearly 50 percent of the trees were harvested, the diameter distribution begins to flatten and shift toward the larger diameter-size classes. The greatest number of trees were in the 8 and 10-inch diameter classes. This trend is usually found in even-aged stands of a single species as they develop and mature (Moehring and others 1980, Meadows and Goelz 2001).

DISCUSSION

The cherrybark oak plantation after 24 years was not growing in diameter at an acceptable rate. Diameter growth was 2.6 inches per decade, well below the 3.5 to 4.5 inches per decade that is considered good to excellent growth on productive bottomland sites (Putnam and others 1960). At age 24, the trees were declining because of the competition for growing space resulting in reduced tree growth, increased mortality and declining stand productivity. After thinning, more growing space was available allowing trees to increase in diameter and volume. Six years after thinning, total plantation volume was similar to that when the trees were cut. The volume increase is on fewer trees per acre with larger diameter size and volume per tree. At present rates of diameter and volume growth, the plantation is projected to need thinning again in four to six years.

The first thinning at age 24 probably occurred too late. Natural mortality in the nine years prior to thinning was 22 percent or about 101 trees per acre. The plantation should have been thinned much earlier to avoid growth declines, stress and mortality. The 9 by 9-foot plantation spacing appears desirable for developing merchantable boles and achieving diameters that can be harvested profitably (depending on markets) during the first thinning and achieving plantation basal area and volume growth. Closer

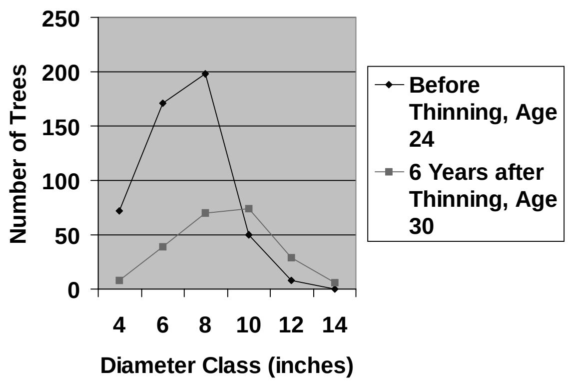

Figure 1—Diameter distribution before thinning and the diameter distribution six years after thinning in a 30-year-old cherrybark oak plantation

spacing will require thinning of smaller diameter material at an earlier age, while wider spacing delays the first thinning, but the tree diameters will be larger.

The tree improvement objective of creating a seed production area from the plantation favored row thinning. The advantage of row thinning is minimal damage to trees within the leave rows. The possible unfavorable effect of row thinning is the removal of good trees and leaving poor trees, creating broad variation between individuals. Many trees in the subordinate crown classes were left within the leave rows. These smaller trees probably deflated the average height, diameter and volume figures reported in this study. Low thinning would have taken most of the subordinate trees and provided a better choice for the leave trees to be retained. A few (eight trees) of the best phenotypic trees were left in the cut rows for future tree improvement studies. The next thinning will probably be a combination of low thinning to remove subordinate trees and a crown or high thinning to remove dominants and codominant trees that are influencing adjacent dominant and codominant trees.

The development of pure plantations generally does not allow the degree of vertical stratification found in mixed species stands. Trees of the same species of similar ages and regeneration origin usually grow and develop at similar rates. Dominance is not expressed quickly since the trees grow at similar rates. In contrast, stratification occurs usually at an early age in mixed species stands (Clatterbuck and Hodges 1988, Oliver 1978). Crown differentiation, especially between different species is readily apparent. The lack of early stratification in single species plantations obscures that these plantations are actively growing and increasing in size. The growth of these stands appears rather gradual. Practitioners should be aware that these pure stands could stagnate after just a few years of intense competition among neighboring trees.

ACKNOWLEDGMENTS

Appreciation is expressed to Russell Cox, staff forester for tree improvement and Phil Hart, forest technician with the Tennessee Department of Agriculture, Forestry Division for the 30-year historical data and measurements, assisting with the thinning operation and maintaining the study area.

REFERENCES

Clatterbuck, W.K. 1987. Height growth and site index curves for cherrybark oak and sweetgum in mixed, even-aged stands on the minor bottoms of central Mississippi. Southern Journal of Applied Forestry. 11(4): 219-222.

Clatterbuck, W.K. 1993. Are overtopped white oak good candidates for management? In: Brissette, J.C., ed. Proc. of the seventh biennial southern silvicultural conference: 1992 November 17-19; Mobile, Al. Gen. Tech. Rep.SO-93. New Orleans, LA: USDA, Forest Service, Southern Forest Experiment Station: 497-500.

Clatterbuck, W.K.; J. D. Hodges. 1988. Development of cherrybark oak and sweetgum in mixed, even-aged bottomland stands in central Mississippi, U.S.A. Canadian Journal of Forest Research. 18(1): 12-18.

Ford, V. 1999. Competition control in plantation oak stands. In: Proceedings from Oak Regeneration Workshop; 1999 April 22; Knoxville, TN. The University of Tennessee, Dept. of Forestry, Wildlife & Fisheries, Knoxville: 27.

Hopper, G.M. (ed.); H. Applegate; D. Dale; R. Winslow. 1995. Forest practice guidelines for Tennessee. Agricultural Extension Service PB 1523, The University of Tennessee, Knoxville. 36 p.

McGee, C.E.; D.L. Loftis. 1986. Planted oaks perform poorly in North Carolina and Tennessee. Northern Journal of Applied Forestry. 3: 114-116.

Meadows, J.S.; J.C.G. Goelz. 2001. Fifth-year response to thinning in a water oak plantation in north Louisiana. Southern Journal of Applied Forestry. 25(1): 31-39.

Moehring, D.M.; J.D. Hodges; T.G. Matney. 1980. Biological assessment of thinning in southern pine plantations. Mississippi State University, Starkville. 171 p.

Oliver, C.D. 1978. The development of northern red oak in a mixed species forest in central New England. Yale University School For. Environ. Stud. Bull., 91. New Haven, CT. 63 p.

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

Smalley, G.W. 1991. Classification and evaluation of forest sites on the Natchez Trace State Forest, State Resort Park and Wildlife Management Area in west Tennessee. Gen. Tech. Rep. SO-85. New Orleans, LA: USDA Forest Service, Southern Forest Experiment Station. 73 p.

Smith, D.M. 1962. The Practice of Silviculture. Seventh Edition, New York: John Wiley & Sons, Inc. 578 p.