GROWTH AND DEVELOPMENT OF YELLOW-POPLAR PLANTATIONS ON THREE SITES RANGING FROM 9 TO 18 YEARS

Wayne K. Clatterbuck[1]

Abstract—Planting pine for conversion of former agricultural land to managed forests is well-documented, but little information is available for hardwood plantings. This study references three yellow-poplar (*Liriodendron tulipifera* L.) plantations (ages 9, 12, and 18 years) on different sites totaling 95 acres. The sites were located in middle Tennessee along a site productivity gradient composed of a floodplain and terrace site near the Cumberland River and an upland footslope site. All three sites had been in row crops or pasture prior to planting. Tree survival at time of measurement was greater than 75 percent for all three plantings. Average annual diameter increment and height increment for the three plantations were 0.5 inch and 4.2 feet, respectively. Comparisons of age, height, diameter, basal area, density, site index, and volume are made between the planted yellow-poplar in this study and three other published studies: natural stands of yellow-poplar and two studies with planted loblolly pine (*Pinus taeda* L.). Although site productivity and stand parameters differ among the studies, the growth of yellow-poplar plantations compares favorably with the natural stands of yellow-poplar and planted loblolly pine.

INTRODUCTION

Tennessee is 55 percent forested (14.4 million acres), and 89 percent of the composition is in hardwoods (Schweitzer 2000). The state has gained nearly 1.4 million acres of new forest land during the last 10 years, with about 600,000 acres reverting to other uses (May 1991, Schweitzer 2000). Through the Conservation Reserve Program, many acres of former agricultural land have been planted to pine. However, most nonindustrial forest landowners in Tennessee prefer to plant hardwood. The incentives for planting pine are poor. Tennessee has a lack of competitive markets for pine resulting in the lowest prices for pine pulpwood and sawtimber in the Southeast (Timber Mart-South 2002). Additionally, the recent southern pine beetle epidemic in Tennessee has killed nearly 400,000 acres of both natural and planted pine, about 33 percent of the total acreage categorized in pine types (Kauffman 2001).

Little information is available on afforestation of hardwoods on the better, more productive sites. Loblolly pine is not as site specific as yellow-poplar which typically occurs on the better sites, with a site index of 80 feet or greater at base age 50 years (Beck and Della-Bianca 1981). Yellow-poplar, with its fast growth and straight form, is a likely candidate for planting, especially on the better sites. The objectives of this study are two-fold: (1) to determine height, diameter and survival of three yellow-poplar plantations (planted in 1985, 1991, and 1994) on similar sites in Tennessee and (2) to compare growth of these plantations with natural yellow-poplar stands and planted loblolly pine as reported in the literature.

STUDY AREA

The study was conducted on three yellow-poplar plantations in Smith and Trousdale Counties in middle Tennessee at the transition between the Eastern Highland Rim and Nashville Basin Physiographic Regions. Braun (1950) described the vegetation of this area as part of the Western Mesophytic Forest, a transition area between the mixed Mesophytic Forest Region of the mountains to the east and the Oak-Hickory Region to the west. The three sites are within 10 miles of each other. Characteristics of each plantation site are as follows:

Site 1 is on a terrace of the Cumberland River. Soils are Ultic Hapludalphs (Armour series) formed in old alluvium overlying or in residuum derived from limestone (USDA-NRCS 2002). It was planted in 1991 and consisted of 32 acres. Site 2 is on the floodplain of the Cumberland River. Soils are Cumulic Hapludolls (Arrington series) formed in silty alluvium on floodplains and along drainageways (USDA-NRCS 2002). It was planted in 1994 and consisted of 25 acres. Site 3 is on the well-drained, footslopes. Soils are Typic Paleudults (Dellrose series), typically deep and well drained, formed in cherty colluvium (USDA-NRCS 2002). It was planted in 1985 and consisted of 39 acres.

Annual precipitation is 51 inches, usually evenly distributed in all seasons. Average site index (base age 50) is from 80 feet for upland oaks to 100 feet for yellow-poplar (Smalley 1983). All three study sites were former agricultural fields that were either row-cropped or in pasture. Each area was site prepared during the fall for planting the following year. Sites were cross-directionally disked followed by subsoiling in one direction. Each site was hand-planted at a 10 by 10-foot spacing using 1-0 yellow-poplar seedlings produced at the Tennessee Department of Agriculture, Division of Forestry nursery. The study sites, though planted at different times (years), were supervised by the same forester using the same procedures.

The only competition control used on these plantations after planting was mowing once or twice a year for the first 2 or 3 years. No herbicide was used during site preparation or following planting.

METHODS

Each plantation was sampled during the fall of 2002. Three 0.1-acre rectangular plots were randomly located in each plantation. Although a larger sample size might be desirable

[1] Associate Professor, Dept. of Forestry, Wildlife & Fisheries, University of Tennessee, Knoxville, TN 37996-4563.

Citation for proceedings: Connor, Kristina F., ed. 2004. Proceedings of the 12th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–71. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 594 p.

with the size of these plantations, each plantation was fairly homogenous with little tree variation. Thus, larger sample sizes were deemed unnecessary. Diameter at 4.5 feet diameter at breast height (d.b.h.) was measured for each tree in the plot. Total height was recorded from a subsample of three dominant or codominant stems. Empty cells (missing trees) in each plot were recorded to determine survival percentages.

Data from this study on planted yellow-poplar stands is compared to three other studies: natural yellow-poplar stands (Beck and Della-Bianca 1970, 1981), loblolly pine plantations on abandoned fields in Tennessee, Alabama and Georgia (Smalley and Bailey 1974, Smalley and Bower 1968), and loblolly pine plantations on cutover sites in the West Gulf Coastal Plain (Feduccia and others 1979).

RESULTS

Growth and stand parameters of each of the three yellow-poplar plantations through the 2002 growing season are shown in table 1. Average annual diameter growth rate of all sampled trees ranged from 0.45 to 0.63 inch per year across the three sites. Average annual height growth rate of dominant trees ranged from 4.0 to 4.4 feet per year. If height growth continues at this rate, site index for yellow-poplar is estimated to be 115 to 120 feet at 50 years (Beck 1962), much greater than that estimated by the soil survey reports (USDA-NRCS 2002) and by Smalley's (1983) land-type classification system. Although Beck's yellow-poplar site index curves were formulated for the Southern Appalachian Mountains, they are the best available for the Eastern Highland Rim of Tennessee.

Table 1—Growth and stand parameters of three yellow-poplar plantations after the 2002-growing season in Smith and Trousdale Counties in Middle Tennessee

	Site 1	Site 2	Site 3
Growing season (yrs)	12	9	18
Mean dominant height (feet)	53	40	73
Mean diameter (inches)	7.6	5.3	8.5
Survival (percent)	76	87	78
Largest diameter tree (inches)	11.4	6.7	11.6
Basal area (ft2 per acre)	101	56	128
Number of measured trees (n)	96	110	98

Tree survival decreased as age of the stand increased (table 1). As trees became larger, the amount of available growing space became more limited causing mortality of lesser stems. Basal area per acre also increased with age.

Table 2 shows the stand, growth and yield parameters of the planted yellow-poplar at age 18 for site 3, natural yellow-poplar stands at age 20, and two growth and yield studies for planted loblolly pine at age 20. The planted yellow-poplar in this study had greater average diameters and dominant heights than the two loblolly pine studies and the natural yellow-poplar stands. The basal areas and volumes per acre fluctuated between studies presumably because of the number of trees per acre originally planted and the number of trees currently present. Site productivity (as measured in volume) in this study is similar to those in the other studies even though as measured by site index, the numerical value between species (yellow-poplar and loblolly pine) is expected to differ.

DISCUSSION

Each of these studies is based on different assumptions and parameters that make direct comparison of growth and yield difficult. The work of Feduccia and others (1979) was based on cutover sites without intensive site preparation before planting. The assumption was that intensively managed loblolly pine plantations, where pine density is carefully controlled throughout the rotation and utilization is more complete at final harvest, would need minimal site preparation for repeated crops of pine. The West Gulf Coastal Plain also has much different soils and geology than middle Tennessee.

Pine plantations measured to predict growth and yield in the Highland regions of Tennessee, Alabama, and Georgia

Table 2—Stand, growth and yield comparisons of planted yellow-poplar, natural yellow-poplar stands and two planted loblolly pine studies

	Planted YPP[a]	Natural YPP[b]	Loblolly pine[c]	Loblolly pine[d]
Age (years)	18	20	20	20
Mean height-overstory (feet)	73	66	61	53
Mean diameter (inches)	8.5	8.2	7.8	8.2
Basal area (ft^2 per acre)	128	112	144	112
Density (trees per acre)	325	310	436	303
Site index at 50 years (feet)	120 YPP	115 YPP	105 LP	105 LP
Average volume (ft^3 per acre)	3,116	2,939	3,625	2,920

YPP = yellow poplar.

[a] Eastern Highland Rim of TN (site 3 of this study) planted at 435 trees per acre.

[b] Southern Appalachian Mountains (Beck and Della-Bianca 1970).

[c] Abandoned fields of Highland areas in TN, AL and GA planted at 500 trees per acre (Smalley and Bowers 1968, Smalley and Bailey 1974).

[d] Cutover sites in the Gulf Coastal Plain planted at 400 trees per acre (Feduccia and others 1979).

(Smalley and Bailey 1974, Smalley and Bower 1968) were based on plantations established on agricultural fields with little evidence of damage from snow, ice, insects and disease; where stands have not been burned, thinned, or pruned; and where survival and tree distribution were judged reasonably good and no reinforcement planting had occurred. One would expect some degree of site preparation was used to establish loblolly pine on old-fields or pastures before planting. However, there is no mention in the text of site preparation or even if site preparation was considered in the selection of sample plantation sites. The sites in this study, although more upland, were more similar to the soils and geology found in middle Tennessee.

The natural yellow-poplar stands (Beck and Della-Bianca 1970) are from the mountains and coves of western North Carolina and north Georgia. Geology and soils are different from that of the study site in middle Tennessee. However, the differences between the planted stand and the natural stand are probably based on the patchiness that occurs with stems in natural stands and the more structured spacing in planted stands. Beck and Della-Bianca also chose to base their growth and yield predictions on the largest 25 yellow-poplar trees per acre in unthinned second-growth Southern Appalachian stands. These trees would be 3 to 5 inches larger than the average dominant at comparable ages (Beck and Della-Bianca 1970).

In this study, the fields were disked twice in perpendicular directions and subsoiled before planting. Disking and subsoiling are common practices to break plowpans or fragipans and soil compaction in old fields. This more intensive site preparation may have attributed to better growth and survival of planted seedlings when compared to the other studies. The fields were mowed once or twice a year for 2 or 3 years to control competition from grass and other broadleaf vegetation. Although mowing reduces the height of competing vegetation, the roots are still present, affecting the moisture uptake of planted seedlings. Most pine planting today uses a herbicide release to aid the early growth of pine seedlings. A herbicide release probably would have assisted the growth of planted yellow-poplar in this study.

SUMMARY

Although this study comparing growth, yield, and stand parameters of planted yellow-poplar to natural yellow-poplar and planted loblolly pine are not directly comparable because of the different site conditions, stand parameters, and assumptions made in collecting information for each study, it appears that the growth and yield of yellow-poplar and loblolly pine are similar. With height growth rates of greater than 4 feet per year and diameter growth rates of 0.5 inch per year after 18 years, yellow-poplar can achieve growth rates comparable to, if not greater than, loblolly pine especially on the more productive sites. Thus, hardwood planting of yellow-poplar is practicable on the studied areas as an alternative to pine planting. Site productivity for yellow-poplar is greater than hypothesized by the soil survey estimations (USDA-NRCS 2002) and Smalley's (1983) site classification system in the first 20 years after planting.

ACKNOWLEDGMENTS

Appreciation is expressed to Jim Replogle, forester with the Tennessee Department of Agriculture, Division of Forestry in Carthage, TN for access to and maintenance of the study areas. The author thanks Daniel Cassidy, Matt Olson, and Chris Oswalt for their assistance with data collection.

LITERATURE CITED

Beck, D.E. 1962. Yellow-poplar site index curves. Res. Notes 180. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 2 p.

Beck, D.E.; Della-Bianca, L. 1970. Yield of unthinned yellow-poplar. Res. Pap. SE-58. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 20 p.

Beck, D.E.; Della-Bianca, L. 1981. Yellow-poplar: Characteristics and management. Agric. Handb. 583. Washington, DC: U.S. Department of Agriculture, Forest Service. 92 p.

Braun, E.L. 1950. Deciduous forests of eastern North America. Philadelphia, PA: The Blakiston Co. 596 p.

Feduccia, D.P.; Dell, T.R.; Mann, W.F., Jr. [and others]. 1979. Yields of unthinned loblolly pine plantations on cutover sites in the West Gulf Region. Res. Pap. SO-148. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 88 p.

Kauffman, B.W. 2001. Tennessee Forest Health Monitor. Nashville, TN: Tennessee Department of Agriculture, Division of Forestry. April 2001 Issue. 7 p.

May, D.M. 1991. Forest resources of Tennessee. Resour. Bull. SO-160. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 65 p.

Schweitzer, C.J. 2000. Forest statistics for Tennessee, 1999. Resour. Bull. SRS-52. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 78 p.

Smalley, G.W. 1983. Classification and evaluation of forest sites on the Eastern Highland Rim and Pennyroyal. Gen. Tech. Rep. SO-43. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 123 p.

Smalley, G.W.; Bailey, R.L. 1974. Yield tables and stand structure for loblolly pine plantations in Tennessee, Alabama, and Georgia Highlands. Res. Pap. SO-96. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 81 p.

Smalley, G.W.; Bower, D.R. 1968. Volume tables and point-sampling factors for loblolly pines in plantations on abandoned fields in Tennessee, Alabama, and Georgia Highlands. Res. Pap. SO-32. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 13 p.

Timber Mart-South. 2002. Third Quarter 2002 Price Report. Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA. 36 p.

U. S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS). 2002. Soil Survey Division, Official Soil Series Descriptions [Online WWW]. Available URL: http://ortho/ftw.nrcs.usda.gov/osd/ [Accessed Dec. 2002].