DYNAMICS OF PLANTED CHERRYBARK OAK SEEDLINGS AND YELLOW-POPLAR FROM SEED FOLLOWING A REGENERATION CLEARCUT

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Abstract.—A bottomland loblolly pine (*Pinus taeda*) stand originating from an early 1940s planting on a minor stream bottom of the Coastal Plain in west Tennessee was harvested in 1992 and allowed to regenerate to hardwoods. Although the pines had been planted, a few naturally regenerated yellow-poplar (*Liriodendron tulipifera*) and sweetgum (*Liquidambar styriciflua*) were present in the overstory at harvest. Cherrybark oak (*Quercus pagoda*) seedlings were planted the spring after the harvest to supplement a non-existent oak component in the regenerating stand. Advance reproduction of any species was not present in the closed canopy stand (stem exclusion stage) prior to harvest. This study follows the growth and development of the planted cherrybark oaks with the natural reproduction present on a productive site for 17 years following the harvest. Most of the planted oaks are in intermediate or suppressed crown positions compared to yellow-poplar after 17 years. Although competing yellow-poplars adjacent to planted oaks were cut within a 3-foot radius after 7 growing seasons, yellow-poplars continue to outgrow the oaks, affecting oak growth from increasing distances. This study suggests that on better sites, yellow-poplar from seed grows faster than planted cherrybark oak such that supplemental plantings of cherrybark oak are not successful. Either intensive site preparation is required to control the establishment and growth of yellow-poplar from seed or intermediate operations are necessary on a 3- to 5-year interval to ensure oaks are not overshadowed by faster growing yellow-poplar. Competition control is essential if oaks are to become an overstory component of the new stand.

INTRODUCTION

Oak (*Quercus* sp.) enrichment plantings have been advocated as a substitute for gaining oak advance reproduction when advance reproduction is not present (Wishard and others 1999, Johnson and others 2002, Spetich and others 2004, Morrissey and others 2007). Most oak regeneration recommendations suggest that adequate advance oak reproduction must be present in sufficient size and number before a regeneration harvest takes place (Sander 1972, Loftis 1990, Johnson and others 2002). If not present, oaks will not be a significant component of the new stand. Developing natural oak advance reproduction of adequate size and number prior to the harvest may take 6 to 12 years depending on seed availability, germination, weather, animal predation, and seedling growth and development. One alternative to securing advance reproduction of oak is substituting enrichment plantings after the harvest.

Oak seedlings grow notoriously slowly after outplanting. Faster-growing species often outgrow oak seedlings on the more productive sites. Research has investigated how to increase the growth of planted oaks through

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nursery protocols by planting high-quality, large seedlings capable of growing in height after outplanting (Clark and others 2000, Kormanik and others 2003) or through oak tree improvement programs (Jacobs 2003). However, equally important and receiving less research attention is controlling competing and faster-growing vegetation. Even with the best oak seedling growth, some species, especially yellow-poplar (*Liriodendron tulipifera*) in Tennessee, will outgrow oak on the better sites without treatments to deter growth of yellow-poplar and enhance oak growth.

Given the dominance of other species, how did current oak forests develop on the better sites when faster-growing species were present? The contemporary thought is that frequent small-scale disturbances, such as repeated use of fire and frequent, light partial harvesting through subsistence activities by landowners for fuel and building supplies, promoted conditions that deterred the growth of yellow-poplar and enhanced the growth of oak. Those anthropogenic management conditions do not exist today. Foresters are continually challenged to create conditions to promote oak regeneration, growth, and development through cost-effective management activities.

The purpose of this study is to document the growth of cherrybark oak (*Quercus pagoda*) planted post-harvest in the presence of a faster-growing species such as yellow-poplar on a high-productivity site. This research will demonstrate a need for rigorous control of competing vegetation to ensure successful oak enrichment planting.

STUDY AREA

The study was conducted in Henderson County, TN, about 4 miles east of Wildersville, TN, on the Natchez Trace State Forest (NTSF) managed by the Tennessee Department of Agriculture, Forestry Division (TDA-FD). NTSF occupies a portion of the Red Hills Belt of the East Gulf Coastal Plain section of the Coastal Plain physiographic province (Fenneman 1938). The study site is within Landtype 23, Narrow Moist Bottoms, as defined by the site classification of Smalley (1991). Soils are Aquic Udifluvents (Collins and Iuka series) formed from alluvium washed from upland soils and formed in loess and sandy, loamy, and clayey Coastal Plain sediments. Soils in these minor bottoms have a variety of textures because of mixing during transport, active erosion, and differential rates of deposition. The site is moderately well-drained, with short-duration flooding (flowing water) and a water table from 2- to 5-feet deep.

Annual precipitation is 51 inches, usually evenly distributed across all seasons. Average site index (base age 50) is estimated to be 100 feet for loblolly pine and cherrybark oak and 105 feet for yellow-poplar (Smalley 1991).

The study area was an agricultural field prior to government acquisition by the Resettlement Administration in the late 1930s and was planted with loblolly pine (*Pinus taeda*) during the early 1940s by TDA-FD to control erosion. The resulting stand was characterized as a bottomland pine stand with planted loblolly pine and volunteer yellow-poplar and sweetgum (*Liquidambar styraciflua*) (Table 1), with basal area bordering overstocked conditions of 140 ft^2/acre. A regeneration harvest was conducted during winter/spring 1992. The stand was in the stem exclusion stage. A formal regeneration survey was not conducted because leaves were not present during the dormant season when the harvest and planting occurred. However, a survey was conducted on twelve 0.004-acre plots to document remaining stems greater than 3 feet in height. Little advance reproduction more than 3 feet tall was present for commercial species (Table 2).

Table 1.—Stand composition, average number of trees per acre, and mean d.b.h. of trees greater than 5 inches present in 1991 before the harvest for the cherrybark oak enrichment planting study at Natchez Trace State Forest, TN. Data are from timber sale inventory conducted by TDA-FD.

Species	Average number of trees/acre	Mean d.b.h. in inches(range)
Loblolly pine	81	16.8 (12 - 24)
Yellow-poplar	7	14.1 (8 - 18)
Red maple	7	6.4 (5 - 9)
Sweetgum	4	7.7 (6 - 12)
Red oak	3	9.3 (8 - 14)

Table 2.—Advance reproduction greater than 3 feet tall present after harvest (March 1992) for the cherrybark oak enrichment planting study at Natchez Trace State Forest, TN. Inventory based on twelve 0.004-acre plots located on 3 acres with each plot 60 feet apart on a transect.

Species	Number of stems per acre > 3 feet tall
Red maple	42
Sweetgum	21
Blackgum	21
Loblolly pine	0
Red oak	0
Yellow-poplar	0

Cherrybark oak 1-0 bare-root seedlings were planted in April 1992 at varied spacings of 8 to 12 feet to avoid logging slash, stumps, skid trails, and other obstacles from the harvest. The intent was to establish oaks within the regeneration pool and follow their growth in relation to other species. Seedlings greater than ⅜ inch at the root collar and with tops greater than 24 inches with at least five first-order lateral roots were planted. No site preparation was required prior to planting because the harvest was fairly clean. The management prescription was to allow natural hardwood reproduction to occur, effectively changing the species composition from pine to hardwoods. Oaks were not present in the advance reproduction. Thus, enrichment planting with cherrybark oak was conducted to (1) provide that oak would be a component in the future stand; and (2) conduct research comparing growth of sheltered and unsheltered seedlings. A 4-foot, brown Tubex® tree shelter (Tubex, UK) was placed on every second seedling, creating 70 pairs of seedlings (with and without shelters).

The sheltered seedling study was a companion study to one reported by Clatterbuck (1999). After 7 growing seasons when there was no difference in height growth between sheltered and unsheltered cherrybark seedlings, the shelters were removed and the shelter study was discontinued. A release cleaning through a crown touching technique was conducted in 1999 if the crown of a planted tree was influenced by an adjacent tree (Miller and others 2007). Competing trees were manually cut, usually within a 3-foot radius of the planted cherrybark oak, and no herbicide was used to control sprouting from the cut trees. The remaining seedlings (both sheltered and unsheltered) are the basis of the present study.

METHODS

After 17 growing seasons, in winter 2008, 117 of the planted cherrybark oak trees were located. Diameters at 4.5 feet (d.b.h.) and crown class of planted cherrybark oak trees were recorded. Distance to the nearest competing tree that was greater than 2 inches d.b.h. were measured and crown class and species were recorded. Bivariate analyses of cherrybark oak diameter and distance to competing trees were explored using JMP 8.0 (SAS Institute Inc., Cary, NC, 2008). A stand inventory was conducted to characterize the stand by establishing a transect and locating ten 0.05-acre plots at 100-foot intervals.

RESULTS

After the 2008 growing season (17 years), the fully stocked stand is dominated by yellow-poplar with a few sweetgum in the upper canopy (Table 3). Planted cherrybark oaks are subordinate to the yellow-poplar. Red maple (*Acer rubrum*), blackgum (*Nyssa sylvatica*), and dogwood (*Cornus florida*) are also present in the subcanopy. Yellow-poplar averages 7.0 inches in diameter with a range of 4.9 to 10.3 inches. The planted cherrybark oak average 1.7 inches with the majority of the stems in the one-inch diameter class (Table 4).

A positive relationship ($r^2 = 0.80$; p F < 0.0001) exists between the diameter of the planted cherrybark oak (transformed log) and distance to the nearest yellow-poplar greater than 2 inches (Fig. 1).

Table 3.—Stand composition, average number of trees per acre, and mean d.b.h. of trees greater than 2 inches present after the 2008 growing season for the cherrybark oak enrichment planting study at Natchez Trace State Forest, TN. Inventory sample based on ten 0.02-acre plots on 3 acres with each plot 100 feet apart on a transect. Planted cherrybark oak trees were not included in this inventory.

Species	Average number of trees/acre	Mean d.b.h. in inches(range)
Yellow-poplar	255	7.0 (2 - 10)
Sweetgum	75	4.3 (2 - 8)
Red maple	55	5.6 (2 - 12)
Blackgum	40	4.4 (2 - 6)
Dogwood	15	3.1 (2 - 4)
Loblolly pine	5	4.8 (*)
Total	445	

*only one tree in sample

Table 4.—Number of planted cherrybark oak (n = 117) by 1-inch diameter class after 17 growing seasons for the cherrybark oak enrichment planting study at Natchez Trace State Forest, TN.

Diameter size class (inches)	Number of planted cherrybark oak
1-inch (0.5 to 1.4)	63
2-inch (1.5 to 2.4)	35
3-inch (2.5 to 3.4)	14
4-inch (3.5 to 4.4)	4
5-inch & greater (> 4.5)	1

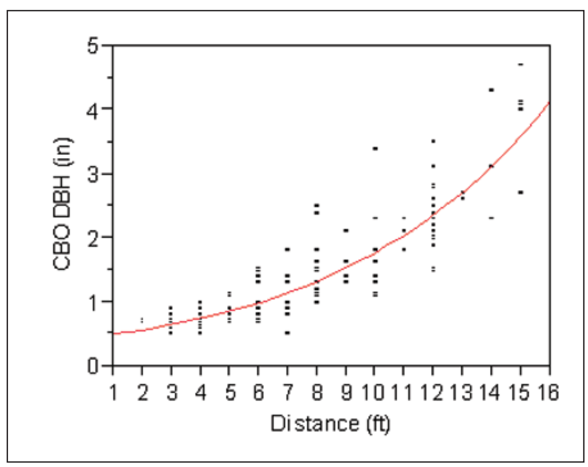

Figure 1.—Logarithmic relationship ($r^2 = 0.80$) of planted cherrybark oak diameter (CBO DBH) to distance of nearest yellow-poplar stem greater than 2 inches in diameter (n = 117) after 17 growing seasons for the cherrybark oak enrichment planting study at Natchez Trace State Forest, TN. Fitted equation: Log [CBO DBH (in)] = -0.856 + 0.143 [Distance (ft)].

DISCUSSION

Although yellow-poplar seedlings were not present in the advance reproduction at time of harvest, viable seed was present in the soil duff. Seed available from adjacent trees also germinated and regenerated the area after the harvest. Yellow-poplar seed is known to stay viable in the forest duff for 4 to 7 years (Clark and Boyce 1964, Beck 1990) and to grow rapidly following disturbance from fire or soil scarification during harvesting operations (Beck and Della-Bianca 1981). Yellow-poplar presently composes nearly 90 percent of the overstory after 17 growing seasons and averages 7 inches in diameter. The present stand is fully stocked, bordering on overstocked conditions.

On these better sites, forest managers at TDF-FD desire a more mixed composition with oaks as part of the composition. Oak does not need to dominate the overstory but should compose a portion of the overstory. Since oaks were not present in the advance reproduction, oaks were planted to supplement the composition of the natural regeneration. The planted cherrybark oaks are suitable for these sites (Smalley 1991) but were influenced by the faster-growing and more numerous yellow-poplar. Planted oaks were relegated to subordinates of yellow-poplar and averaged 1.7 inches d.b.h. in 17 growing seasons. A distance relationship between cherrybark oak and competing yellow-poplar was apparent in this study, with larger diameter oaks occurring at increasing distances from yellow-poplars. However, only 19 of 117 oaks (16 percent) surviving the 17 growing seasons were 3 inches in d.b.h. or greater in contrast with the larger yellow-poplar. Even though cherrybark oak seedlings were graded such that the best seedlings with adequate root systems were planted, the planted oaks could not keep up with the faster-growing yellow-poplar.

Although competition adjacent (3-foot radius) to the planted cherrybark oaks was cut after 7 growing seasons, the faster growth of yellow-poplar outside the 3-foot radius still affected the growth of the cherrybark oak. As the yellow-poplar grew, they progressively influenced the slower growing oaks from greater distances. Although spacing was wider, similar relationships were found in a sycamore and cherrybark oak plantation (Clatterbuck and others 1987).

This study did not have a control to monitor the growth of planted cherrybark oak without any competition from adjacent stems. However, a cherrybark oak plantation on a similar site at NTSF where competition was controlled averaged 5 inches in d.b.h. after 15 growing seasons (Clatterbuck 2002).

If advance oak reproduction is absent and oaks are desired in the new stand, yellow-poplar regeneration from seed must be controlled. Even with the use of high-quality oak seedlings that are capable of growth once outplanted, natural yellow-poplar reproduction will usually overwhelm the oaks, relegating oaks to the subordinate canopy. Several options could be available to control the yellow-poplar and promote the growth of oaks, even though most of these options remain untested. These alternatives include:

1. Conduct post-harvest burning to consume the viable yellow-poplar seed and provide less competition to the oaks once outplanted. Adjacent remaining yellow-poplar seed trees should be cut so the seed from the current year would not disseminate into the harvested opening.
2. Use herbicides on an annual or biennial basis to control yellow-poplar seedlings
3. Use a pre-emergent herbicide to control the viable yellow-poplar seed in the forest duff during site preparation prior to planting.
4. Perform a crop tree release at intervals of 3 to 5 years to allow the planted oaks to grow and develop and control yellow-poplar at progressively greater distances.

Site productivity affects the development of cherrybark oak and yellow-poplar. On the highly productive site in this study, yellow-poplar grows faster than cherrybark oak. With decreases in site productivity, however, yellow-poplar growth may not be as great (O'Hara 1986). Cherrybark oak has a greater probability of growing, surviving, and forming stand mixtures with yellow-poplar on lower-productivity sites.

SUMMARY

Yellow-poplar from seed has the ability to outgrow and overwhelm planted cherrybark oak seedlings on highly productive sites that support the growth of both species. Most research has explored methods to increase the growth of oak through tree improvement programs and nursery protocols to produce seedlings capable of greater growth during the first growing season. However, control of faster-growing species/competition is also necessary through site preparation or intermediate operations to allow oaks to grow and develop with little hindrance. This study demonstrates that even with larger planted seedlings where advance reproduction of any species is not present, some type of control of yellow-poplar is essential for oak to become a viable component of the future stand

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