THIRTY-YEAR ASSESSMENT OF RELEASED, OVERTOPPED WHITE OAKS

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Abstract.—White oak (*Quercus alba* L.) is a slow-growing species that is often overtopped in the mixed upland hardwood forests of the Cumberland Plateau. Forest managers have concerns about the potential economic value of releasing overtopped white oaks to become valuable crop trees. This study follows the growth and development of 104 overtopped white oaks after a diameter-limit cut in a forest stand on the Cumberland Plateau in Tennessee. A 30-year assessment is presented following initial and 15-year reports on diameter, height, volume growth, and stem quality of released and unreleased individuals. Released trees experienced more diameter growth when compared to unreleased trees. However, released trees developed a multitude of epicormic branches along the central bole. Over time, many of these persistent epicormics became larger, degrading log quality. Therefore, long-term results indicate that overtopped white oaks are not suitable as future crop trees. Data after 30 years are consistent with previous studies suggesting the release of overtopped white oaks perpetuates a low-quality stand that does not achieve the potential productivity of the site.

INTRODUCTION

The upland hardwood forests of the Cumberland Plateau contain a considerable number of overtopped white oaks (*Quercus alba* L.). Few studies have been developed to investigate the potential for overtopped white oaks to become high-quality timber following release. Land managers and researchers have expressed varied beliefs concerning the benefit of releasing suppressed white oaks. Most of this uncertainty is based on the diameter of trees at the time of release. Forest managers have concerns about the potential economic value of releasing overtopped white oaks to become valuable crop trees. Many practitioners assume small-diameter trees are a younger age class than overstory trees and will respond to release. Further, results of previous studies concerning this issue have varied. Some indicate that release treatments of suppressed white oaks produced lower quality and less desirable timber (Roach and Gingrich 1968, O'Hara 1986, Clatterbuck 1992). Other studies, however, demonstrate the value of releasing pole-sized white oaks where increased diameter growth is gained post-treatment (Minckler 1967, Schlesinger 1978, Dale and Sonderman 1984).

This report is an extension of two previous reports (McGee and Bivens 1984, Clatterbuck 1992) of a study that addressed the potential for released overtopped white oak trees to become merchantable after harvesting. Trees within this study were initially harvested in 1978 using a 14-inch diameter-limit cut. The effects of the release were remeasured and reported at 4 and 15 years post-treatment. The 30-year results are reported in this paper. Our objective was to quantify long-term growth effects following release of overtopped white oaks on the Cumberland Plateau.

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STUDY AREA

The study was conducted in Franklin County, TN, on the forest domain owned by Sewanee: The University of the South. The site is typical of upland hardwood forests of the weakly dissected Cumberland Plateau surface with elevations of 1,900 ft (Smalley 1982). Repeated harvesting, burning, and grazing occurred on this site for more than a century preceding the study. However, no cutting occurred during the 20 years before the study began in 1978. The study site is approximately 100 acres and contains predominately oak species, including white, chestnut (*Q. prinus*), northern red (*Q. rubra*), and black (*Q. velutina*) oaks. Other species associates include sourwood (*Oxydendrum arboreum*), yellow-poplar (*Liriodendron tulipifera*), blackgum (*Nyssa sylvatica*), and maples (*Acer* sp.). The site index at base age 50 for upland oaks ranged from 60 to 70 feet. Agronomical, climatological, and geological characteristics of the area are described by Smalley (1982). A diameter-limit harvest was conducted on 60 acres in 1978. Prior to the harvest, the site was fully stocked. Prism tally conducted following harvesting activities indicated an average residual basal area of 30 square feet per acre following the harvest. Current site stocking is around 60 percent, near the "B" line of the Gingrich Stocking Diagram (Roach and Gingrich 1968).

METHODS

Previous studies by McGee and Bivens (1984) and Clatterbuck (1992) described the use of tree age, diameter, height, and tree quality to predict response to release. This study closely follows the methodology outlined by both.

In 1978, suppressed/overtopped white oaks were released via a commercial harvesting operation. The harvesting method utilized was a 14-inch diameter-limit harvest and could be described as a "logger's choice harvest," where all merchantable trees were harvested. Following harvest, remaining overstory trees adjacent to sample trees were also felled. The study examined 104 overtopped white oaks after the harvest. Sample trees were selected and subjectively classified as low-, medium-, and high-quality trees based on crown form, crown size, and straightness of the stem (refer to McGee and Bivens [1984] for definitions), tagged, and recorded with an azimuth and distance from the previous tree. Of the released trees, 42 were high quality, 37 were medium quality, and 25 were low quality. In the uncut area (40 acres), 40 unreleased trees were selected and classified as high quality using the same methodology as the aforementioned released trees. The original study design was to compare the performance of high-quality released and unreleased trees only. Since medium- and low-quality unreleased trees were not a component of the original study design, comparisons of medium- and low-quality released and unreleased trees could not be evaluated. Immediately post-harvest, volume was calculated and age, diameter at breast height (d.b.h.), and total height were measured for each tree. Trees were again re-measured and calculated at 4 (McGee and Bivens 1984), 15 (Clatterbuck 1992), and 30 years post-release. Epicormic branches greater than 6 inches long on the bottom 16-foot log, hereafter referred to as the "butt log," were tallied as an indication of bole quality. Age was initially determined using a tree corer. Height and volume were measured initially and at 4 years with a Barr and Stroud dendrometer from fixed, relocatable ground locations. At 15 years, a Suunto clinometer was used to measure height from the same locations. In autumn 2008, 30-year measurements were conducted. Total height was measured with a Haglof Vertex III hypsometer. Diameter at breast height was measured with diameter tape. Volume of total wood above stump was estimated using regression equations (Formulas 1 and 2) from Clark and others (1986).

Formulas 1 and 2.—Regression equations for estimating white oak cubic-foot volume of above-stump total tree wood.

1: Trees <11.0 in. d.b.h.:

$$Y = 0.00274(D^2Th)^{0.98507}$$

2: Trees ≥11.0 in. d.b.h.:

$$Y = 0.00171(D^2)^{1.08362}(Th)^{0.98507}$$

Where: Y = Volume of above-stump total tree wood in cubic feet.
D = Tree d.b.h. in inches.
Th = Tree total height in feet.

DATA ANALYSIS

The model for this case study was a completely randomized design with pseudo-replication. Dependent variables were height, d.b.h., volume, and epicormic count. Independent variables were quality rating and existence of release. Analysis of variance was conducted using mixed models (SAS Institute, Inc., Cary, NC) and least square means were separated using Tukey's significant difference test. Data were analyzed with a confidence interval of 0.05.

RESULTS

Diameter distributions of white oak sample trees in 1978 ranged from 2 to 12 inches (McGee and Bivens 1984). However, only 7 percent of the sample trees exceeded 10 inches in diameter. Initial heights of sample trees ranged from 20 to 70 feet. Age class of sample trees ranged from 20 to 120 years before the release treatment. Only two trees were greater than 100 years old.

The release of high-quality overtopped white oaks resulted in significantly more volume growth after 30 years when compared to unreleased trees ($p<0.05$) (Table 1). Growth in diameter, height, and volume from initial measurements to 30 years were similar for the high- and medium-quality trees ($p<0.05$). Diameter growth of high-quality released oaks after 30 years was weakly correlated ($r^2 = 0.59$) with volume growth. Diameter growth of high-quality unreleased oak after 30 years was moderately correlated with volume growth ($r^2 = 0.69$). High-quality unreleased oaks responded with greater volume growth at a lower diameter growth rate compared to high-quality released oaks (Fig. 1). However, released high-quality trees accumulated more volume when d.b.h. growth rates were greater. Volume growth rate for high- and medium-quality trees was 8.6 and 7.7 ft^3 per decade, respectively. Volume growth rate for low-quality and high-quality unreleased trees were 5.6 and 5.5 ft^3, respectively (Table 1). Of the 104 released trees, eight trees were dead and missing, standing dead, or dead and down after 30 years. After 4 years, 20 of the 104 trees experienced negative growth (McGee and Bivens 1984). Negative growth is the result of dead or drooping tops. However, these 20 trees recovered their growth rates after 15 and 30 years. In year 30, only two trees experienced negative growth. Negative growth of trees influenced the mean height growth values in Table 1.

Following harvest, all overtopped oaks showed a sharp increase in the number of epicormic branches. At year 15, the number of new epicormics decreased (Table 2). At year 30, however, the epicormics remained persistent, degrading log quality. Unexpectedly, the epicormic count for low-quality trees decreased after 30 years, while the number increased for higher-quality trees.

Table 1.—Initial characteristics of released and unreleased overtopped white oak sample trees and their average growth responses after 15 and 30 years for the overtopped white oak study, Franklin County, TN. Significance at an alpha level of 0.05 is indicated by letter for 30-year growth.

			Initial mean values (1978)			Avg. 15-year growth			Avg. 30-year growth		
Treatment	Sample trees (n)*	Avg.age in 1978 (yrs.)	Ht. (ft.)	d.b.h. (in.)	Vol. (ft^3)	Ht. (ft.)	d.b.h. (in.)	Vol. (ft^3)	Ht. (ft.)	d.b.h. (in.)	Vol. (ft^3)**
High-quality	38	53	42	5.7	5.5	5.8	3.5	7	28.7a	6.4a	25.7a
Medium-quality	35	60	42	5.9	4.8	4.8	3.2	7.5	27.3a	5.7ab	23.19ab
Low-quality	23	62	35	5.2	4.3	7	3.1	4.5	25.7ab	4.9b	16.9b
No release, High-quality	40	49	45	6.2	6.2	7.2	2	4.4	22.2b	3.5c	16.5b

* Value at the time of the 30-year assessment
** Volume estimates from Clark and others 1986.

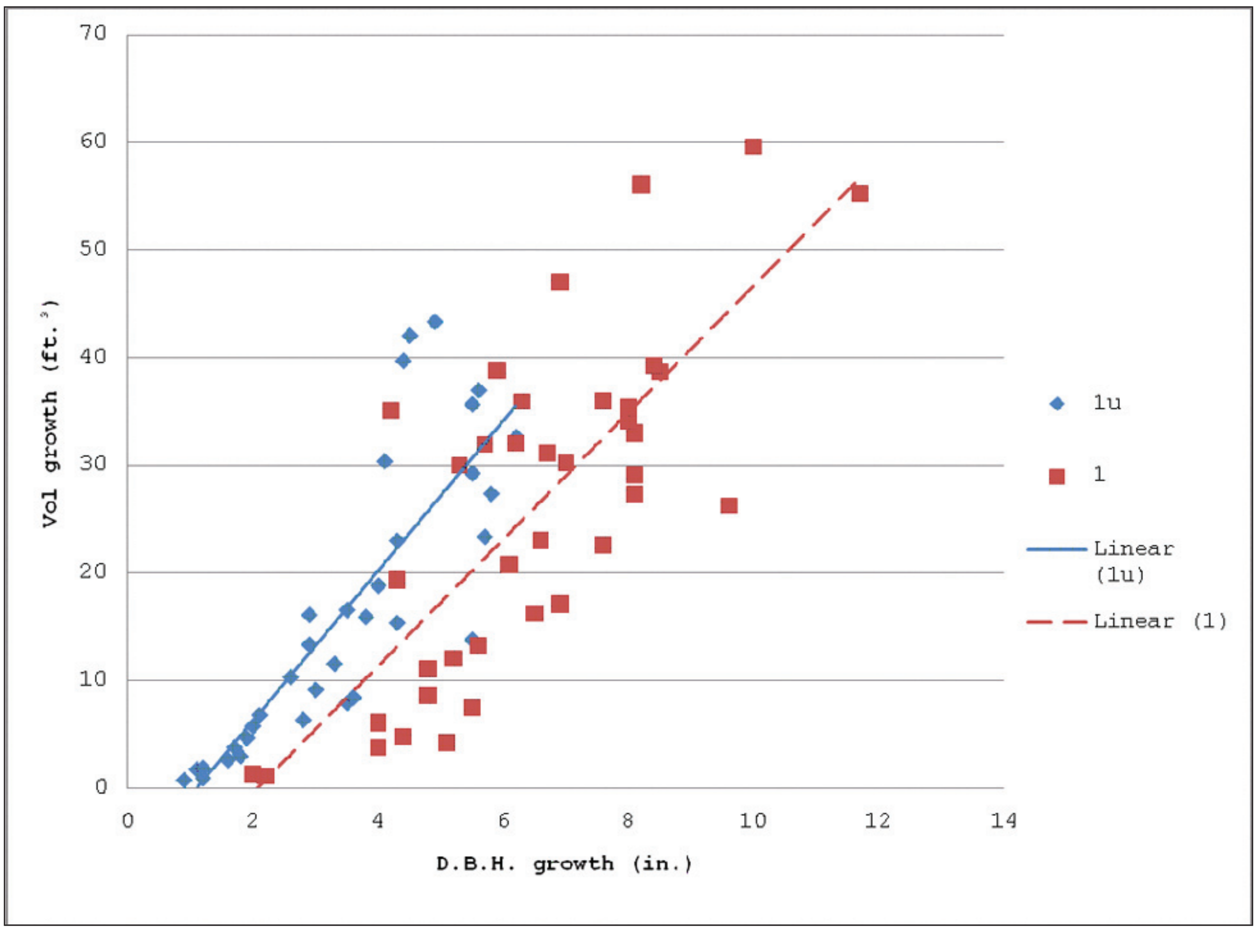

Figure 1.—Thirty-year volume growth for high-quality, released (1) and unreleased (1u) white oak in relation to growth in stem diameter for the overtopped white oak study, Franklin County, TN. Correlation for high-quality released oaks was r^2 = 0.59. Correlation for high-quality unreleased oaks was r^2 = 0.69.

Table 2.—Average number of epicormic branches (greater than 6 inches in length) on released and unreleased white oak butt logs relative to tree quality for the overtopped white oak study, Franklin County, TN. Significance at an alpha level of 0.05 is indicated by letter at 30 years.

	Average number of epicormic branches			
Treatment	Initial	4 years	15 years	30 years
High-quality	3.8	15.4	6.4	4.1ab
Medium-quality	6.4	14.9	7.2	5.1ab
Low-quality	5.9	13.2	6.9	2.7b
No release, high-quality	4.8	7.2	7.0	7.4a

DISCUSSION

Overtopped white oaks on the Cumberland Plateau will respond to release with increased growth rates. High-quality trees are associated with larger, healthier crowns as described by McGee and Bivens (1984). As a result, higher-quality trees performed better than released lower-quality trees and unreleased high-quality trees. Low-quality overtopped oaks experienced crown dieback and drooping more frequently. Upon release, an increase in epicormic branching of overtopped white oaks can be expected. Many of these initial epicormics have become persistent branches, degrading log quality. However, the epicormic count decreased after 15 years, and remained constant to 30 years. Although this study did not specifically address potential changes in tree grade or log grade by following the placement or growth of epicormic branches of released white oaks, the persistent epicormics that do remain, the larger diameters of the epicormics, the advanced age of the released trees (nearing 100 years), and the small diameters (less than 12 inches) of released, overtopped trees indicate that these trees did not increase in value after 30 years.

The overtopped white oaks in this study were released in a diameter-limit harvest that is similar to high-grading or a logger's choice harvest. Most of these overtopped oaks were greater than 75 years of age, averaged 6 inches in diameter and 40 feet tall at release, and had small, sparse, flat-topped crowns. These are not vigorous trees and did not respond well to release from overstory removal. These trees may be the result of a series of past high-grading events, as has been common practice in the hardwood forests of the Cumberland Plateau (McGee 1982) and may represent inferior genetic stock. After 30 years, these same trees averaged 10 to 12 inches in diameter and 60 to 70 feet tall. Considering that site index for upland oaks on these sites is 60 to 70 feet in 50 years, the overtopped trees took more than twice as long to reach these heights, suggesting that these trees did not realize the potential productivity of the site.

Although volumes and total heights of released and unreleased trees did increase over 30 years and more so in the last 15 years than the previous 15 years, the rate of diameter growth decreased in the last 15 years compared to the first 15 years (Table 1). The increase in volume may be skewed because the volume equation is more sensitive to the 50-percent increase in total height of small, overtopped trees rather than diameter growth. In addition, some bias in collective height measurements could have been introduced with the different instruments (dendrometer, clinometer, hypsometer) used during each of the measurement periods.

While overall volume growth was greater for high-quality released trees compared to high-quality unreleased trees (Table 1), the unreleased trees had more volume per unit d.b.h. (Fig. 1). Two causes related to study implementation are hypothesized for this relationship: (1) minor site differences within the study area; and

(2) skewed designation of high-quality trees between the cut and uncut areas during the initial tree selection process, i.e., the released trees were selected after the harvest cut and unreleased trees were selected in a fully stocked stand that was not cut.

The major decision to be made in these stands before the harvest is whether the remaining stems are capable of increasing in value (McGee 1982, Ezell 1992, Clatterbuck 2006). Is there enough acceptable growing stock remaining to continue to manage these stands, or should the stand be completely regenerated? The performance of advanced-age, overtopped white oak in this study on the Cumberland Plateau suggests that these stems will not increase in value appreciably, although volumes of small-diameter trees will increase somewhat with additional light and space resources. Thus, 30 years of growth that could be occurring on young vigorous regeneration is being sacrificed for 30 years of growth on residual, overtopped trees that will not increase in value.

In contrast to this study, a typical crop tree release is an intermediate silvicultural treatment intended to provide increased growing space to selected trees through removal of crown competition from adjacent trees (Miller and others. 2007). Generally, crop tree release is performed during the stem exclusion stage at much younger ages (10 to 30 years of age), when codominant trees are released from surrounding vegetation. The increased growth rates of the more vigorous codominant trees occur with little degradation of log quality.

CONCLUSION

Although overtopped oaks exhibited greater growth rates when released, conditions varied. Persistent epicormics, drooping tops, low-quality stems, and tree mortality were all present after release (McGee and Bivens 1984, Clatterbuck 1992). Thirty-year results were similar to 4- and 15-year results and showed that overtopped white oaks were not good candidates for release. Selection of crop trees based on form and quality offers the greatest potential benefits associated with release (Minckler 1957). However, slow growth rates of overtopped trees exhibited in our study indicate little benefit from the release (McGee and Bivens 1984, Clatterbuck, 1992). The results of this long-term study suggest that diameter-limit harvests or high-grading on the Cumberland Plateau will not create a future stand of high-quality and valuable white oaks. Although released overtopped white oaks did increase in volume, with greater volumes on higher-quality trees, these trees will remain degraded due to the persistence of epicormic branches, advanced age, and relatively slow growth.

LITERATURE CITED

Clark, A.; Phillips, D.; Frederick, D. 1986. **Weight, volume, and physical properties of major hardwood species in the Upland-South.** Res. Pap. SE-257. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 61 p.

Clatterbuck, W.K. 1992. **Are overtopped white oak good candidates for management?** Gen. Tech. Rep. SO-93. Proceedings at the seventh biennial Southern silvicultural research conference. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 497-500.

Clatterbuck, W.K. 2006. **Treatments for improving degraded hardwood stands.** Publication SP680. Knoxville, TN: University of Tennessee, Extension Service. 12 p.

Dale, M.E.; Sonderman, D.L. 1984. **Effect of thinning on growth and potential quality of young white oak crop trees.** Res. Pap. NE-539. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

Ezell, A.W. 1992. **Evaluating high-graded hardwood stands.** Publication 1834. Mississippi State, MS: Mississippi State University, Cooperative Extension Service. 6 p.

McGee, C.E. 1982. **Low-quality hardwood stands. Opportunities for management in the Interior Uplands.** Gen. Tech. Rep. SO-40. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 22 p.

McGee, C.E.; Bivens, D.L. 1984. **A billion overtopped white oak – assets or liabilities.** Southern Journal of Applied Forestry. 8(4): 216-220.

Miller, G.W.; Stringer, J.W.; Mercker, D.C. 2007. **Technical guide for crop tree release in hardwood forests.** Publication PB1774. Knoxville, TN: University of Tennessee Extension. 24 p.

Minckler, L.S. 1957. **Response of pole-sized white oak trees to release.** Journal of Forestry. 55(11): 814-815.

Minckler, L.S. 1967. **Release and pruning can improve growth and quality of white oak.** Journal of Forestry. 65: 654-655.

O'Hara, K.L. 1986. **Development patterns of residual oaks and oak and yellow-poplar regeneration after release in upland hardwood stands.** Southern Journal of Applied Forestry. 10: 244-248.

Roach, B.A.; Gingrich, S.F. 1968. **Even-aged silviculture for upland central hardwoods.** Agriculture Handbook 355. Washington, DC: U.S. Department of Agriculture, Forest Service. 38 p.

Schlesinger, R.C. 1978. **Increased growth of released white oak poles continues through two decades.** Journal of Forestry. 76: 726-727.

Smalley, G.W. 1982. **Classification and evaluation of forest sites on the mid-Cumberland Plateau.** Gen. Tech. Rep. SO-38. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 58 p.