# RELEASING 75- TO 80-YEAR-OLD APPALACHIAN HARDWOOD SAWTIMBER TREES: 5-YEAR D.B.H. RESPONSE

H. Clay Smith and Gary W. Miller[1]

Abstract: Generally, mature trees on good growing sites are seldom thinned or released. Instead, at maturity the trees are harvested. Data were summarized from north-central West Virginia study areas (northern red oak site index 70 feet and above) where mature trees were released on all sides of the crown (full release). Five-year d.b.h. growth and rates of return information indicate that several species respond to release. Yellow-poplar and northern red oak were the fastest growing species, averaging 1.8 and 1.6 inches d.b.h. Thus, some mature trees will respond and it may be economical in some instances to retain mature trees for esthetics, seed production, and so on, while continuing to earn a good rate of return.

## INTRODUCTION

All of us have wondered if a particularly large or "mature" sawtimber tree would respond to a thinning. Growth rings from freshly cut large stumps often indicate that an individual tree had periods of fast growth. There is little information about mature, larger hardwood trees responding to a thinning and this is expected. Simply, managed stands with mature trees usually are scheduled for a harvest cut such as some form of clearcutting, shelterwood, or diameter-limit.

A major problem in eastern hardwood stands is that many trees are about the same age due largely to activities in the past--especially logging and associated site or fire disturbance. These tree stands are now nearing maturity. Once the trees are mature and approach overmaturity they become more vulnerable to insect, disease, and climatic problems. One way to maintain tree-stand-forest health in maturing and mature trees is to try to stimulate growth through a thinning or release. Admittedly, these sawtimber trees often are economically mature since they may be growing, but earning less than an acceptable real rate of return. Also, some forest managers have an underlying belief that larger, mature trees do not respond to release.

---

[1]Project Leader and Economist, respectively, U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Parsons, WV 26287.

There are a number of concerns when releasing larger mature trees.

1. How much will trees in the dominant-codominant crown class position respond? With normally larger crowns, aren't these trees already growing as fast as possible?

2. Is the growth response for mature trees economical? A real rate of 4 percent is about the breaking point for an alternative investment.

3. How long are the desired species expected to live after release? Options for some current management plans are to grow trees up to 150 to 200 years (Sander and Smith 1989). Longer rotations may become reality due to landowner objectives or physical limitations, that is, too much land base for available personnel to manage.

4. What is the diameter breast height (d.b.h.) response of mature trees left for a short period (shelterwood concept), or two-age, or esthetic management where trees could remain from a short to an indefinite period?

The purpose of this paper is to report the 5-year d.b.h.-growth results of released, mature 75- to 80-year-old sawtimber Appalachian hardwood trees.

## METHODS

This study was done on the Fernow Experimental Forest (USDA Forest Service research forest near Parsons, WV) and on the Monongahela National Forest in north central West Virginia. The study areas (four treated areas, plus three controls) were established on good-to-excellent growing sites with a site index for northern red oak (*Quercus rubra* L.) of 70 feet or higher. Annual precipitation ranges from about 55 to 60 inches. During the early 1900's, study areas were logged using forms of clearcutting and high grading.

There were two study treatments. Trees were released to a free-to-grow position, that is, tree crowns released on all sides: and tree crowns not released. Mature, dominant- and codominant-crown class Appalachian hardwood trees were selected as study trees. The average number of mature, released trees in the residual stands ranged from 12 to 20 trees per acre. Average residual basal area was about 20 $ft^2$/acre with one exception of 30 $ft^2$/acre. After logging, a stand with released trees resembled a seed-tree cut (Figure 1).

Growth of released trees was compared to similar trees in three uncut fully-stocked mature stands. The trees were in areas set aside for non-management (control areas), where cutting was not permitted and were the only available comparison areas. The three areas were on excellent growing sites--northern red oak site index 80. Also for comparison purposes, the overall growth rates should generally be higher on the control versus the released areas. Thus, any significant differences in results would be conservative. In general, study trees in

Figure 1. Stand with released dominant-codominant, mature 75- to 80-year-old hardwood trees.

the control area had larger initial d.b.h. than the released sample trees. This indicates that trees were growing on better sites and that some trees, such as sugar maple (*Acer saccharum* Marsh.), red maple (*Acer rubrum* L.), and beech (*Fagus grandifolia* Ehrh.), were older and more mature.

Five-year data were collected for 11 Appalachian hardwood species. Sawtimber trees treated included hickory (*Carya* spp.), beech, white oak (*Quercus alba* L.), chestnut oak (*Quercus prinus* L.), red oak, yellow-poplar (*Liriodendron tulipifera* L.), black cherry (*Prunus serotina* Ehrh.), sugar maple, red maple, basswood (*Tilia americana* L.), and white ash (*Fraxinus americana* L.). Initially, all trees 1.0 inch d.b.h. and larger were cut except the study trees. The d.b.h. growth was recorded at the same point on the trees using the Fernow Experimental Forest tree-identification wiring technique as indicated in Figure 2 (Lamson and Rosier 1984).

Figure 2. Permanent tree identification and d.b.h. measuring point using Fernow Experimental Forest technique.

Data were collected before release and 5 years later for treated and untreated trees. Data were analyzed using Analysis of Variance techniques with significance tested at the 1- or 5-percent level, and graphics were developed using SYSTAT software.

## RESULTS

Average initial d.b.h. for the 742 released trees was 16.5 inches while the 268 non-released trees had an average d.b.h. of 19.8 inches (Table 1). Overall 5-year d.b.h. growth for the 742 released trees averaged 1.6 inches while similar growth for the 268 non-released trees was 1.0 inch d.b.h.--a difference of 60 percent. If the current growth rates continue, within 10 years after initial treatment periodic growth of released trees will exceed that of non-released trees by more than 1.0 inch, 3.2 inches compared to 2.0 inches.

### Five-Year Growth.

The faster growing species for the 5-year period were yellow-poplar and red oak. A surprise was beech, a noted slow grower (Trimble 1969). However, we had only a few sample beech trees.

Five-year results are summarized for individual species in Table 1. For the 742 released trees, 38 percent (281) were yellow-poplar and 31 percent (232) were red oak. Yellow-poplar grew 1.8 inches d.b.h. in 5 years with red oak at 1.6 inches. Beech grew about 1.5 inches d.b.h. Red maple, basswood, and white oak were grouped around 1.4 inches while black cherry and sugar maple grew 1.0 to 1.2 inches d.b.h. Chestnut oak, hickory, and white ash were in the group with the lowest 5-year d.b.h., with a growth response between 0.8 and 0.9 inches d.b.h.

For the non-released trees, the fastest growing species were black cherry (1.2 inches d.b.h.) with red maple, red oak, yellow-poplar, and white ash averaging about 1.0 inch. The slowest growing trees were hickories.

The released trees had significantly greater d.b.h. growth response than non-released trees for the following species--yellow-poplar, red oak, beech, basswood, and hickory. Though released white oak trees grew significantly faster than non-released trees, we had only a three-tree sample for non-released trees. This sample size was definitely too small to make any meaningful comparisons between treatments. However, a number of species did not indicate a significant d.b.h. growth-response difference between released and non-released trees. These species were red maple, chestnut oak, sugar maple, black cherry, and white ash. Also, in two instances (black cherry and white ash), the average d.b.h. growth response for non-released trees was higher than that for released trees, though not significantly higher ($p > 0.05$).

Table 1.--Five-year d.b.h. growth and rate of return for released and non-released, sawtimber-size hardwood trees.

| Species | No. trees | Initial d.b.h. (in.) | D.b.h. growth (in.) | Rate of return (%) | No. years before RR (<4%) |
|---|---|---|---|---|---|
| | | | Released | | |
| Yellow-poplar | 281 | 17.6 | 1.8** | 12.8 | 20+ |
| Red oak | 232 | 17.1 | 1.6** | 5.6 | 20+ |
| Beech | 7 | 18.2 | 1.5** | 17.9 | 20+ |
| Red maple | 10 | 13.5 | 1.4NS | 6.1 | 20+ |
| Basswood | 20 | 15.7 | 1.4** | 9.6 | 20+ |
| White oak | 59 | 14.6 | 1.4* | 17.6[a] | 20+ |
| Black cherry | 91 | 14.8 | 1.2NS | 11.1[a] | 0-10 |
| Sugar maple | 8 | 12.8 | 1.0NS | 7.9 | 0-10 |
| Chestnut oak | 12 | 14.4 | 0.9NS | 4.2 | 0-10 |
| Hickory | 6 | 13.2 | 0.9** | 14.2 | 20+ |
| White ash | 16 | 13.1 | 0.8NS | 4.1 | 0-10 |
| Totals/mean | 742 | 16.5 | 1.6 | | |
| | | | Non-Released | | |
| Yellow-poplar | 46 | 18.3 | 1.0 | 6.5 | 20+ |
| Red oak | 65 | 21.1 | 1.1 | 3.2 | 0-10 |
| Beech | 7 | 25.9 | 0.7 | 3.2 | 20+ |
| Red maple | 11 | 15.5 | 1.1 | 5.4 | 0-10 |
| Basswood | 9 | 19.4 | 0.8 | 3.9 | 0-10 |
| White oak | 3 | 26.9 | 0.9 | 2.4 | 0-10 |
| Black cherry | 52 | 18.0 | 1.2 | 3.8 | 0-10 |
| Sugar maple | 28 | 25.9 | 0.7 | 2.0 | 0-10 |
| Chestnut oak | 6 | 18.0 | 0.8 | 2.4 | 0-10 |
| Hickory | 11 | 17.4 | 0.5 | 3.4 | 0-10 |
| White ash | 30 | 17.8 | 1.0 | 3.3 | 0-10 |
| Totals/mean | 268 | 19.8 | 1.0 | | |

*;** Indicate average growth for released tree species significantly different from non-released species at 5 percent (*) or 1 percent (**) level of testing.
[a]Improved from grade 2 to grade 1 in 5 years.
+ More than 20 years
RR=Rate of return

Table 2.--Differences in 5-year average d.b.h. growth among released mature Appalachian hardwood tree species.

| Species | 5-year growth* |
|---|---|
| Yellow-poplar | 1.8b |
| Red oak | 1.6b |
| Beech | 1.5ab |
| Red maple | 1.4a |
| Basswood | 1.4a |
| White oak | 1.4a |
| Black cherry | 1.2a |
| Sugar maple | 1.0a |
| Chestnut oak | 0.9a |
| Hickory | 0.9a |
| White ash | 0.8a |

*Columns with means having same letter are not significantly different. Significance tested at the 1 percent level.

Species growth differences.

Using ANOVA techniques and the Tukey HSD for multiple comparisons, differences in 5-year growth rates were evaluated among the released species. Results indicated d.b.h. growth rates were significantly different among the following species or species groups (Table 2). Yellow-poplar, red oak, and beech grew significantly faster in d.b.h. than the other species, but growth response was not significantly different among the three species. Also, growth for beech was not significantly different from any evaluated species. Differences were not detected among any other species.

Predicted 10-year growth.

Often it is easier relating 10-year growth response than 5-year (Table 3, Figure 3) and we assumed the 10-year growth was twice as much as the 5-year growth. At 5 years, released trees remained in a free-to-grow crown position. As indicated, released yellow-poplar, red oak, and beech grew 3 or more inches in 10 years while released white ash, hickory, and chestnut oak grew less than 2.0 inches d.b.h. for the same period. Overall the released trees averaged 3.1 inches d.b.h. growth and the non-released trees 2.0 inches growth, a 56 percent increase.

Comparing d.b.h. growth of larger trees.

In general, trees from the non-released areas were larger in d.b.h. than trees from the released areas. Smaller and sometimes younger trees have a tendency to grow faster than larger and perhaps older trees. For this reason, the data were divided into two d.b.h. classes, trees $\leq$22.9 inches and $\geq$23.0 inches d.b.h. Five-year d.b.h. growth for the released and non-released large trees (d.b.h. $\geq$23.0 inches) averaged 1.9 and 0.9 inches, respectively. For small trees ($\leq$22.9 inches d.b.h.), the released trees grew 1.5 inches while the non-released trees averaged 1.0 inches d.b.h. Red oak and yellow-poplar were the only species having enough samples to make comparisons. For red oak, it was apparent that when released, the larger trees grew more than the smaller (2.0 compared to 1.5 inches d.b.h.). However, the larger yellow-poplar trees grew the same as the smaller sawtimber trees (1.8 inches d.b.h. in 5 years).

For the non-released tree species, red oak and sugar maple had adequate samples in the diameter-class categories. There was little difference in d.b.h. growth among the two d.b.h. categories.

Table 3.--Ten-year predicted d.b.h. growth for released and non-released sawtimber hardwoods.

| | Released | | Nonreleased | | |
|---|---|---|---|---|---|
| Species | No. trees | D.b.h. growth (in.) | No. trees | D.b.h. growth (in.) | Difference (%) |
| Yellow-poplar | 281 | 3.6 | 46 | 2.0 | 82.8 |
| Red oak | 232 | 3.1 | 65 | 2.2 | 43.5 |
| Beech | 7 | 3.0 | 7 | 1.3 | 138.8 |
| Red maple | 10 | 2.9 | 11 | 2.2 | 31.8 |
| Basswood | 20 | 2.8 | 9 | 1.6 | 71.6 |
| White oak | 59 | 2.7 | 3 | 1.8 | 51.1 |
| Black cherry | 91 | 2.3 | 52 | 2.4 | - 3.3 |
| Sugar maple | 8 | 2.1 | 28 | 1.5 | 41.1 |
| Chestnut oak | 12 | 1.9 | 6 | 1.5 | 20.8 |
| Hickory | 6 | 1.8 | 11 | 1.0 | 91.7 |
| White ash | 16 | 1.7 | 30 | 2.0 | -16.2 |

## RATE OF RETURN

Real rates of return (net of inflation) were determined for both released and non-released trees (Table 1). Individual tree values were determined using updated tree- value conversion

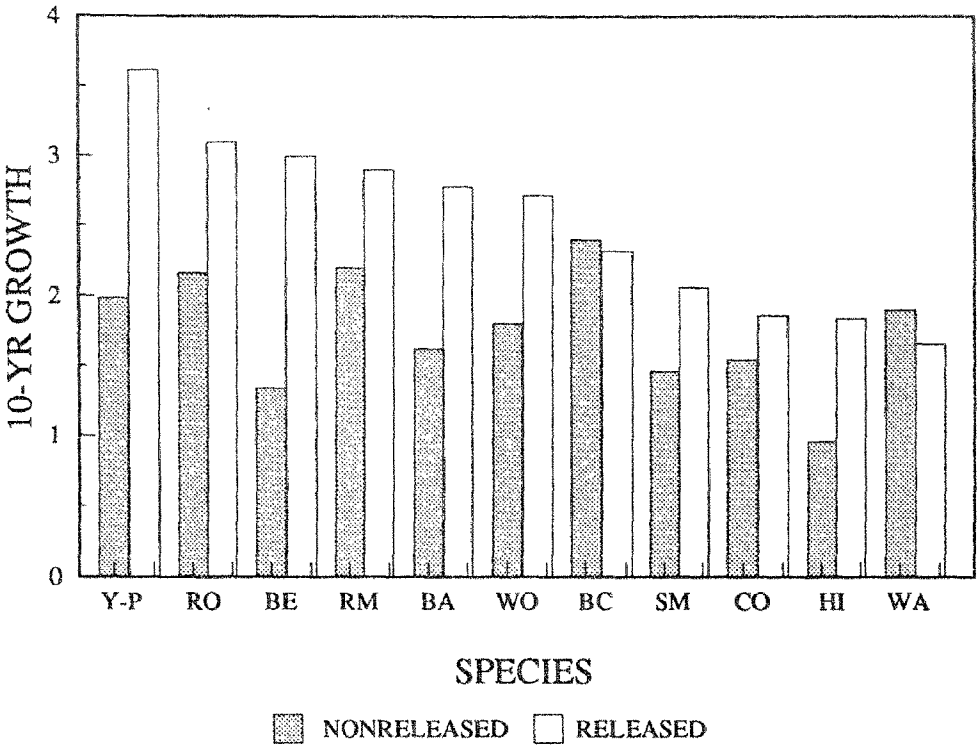


Figure 3. Anticipated 10-year growth information for species of released compared to non-released mature, Appalachian hardwood tree species.

standards, whereby tree values are derived from the value of lumber contained in a particular size and quality tree (DeBald and Dale 1990). Rate of return over the 5-year study period was based on observed growth, initial d.b.h., and merchantable height, assuming trees qualified for the highest possible grade in their size class. Projected rate of return was based on assuming that the observed d.b.h. growth would continue in the future; maximum merchantable height was fixed at 2.5 16-foot logs and trees qualified for grade 1 beyond 16 inches d.b.h.

In general, released trees earned a competitive rate of return over the 5-year period, and we expect many of them to earn at least a 4 percent return for more than 20 years in the future (Table 1). Most non-released trees earned less than 4 percent over the study period. It is clear that release improved the earning power of individual trees, but growth rates must continue for more than 5 years to make release of mature trees a desirable practice from a financial point of view.

If observed d.b.h. growth continues, several species have the potential to earn competitive rates of return for more than 20 years following release. Among released trees, black cherry, chestnut oak, sugar maple, and white ash will earn at least 4 percent for about 10 years after release. All other species will earn at least 4 percent for 20 years or more after release.

Among non-released trees, yellow-poplar and red maple will earn at least 4 percent for 20 years or more. Other species will earn less than 4 percent if not released.

The initial size of released trees influences potential rate of return following release. Rate of return decreases as d.b.h. increases, even though returns can remain positive for large trees. Returns were projected for each species using the observed 5-year d.b.h. growth, assuming individual trees were 18 inches d.b.h., with butt-log grade 1 and merchantable height of 2.5 logs at the time of release. By projecting value increases for trees of similar initial size and quality, we were able to isolate the effect of d.b.h. growth response to evaluate individual species as candidates for release.

Black cherry, sugar maple, chestnut oak, and white ash do not appear to provide an acceptable rate of return for more than 10 years following release. Other species studied will earn at least a 4 percent rate of return for 20 years or more following release. Without release, only yellow-poplar and beech promise competitive earnings for more than 20 years.

## DISCUSSION AND CONCLUSIONS

What does this information mean to the forest manager? The bottom line is that some dominant and codominant sawtimber-size tree species on good growing sites will respond to a free-to-grow crown release. For yellow-poplar, the growth response is expected to be more than 3.5 inches 10 years after release. Similarly, northern red oak, red maple, and perhaps beech may grow about 3.0 inches d.b.h. Though all sides of the mature tree crown were released, we do not know the response when releasing two or three sides of the crown. However, in small sawtimber- and pole-size stands dominant and codominant tree crowns should be released on at least three sides for a significant growth response (Lamson and others 1990).

Recommended stand rotation lengths in the Appalachians are often 80 to 120 years based on site index, but in reality, the actual rotations may be 150 to 200. Also, butt-log quality on large mature trees is not influenced by release (Smith and others 1989). In a sample of more than 300 large trees, 20 trees (less than 7 percent) had a loss of quality in the butt log due to epicormic branching. Ten of these trees had epicormic branches on the tree bole before release and most of the individual trees were basswood.

The butt log is the most valuable log in the tree and at this time, 5 years after release, there is little reason to be concerned with the loss of butt log value due to epicormic branching, particularly if the tree boles do not have any epicormic branches before release. Also, a release that is heavy enough to stimulate butt- or second-log epicormic branching on codominant trees would also stimulate the establishment of reproduction--as in a shelterwood. Five years after a heavy release, the reproduction in most hardwood stands provides shade on much of the butt log, and within 10 years after release the crowns of the taller regeneration should shade most of the second log (Smith and others 1989).

Though the number of trees released in the study averaged 12 to 20 per acre, we know that for mature, fully-stocked, sawtimber-size Appalachian hardwood stands, we could expect to release about 20 to 25 good quality timber trees per acre. Most of these trees would be released on at least three sides of their tree crowns. Thinning mature hardwood stands could become more significant in the future as stands continue to mature and then become overmature, that is, trees are maturing faster than buyers are willing to harvest them (Arner and others, this proceedings).

A very heavy thinning in a mature stand where at least three and preferably four sides of the tree crown are released will most likely stimulate a worthwhile diameter-growth increase. Released trees can earn 4 percent or more for up to 10 years following release. If the observed d.b.h. growth continues (an unknown at this time), most species evaluated in this study will earn in excess of 4 percent for 20 years or more. Black cherry, sugar maple, chestnut oak, and white ash may not earn competitive returns beyond 10 years after release. For the cherry and oak trees, 5-year d.b.h.-growth data indicated non-released trees grew faster than released trees. Since study trees were codominant and the released trees were free to grow, it is quite possible these 75- to 80-year-old black cherry and chestnut oak trees will not respond to release.

Normally, fully stocked, even-aged stands on good Appalachian sites with overstory trees at least 75 to 80 years old and pole-sawtimber trees averaging 16 inches d.b.h. can be considered mature and ready for a regeneration harvest cut such as clearcutting. However, clearcutting may not be acceptable to the landowner. Besides partial cuts such as single-tree selection, diameter-limits, shelterwoods, or perhaps no cutting, the forest manager and landowner may have another option on good hardwood growing sites. If an economic cut is possible, consider giving the most desirable dominant and codominant sawtimber trees in the stand room to grow. The residual stand has a shelterwood or seed-tree look but these trees would not be harvested for several years. Many large trees will respond and become more valuable as a result of the release. Even if these trees can be released only on two or three sides of the crown and none of the understory is removed, there should be a d.b.h. response without loss of butt-log value due to the release. Tree vigor and perhaps seed production would increase too. There are site limitations to consider when applying this practice such as shallow soils or soils with fragipans. Also, at the higher elevations trees may become susceptible to glaze-snow damage. All of these limitations could lead to possible blowdown and/or loss of stem quality/value. However, retaining some mature hardwood trees for timber, esthetics and/or sources of seed for wildlife food or the regeneration of difficult species such as oak, is an option that could be acceptable to some landowners. This option could become even more acceptable, if continuing to earn a desirable rate of return is possible.

## LITERATURE CITED

Dale, Martin E.; DeBald, Paul S. (in preparation). Tree value conversion standards revisited.

Lamson, Neil I.; Rosier, Robert L. 1984. Wires for long-term identification of trees. J. For. 82(2):110-111.

Lamson, Neil I.; Smith, H. Clay; Perkey, Arlyn W.;Brock, Samuel M. 1990. Crown release increases growth of crop trees. Res. Pap. NE-635. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Sander, Ivan L.; Smith, H. Clay. 1989. Managing mature, even-aged stands. In: Clark, F. Bryan; Hutchinson, Jay G., eds. Central Hardwood Notes. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. p. 6.07-6.07.4.

Smith, H. Clay; Lamson, Neil I.; Miller, Gary W. 1989. An esthetic alternative to clearcutting? J. For. 87:14-18.

Trimble, G.R., Jr. 1969. Diameter growth of individual hardwood species. Res. Pap. NE-145. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 25 p.