



FOREST RESEARCH REVIEW

March 2007



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VDOF RESEARCH PROGRAM

Welcome to the second issue of the Virginia Department of Forestry (VDOF) Forest Research Review. We'll bring you up to date on the most recent results from several ongoing studies, including information on establishment methods for shortleaf and eastern white pines and northern red oak, release and fertilization of white oak, control methods for tree-of-heaven, and long-term growth of thinned yellow-poplar. We also have compiled an overview of our 50+ year loblolly pine tree improvement research.

In this issue, you will find a number of articles reporting on study installations, progress and results from around the state. We hope you will find this material useful. You may also want to browse through the publications and links provided on our Web site, where you can find the complete text of all 124 VDOF Occasional Reports (dating from 1955), fact sheets, analysis tools, and copies of recent journal publications. As always, please feel free to contact the research program staff with any questions or suggestions you may have:

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RECENT DEVELOPMENTS

The past six months have seen several exciting developments in the research program.

1. In late 2006, the National Science Foundation approved funding for the development of the Center for Advanced Forestry Systems (CAFS). This will be an integrated research effort initially involving four universities and members of cooperatives housed at those schools. Through our memberships in the NC State Forest Nutrition Cooperative and the VPI Growth and Yield Cooperative, VDOF will benefit from this new research funding and the efforts it supports. The objective of CAFS is to foster multi-university, interdisciplinary, collaborative studies aimed at linking knowledge of tree genetics and physiology with silvicultural performance and value in forest stands.
2. In December, we hosted the annual meeting of the Virginia Tech Growth and Yield Cooperative at the Appomattox-Buckingham State Forest. In addition to co-op members from across the Southeast, the group included a dozen invited guests from the Foothills Growth & Yield Association of Alberta, Canada.
3. In January, the Virginia Chapter of the American Chestnut Foundation held an organizational meeting at which Wayne Bowman of VDOF was invited to sit on the Board of Directors. This will bring a new level of focus and support to the long-term breeding work ongoing at the Lesesne State Forest in Nelson County.
4. January also saw the completion of the first-ever, large-scale collection of native Virginia longleaf pine cones and seeds. In collaboration with the Department of Conservation and Recreation's Division of Natural Heritage, more than 200 bushels of cones were collected and yielded enough seed for approximately 300,000 seedlings for 2008 restoration efforts.

ON THE HORIZON

In addition to completing scheduled dormant season measurements and maintenance of our existing studies, we are launching several new tests.

1. A study is being installed in Essex County to compare the tree growth effects of municipal biosolids to those achieved with traditional fertilizers (urea and DAP) when applied to mid-rotation thinned loblolly pines.
2. In collaboration with MeadWestvaco and VPI, we are applying treatments and conducting assessments on a 10-year-old study of the interactive effects of stand density and nutrition in loblolly pine.
3. In March, we will establish a planting at the New Kent Forestry Center to demonstrate differences in growth and uniformity among open-pollinated, control-pollinated and clonal loblolly pine seedlings (Figure 1).

Figure 1. A row of clonal loblolly pine seedlings established to look for differences in growth and uniformity between clonal and open-pollinated seedlings.



GENETICS AND RESTORATION

LOBLOLLY PINE TREE IMPROVEMENT PROGRAM

Seventy-eight percent of the nation's tree planting is done by landowners in the Southeast, and 84 percent of that total is done with genetically improved loblolly pine. Tree improvement research is based on a simple premise: select individual trees with the most desirable traits (such as growth rate, straightness, branching characteristics or disease resistance) and then use their flowers, pollen and seed for breeding future generations of nursery stock. But it becomes very complex when we factor in the large number of selected trees (parents) available; the long time involved in growing and evaluating possible new selections, and the wide variety of selection criteria that different customers value most.

Prior to tree improvement, loblolly seeds were collected from unimproved natural stands – mostly from trees felled during logging operations. Seedlings raised in those days were of only average quality and growth after planting. In 1956, the North Carolina State University – Industry Cooperative Tree Improvement Program was created. Today, this program is a partnership among 12 industries, four state forestry agencies, including VDOF, and North Carolina State University. The mission of the program is to economically increase forest productivity through the selection process. Our objective as a co-op member is to breed, test and select trees that result in economic benefit to Virginians and other co-op members. The co-op has accumulated 7,511 selections to conserve the precious loblolly pine genetic resource for future generations of breeders and foresters, and 6,230 control crosses among loblolly pine selections have been tested in field trials.

Selection in Virginia and elsewhere was first done in natural stands. Selected trees were grafted and used to establish the 300-acre first-

generation seed orchard at New Kent Forestry Center and Appomattox-Buckingham State Forest. Offspring from those trees were tested to evaluate parent performance, and the poorer performers were removed (or rogued) from the orchard. This further increased volume gains over unimproved seedlings, since the the poorer performers were no longer part of the pollen "mix." Crosses of parents from that first orchard along with new selections were then used to establish a second-generation orchard in Milledgeville, GA (Figure 2). After years of further testing and selection, VDOF will soon complete establishment of a third-generation orchard, also at New Kent Forestry Center and Appomattox-Buckingham State Forest.

Figure 2. The second generation loblolly pine seed orchard in Milledgeville, GA.

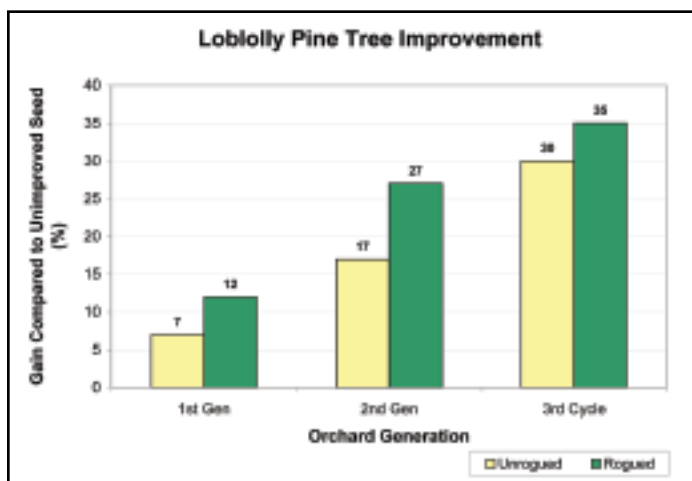


By 1988, all seedlings produced in Virginia nurseries were from this genetic "improvement" process. The impact of tree improvement on forest productivity has been substantial (Figure 3). Unrogued first-generation seedlings grow seven percent more in volume than the original "wild" seedlings, while the rogued orchard has a 12 percent gain. The second-generation gains are 17 percent to 27 percent. These gain estimates are the average of all open pollinated seed in the orchard. Some individual parent trees have much higher volume gain.

Cone collection from the first-generation orchard was phased out in 1997, and collections from the second-generation orchard peaked in 2003.

In 2006,

Figure 3. Volume gains of loblolly pine orchards compared to unimproved "wild" seed.



we harvested 200 bushels of green cones from the first third-generation trees (established in 1997) (Figure 4). These seeds should produce more than two million seedlings for the 2008 planting season (Figure 5). The number of seedlings of third-generation origin will gradually increase to 100 percent of VDOF's nursery production by 2012.

In the future, we plan to adopt a system of ranking all loblolly pine families developed in collaboration with the NC State cooperative program. These rankings are based on productivity (volume growth), rust resistance and straightness of these families in hundreds of tests over many years, and will allow us to identify the "best of the best" for our customers. This will help to capture even more benefits from the tree improvement effort for Virginia landowners. To that end, in 2006, only cones from the best ranked parents were collected from the second-generation orchard, and their seed has been kept separated by parent. Eventually, seed collected from the third-generation orchard will also be available by individually-ranked parent.

Fifty years of tree improvement research have led to large gains in the health and growth of Virginia's loblolly pine forests. Although the time to complete one generation of planting and testing is longer than that for agricultural crops, such as corn or wheat, the same principle of continuous improvement applies. One day, we will probably be talking about a fourth or fifth generation of improved loblolly pine, with the VDOF still in a lead role for the state of Virginia.

Figure 4. Collecting cones from the third-generation loblolly pine seed orchard at the Appomattox-Buckingham State Forest in September 2006.



Figure 5. One of many crates of loblolly pine cones collected at the second-generation orchard in Milledgeville, GA in September 2006.



SHORTLEAF PINE

In the last issue, we reported on the installation of a study to look at whether different methods of competition control with and without supplemental fertilization affect the early survival and growth of planted shortleaf pine in old field and cutover sites. Fertilizer treatments have not yet been applied, so the treatments that can be compared so far are: 1) no treatment; 2) scalping (mechanically turning over the top 3-5 inches of sod along an approximate 2-3 foot swath); 3) weed control using 4 oz. Arsenal + 2 oz. Oust (imazapyr + sulfometuron); and 4) weed control using 12 oz. Oustar (sulfometuron + hexazinone).

We measured height, groundline diameter (GLD), and survival after the first year, and based on those we calculated an average tree volume index and estimated a volume index per acre for a stand receiving these treatments. The results are listed in Table 1, and Figure 6 shows the trend in volume per acre index.

The early growth overall has been quite slow and survival has been mediocre (Figure 7), but nonetheless there are differences among the treatments. It's pretty clear that competition control aids both survival and growth after one season, and the combined effects of these two responses – estimated by the volume index – is that the best treatment (scalping) has grown nearly four times as much tree volume as no treatment. These effects of the treatments on volume per acre are highly statistically significant. Fertilizer treatments will be applied to the studies in 2007, and we'll continue to follow the plots to see if these preliminary results continue.

Table 1. First-year results of shortleaf pine establishment study.

Treatment	Height (ft.)	Groundline Diameter (in.)	Survival (%)	Volume (in. ³ /tree)	Volume (in. ³ /acre)
Untreated	0.82	0.14	48	0.21	34
Oust x Arsenal	0.81	0.16	78	0.28	78
Oustar	0.88	0.16	67	0.31	69
Scalp	1.00	0.17	82	0.41	125

Figure 6. Volume index per acre after one year on plots of the shortleaf pine establishment study. The effects of the treatments are highly statistically significant.

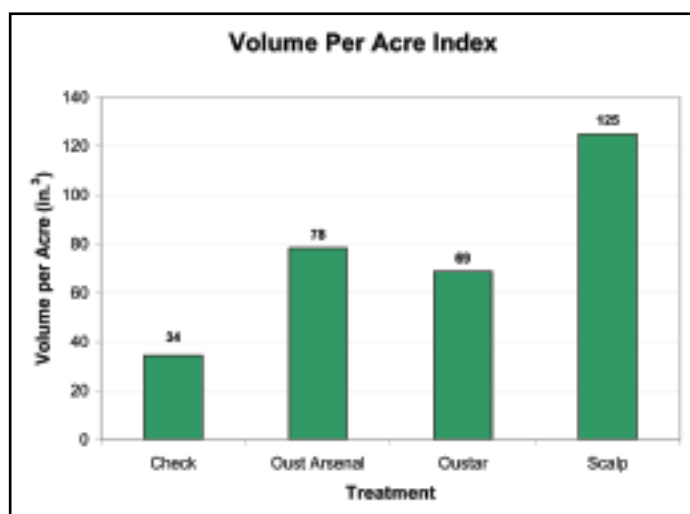


Figure 7. Typical shortleaf pine seedling growing in a scalped treatment row on an old field after one year.



PINE SILVICULTURE

WHITE PINE ESTABLISHMENT

This trial was planted in the spring of 2006 on an old field site near Glade Spring, VA (described in the last issue of the research review). It compared seedlings stored for 78, 50, 28 and 5 days after lifting; herbicide treatment, scalping and no treatment for control of competing weeds; and seedlings showing lammas shoots vs no lammas shoots (extra whorls of branches or leader growth extension, which develop late in the growing season).

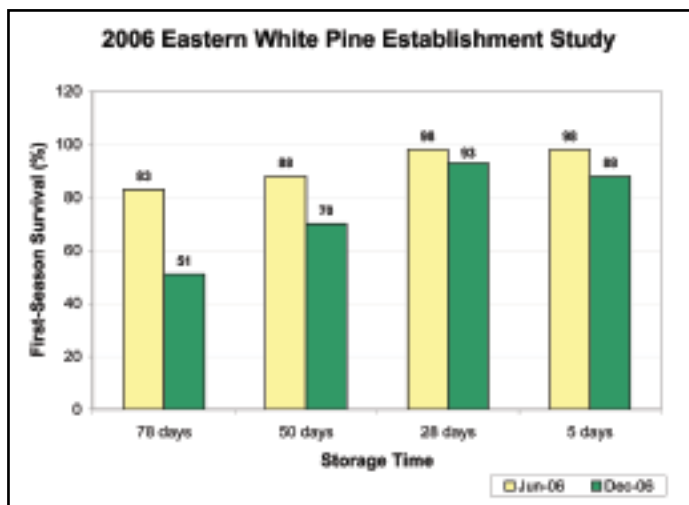
Plots treated with herbicide and (to a lesser extent) those that were scalped were colonized by thistle over the summer. Such changes in plant community are an important consideration when planning any competition control treatment. Since it is an annual weed, thistle will most likely diminish next year, but it was a problem in 2006 and could have been a seed source for any surrounding disturbed sites.

In November, we measured seedling height and survival (Table 2). There were no differences between seedlings with and without lammas shoots, so those data were combined under the 5-day storage treatment averages. There were no significant effects on tree heights at the end of the first year, although there is a trend of increasing height with shorter storage times. But there were significant effects of both storage and establishment treatment on survival. Survival improved with reduced time in cold storage after lifting (Figure 8) and with competition control. The take home lesson is to minimize cold storage time and control competition to maximize eastern white pine seedling survival.

Table 2. First-season survival and height of white pine in the 2006 establishment study.

First-Season Survival and Height	Storage Time (days)	Herbicide	Scalp	No Treatment	Average
Height (ft.)	78 days	0.7	0.7	0.8	0.7
	50 days	0.7	0.9	0.8	0.8
	28 days	1.0	0.8	1.0	0.9
	5 days	0.8	0.9	1.0	1.0
	Average	0.8	0.9	1.0	
Survival (%)	78 days	40	70	43	51
	50 days	63	87	60	70
	28 days	97	97	87	93
	5 days	75	97	94	88
	Average	70	89	75	

Figure 8. Response of eastern white pine first-year survival to varied durations of cold storage after lifting.



URBAN FORESTRY

SUBORDINATION PRUNING METHODS TO ENHANCE STRENGTH OF URBAN TREES

Rob Farrell, forester, Region 2

In the winter of 2004, a study of pruning methods for urban trees was undertaken by VDOF's Rob Farrell in collaboration with Dr. Joe Murray of the Blue Ridge Community College (BRCC) at Weyers Cave, VA. It is hoped that the results of this study will increase our knowledge of branch growth habits and provide guidance for the structural pruning of young trees.

Structural pruning is intended to modify the growth of a tree to increase the strength of the trunk and main branches. Features associated with strong tree structure include a single main trunk and branches that are smaller in diameter than the trunk, are well-spaced along the trunk, and adjoin the trunk at wide angles. During structural pruning, the complete removal of a weak branch or codominant trunk may not be desirable. Complete removal may leave too large of a pruning wound; remove too much green foliage, or leave the crown misshapen. It may be possible to prune the branch in such a way that its future growth is altered without removing it entirely.

It is thought that pruning a codominant stem or large branch can reduce its growth rate and allow the main trunk to assert dominance, thereby growing larger than the pruned stem and increasing the strength of the attachment. This pruning method has been termed "subordination" pruning. Although subordination pruning has been widely accepted in the arboriculture community, there are few studies evaluating its application or effectiveness.

In this study, three methods of subordination pruning were applied to trees to determine if their growth is altered relative

to that of unpruned trees. The first study site consists of eight 16-year-old northern red oaks (*Quercus rubra*) growing in a lawn area in front of the VDOF office in Charlottesville. Three branches were selected and measured in each tree, and in four of the trees, one of the selected branches was then pruned by reducing its length by 50 percent (Figure 9). The second study site consists of 20 8-year-old white oaks (*Quercus alba*) growing in an open lawn area at BRCC. Again, three branches were selected and measured in each of these trees in the same manner as the other site.

Figure 9. Northern red oak branch after a 50 percent length reduction pruning.



One of the measured branches in each of these trees then received one of four pruning treatments; 50 percent length reduction, 25 percent length reduction, 50 percent thinning pruning or control. Reduction pruning involves cutting the branch back to a suitable lateral branch in such a way that the overall length of the branch is reduced by 25 percent or 50 percent. Thinning pruning is the removal of secondary branches so that 50 percent of the foliage of the entire limb is removed.

The study trees have been measured before pruning and again one and two years after. Ongoing measurements include: branch and adjacent trunk diameters; branch length and growth; and tree height, diameter, and growth. Preliminary results indicate that each of the subordination pruning methods was effective in reducing the diameter of the branch

SUBORDINATION PRUNING METHODS, CONTINUED

relative to that of the trunk. However, this same reduction occurred in almost all of the control branches. We believe that this two-year decrease in branch diameter relative to the trunk is a form of natural subordination and is an expression of apical dominance. It was more consistent in the younger white oak trees than the older red oaks, which may indicate that natural subordination is an age-related process

whose effect may diminish over time. Continued annual measurements may provide new insights into the development of tree structure in landscape trees. Future study goals include more extensive data analysis, continued annual measurements and additional study sites to test more species and ages of trees.

HARDWOOD SILVICULTURE

WHITE OAK CROP TREE RELEASE

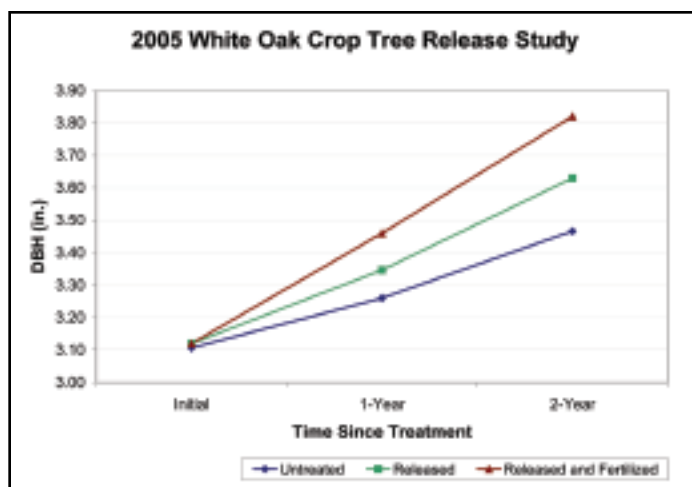
On April 26, 2005, a study was installed in the Burnham Unit of the Appomattox-Buckingham State Forest in a 15-year-old mixed hardwood stand. The objective was to evaluate the effects of crop tree release and fertilization on the growth of white oak. Groups of three trees were matched based on diameter breast height (dbh) and total height. Two of the three were selected at random for release (by felling all surrounding trees touching their canopy), and one of those two was then randomly selected to be fertilized at a rate of 200 pounds nitrogen plus 50 pounds phosphorus per acre over tree-centered 10-foot radius circle. A total of 15 groups of three trees were established in this manner.

At the end of the 2005 and 2006 growing seasons, the trees were re-measured for dbh and total height (Table 3). Heights have not been strongly affected by any of the treatments. But, through two years, there is a clear response in diameter growth to both release and fertilization. Moreover, the difference among the responses is increasing, indicating that the response is likely to become more pronounced in coming years (Figure 10). We will follow the plots closely to determine if and when the effects begin to diminish.

Table 3. Summary of height (feet) and diameter breast height (dbh – inches) growth of white oak following release and fertilization treatments applied at age 15.

Treatment	Total Tree Height			DBH			Growth	
	Initial	1-Year	2-Year	Initial	1-Year	2-Year	DBH (in.)	Height (ft.)
Untreated	25.97	28.33	31.23	3.11	3.26	3.47	0.36	5.26
Released	26.31	28.20	30.33	3.12	3.35	3.63	0.51	4.02
Released and Fertilized	26.61	28.93	31.33	3.12	3.46	3.82	0.70	4.72

Figure 10. Growth in diameter breast height (dbh – inches) of released and fertilized white oak during two years after treatment.



TREE OF HEAVEN (AILANTHUS) CONTROL METHODS

Although there are many invasive plants to contend with in Virginia, tree of heaven is considered the most serious woody invasive. It is invading interior forest habitat where canopy gaps occur and is now the 46th most abundant tree out of a list of 104 tree species for the Commonwealth. In a collaborative effort with Chris Asaro (forest health manager) and Charlie Becker (forest utilization and marketing manager), a study was initiated in early 2006 to (a) evaluate the effectiveness of several herbicide treatments and harvesting strategies in controlling existing and resprouting plants and (b) assess the market value of the resulting tree of heaven wood. The following summarizes the results of the control phase (a) of the study.

All herbicide treatments in the test involved a tank mix of Garlon 4 (triclopyr) in JLB Oil Plus carrier at a ratio of 1:3 Garlon:oil applied using a Solo backpack sprayer. Three herbicide application strategies – basal stem spray (Figure 11) followed by chainsaw harvest one week later, basal stem spray followed by chainsaw harvest four weeks later, and chainsaw harvest followed immediately by a cut-stump treatment (Figure 12) – were compared to harvesting with no herbicide treatment in a completely randomized design at each location. Each of these four treatments was applied to five stems in each of three dbh size categories (<4 inches, 4-10 inches, and >10 inches) at each location. This resulted in a total of 10 Ailanthus stems (5 at each location) in each treatment and size class category – a total of

Figure 11. Applying the basal spray treatment to a tree of heaven.



120 stems in the study. The diameter breast height of treated trees ranged from 1 inch to 16 inches.

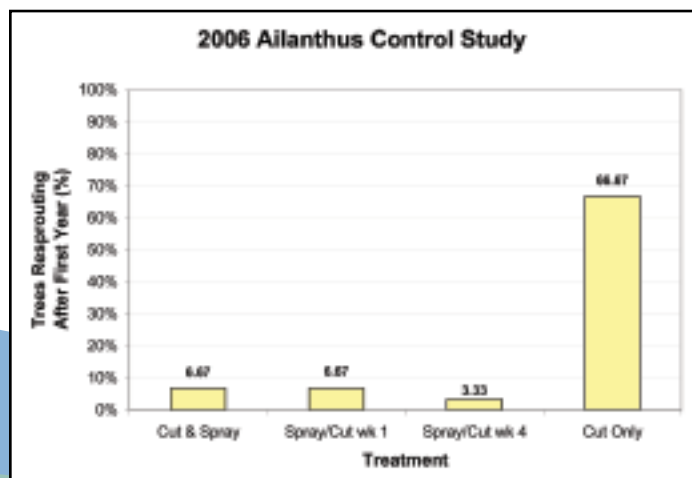
Figure 12. Applying the cut stump treatment to a tree of heaven.



The pre-harvest herbicide treatments were applied on June 5-6, 2006. These stems were then harvested either one week later (June 12-14, 2006) or four weeks later (July 5-6, 2006). Also on July 5-6, 2006, the stems receiving the cut-stump treatment and those left unsprayed were harvested.

The number of stump sprouts arising from all harvested stems in the study was tallied Sept. 25, 2006. All of the herbicide treatments have worked well so far. Fewer than 10 percent of the original stems receiving the treatments have resprouted, compared to nearly 70 percent of those left unsprayed (Figure 13). And even on those stems that have resprouted, there have been relatively few sprouts, most tending to occur on the smallest diameter treated trees. Based on these early results, it appears that a mixture of Garlon 4 herbicide in an oil-based carrier and applied as a basal or cut-stump spray shortly after leaf development in the spring is a good treatment for removing tree of heaven up to 16 inches in diameter.

Figure 13. Percentage of tree of heaven stems resprouting one season after treatment.



GROWTH OF THINNED AND UNTHINNED YELLOW POPLAR AFTER 34 YEARS

In the spring of 1972, VDOF planted a test designed to examine effects of various nursery practices and seedling size on the performance of yellow poplar. The trees were planted at a 6.6 x 6.6 foot spacing on the Lesesne State Forest in Nelson County. The site lies at the eastern foot of Three Ridges Mountain, one of the tall mountains that form the crest of the Blue Ridge in Central Virginia. These are good hardwood soils, formed in fertile material eroded from the mountain above.

The results of the original study through age 17 were reported in 1993 in Occasional Report #109 (occasional reports are available on line at <http://www.dof.virginia.gov/info/index-pubs-forest-res.shtml>). After the age 17 measurement, half of each block of study plots was thinned (from a basal area of 156 ft.²/acre to 85 ft.²/acre) with the other half left unthinned. Figure 14 shows the contrast between the two treatments after the 2005 growing season – at

Figure 14. Unthinned and thinned yellow poplar stands 34 years after planting on the Lesesne State Forest in Nelson County.



age 34 – when the plots were remeasured. Table 4 summarizes the data from the pre-thinning, age 20 and age 34 measurements.

Seventeen years after thinning, the unthinned plots contain more basal area than those that were thinned. But, due to the smaller average tree size on those plots, the merchantable volume (board feet) is greater on the thinned plots. Thinned trees average nearly 100 feet in height and 14 inches in dbh. The volume growth on these plots (18,000-32,000 board feet per acre in 34 years) attests to the high yellow poplar site quality on these Blue Ridge slopes.

HARDWOOD ESTABLISHMENT AND SURVIVAL TRIALS

In early 2006, we installed a trial on the West End Farm property owned by Henry Taylor in Louisa County and on Virginia Tech's Southwest Ag Research and Experiment Station in Washington County to test the effects of different establishment methods and initial seedling size on northern red oak survival and growth. The sites were planted in mid-March with seedlings of three root collar diameter classes – small (0.2 inches), medium (0.3 inches), and large (0.4 inches) using one of five establishment treatments: 1) no treatment; 2) VisPore mulch mat plus 4-foot Tubex tree shelter; 3) spot spraying of a 2-foot radius spot using a 2 percent glyphosate solution; 4) 4-foot Tubex tree shelter plus 2-foot radius glyphosate spot spraying; and 5) VisPore mulch mat only.

There were no differences in trends between the two locations, so the data were combined. None of the seedlings at either study location grew significantly in diameter over the first year, so those data are not

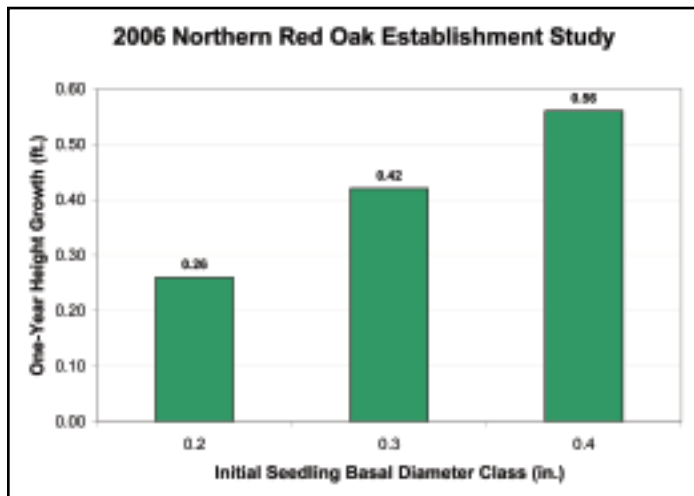
Table 4. Summary of individual-tree and stand attributes at ages 17 (post-thin), 20, and 34 on the yellow poplar thinning study plots.

Attribute	Age 17		Age 20		Age 34	
	Thinned	Unthinned	Thinned	Unthinned	Thinned	Unthinned
Trees per Acre	225	650	225	617	170	407
Height (ft.)	61	63	68	71	97	73
DBH (in.)	8.2	6	9.6	6.7	13.9	9.7
Basal Area (sq. ft./acre)	85	153	117	183	197	256
Volume (bd. ft./acre)	3,291	281	8,101	5,008	32,447	17,650

HARDWOOD ESTABLISHMENT AND SURVIVAL, CONTINUED

presented. Height growth was affected by both initial seedling size (Figure 15) and establishment method (Figure 16). Larger seedlings grew more than twice as much in height as smaller ones, and those protected by Tubex tree shelters grew three to nine times more than those not in tubes. The reason is easily seen if we consider browse damage. Thirty-five percent to 45 percent of the unsheltered seedlings were browsed (by rodents) compared to fewer than 10 percent of

Figure 15. First-year height growth of northern red oak in a range of initial root collar diameter classes (average of two locations).



those in tubes. Survival was generally quite good for the first season, although a trend similar to that in height occurred. Increasing initial seedling size and protection by tree shelters tended to result in lower mortality.

In summary, the first year data show that planting larger seedlings and protecting them from browse damage by using tree shelters will produce more rapid initial height growth and improve survival.

Figure 16. First-year height growth of northern red oak under different establishment regimes (average of two locations).

