FOREST RESEARCH REVIEW

October 2008

The northern red oak establishment study at age two.

In this issue...

VDOF Research Program

Welcome to the fall 2008 edition of the Virginia Department of Forestry's Research Review. The VDOF Research Program staff continues to install and monitor a network of study locations across the Commonwealth to answer questions about a wide array of forestry topics. A number of those ongoing studies are nearing completion and several new ones are at a point where interesting preliminary results are available.

Since the March issue was published, we've made progress in a number of areas. Plots for our new loblolly pine thinning and fertilization study have been established and cleared of competing vegetation and the crop trees will be measured this fall; thinning and fertilizer treatments applied over the winter and spring will complete test establishment. Beginning in March, we established and monitored a test of two promising new insecticide products that could provide long-term control of Nantucket pine tipmoth. This summer saw the last of our follow-up evaluations for our tree-of-heaven control studies. In early April, we hosted the undergraduate silviculture class from North Carolina State University on a tour of our hardwood research and in June, we hosted a field tour for the North American Forest Soils Conference – both at the Appomattox-Buckingham State Forest. We co-authored a publication submitted to the Southern Journal of Applied Forestry describing the results to date from the study of planting density and nutrient regimes in loblolly pine.

In the following pages, we'll bring you up to date on our latest information. First, we'll summarize some recent publications from the Tree Improvement and Forest Nutrition cooperatives in which VDOF participates. We'll report on our progress in grafting native Virginia longleaf pine and summarize results from studies relating to establishment methods for shortleaf pine and northern red oak. There are also articles describing results from the new tipmoth control tests and the effects of basal spraying to control tree-of-heaven at various seasons of the year.

As always, we hope you'll find the information useful. Please let us know if you have any questions or comments, and visit http://www.dof.virginia.gov/research/index.shtml to browse publications, fact sheets and analytical tools delivered by the VDOF Research Program. IN ADDITION – we have begun posting interim updates and other observations and commentaries on our new Virginia Forests Blog at http://virginiaforests.blogspot.com/ – check it out between issues of the review!

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From: McKeand, S.E., D.M. Gerwig, W.P. Cumbie and J.B. Jett. 2008. Seed orchard management strategies for deployment of intensively selected loblolly pine familes in the southern US. p. 177-182, In: Lindgren, D. (ed.). Seed Orchards, Proceedings from a conference at Umea, Sweden, September 26-28, 2007 (ISBN: 978-91-85911-28-8)

Planting of individual open-pollinated (half-sib) families and, more recently, control-pollinated (full-sib) families and clones, has become standard practice in the southern United States. In the early 2000s, 59 percent of the loblolly pine plantations were established as single-family open-pollinated (OP) blocks. About 80 percent of the regeneration on company lands was with individual OP families, and 48 percent of seedlings used for market sales were as individual OP families. Since then, the percentage of plantations established with individual families as opposed to seed orchard mixes has increased. Companies sell very few mixed seedlots, and state agencies have begun to sell individual OP families. We believe that about 75 percent of the loblolly pine plantations are now established as single OP family blocks.

In our opinion, nothing has had a greater impact on operational genetic gain than deployment of individual families of loblolly pine to specific sites. With loblolly pine, deployment is fairly straightforward: plant the best families on the best sites to realize the most genetic gain. The best families tend to be the best on all sites within broad adaptability zones, so more wood production is realized from the combination of the best families, sites and silvicultural practices. Even with the availability of many tons of loblolly pine seed available each year, foresters don't plant the best family everywhere since seedlings of best genotypes are always in short supply and because of diversity concerns.

Over the last 10 years, seed orchard managers have had great success in developing methods to mass produce full-sib (control-pollinated or clonal) families for operational planting. The gains from improved quality and yield are very impressive when both the female and male parents are controlled. As forest managers in the southern United States move almost exclusively to silvicultural regimes to promote sawtimber production, the improvement in stem quality from lower levels of rust and better stem straightness have exceptionally high economic value.

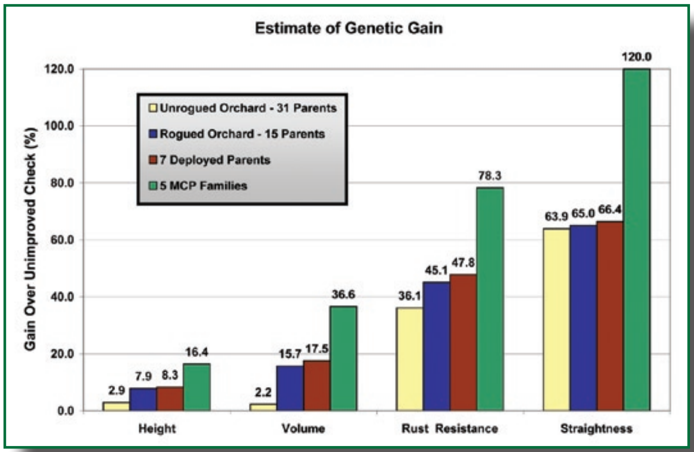


Figure 1. Estimates of genetic gain over unimproved checklots for different levels of genetic entries from the MeadWestvaco/ArborGen tree improvement program in the Atlantic Coastal Plain in South Carolina.

In Figure 1, the yellow bar is for the average of all 31 parents in the unrogued orchard. The blue bar is for the average of the 15 parents in the rogued orchard. The orange is the mean of seven OP families that were operationally deployed in the 1990s by MeadWestvaco. The green bar represents the mean of the five control-pollinated families now planted.

From: Fox, Tom, H. Lee Allen and Eric Jokela. 2007. The Development of Pine Plantation Silviculture in the Southern United States. Forest Nutrition Cooperative Research Note No. 25, October 2007.

In the 1950s, less than two million acres of southern pine plantations existed in the southern United States. By the end of the 20th century, there were 32 million acres of southern pine plantations in the region. This success story was facilitated by the application of results generated through cooperative research of the USDA Forest Service, southern forestry schools, state forestry agencies and forest industries. This report reviews the contributions of applied research in tree improvement, nursery management, site preparation, weed control and fertilization to plantation forestry in the South. These practices significantly increased productivity of southern pine plantations. Plantations established in the 1950s and 1960s that produced less than 90 cubic feet per acre per year have been replaced by plantations established in the 2000s that may produce in excess of 400 cubic feet per acre per year.

These intensively managed plantations offer landowners attractive financial returns. Although the costs associated with intensive management are higher, returns are higher because the growth rates are much greater and the rotation lengths are shorter. This improved productivity makes it possible to maintain and increase the amount of timber produced, even as urban expansion reduces the amount of forest land in timber production.

In the last 10 years, most of the large integrated forest products companies that dominated southern pine plantation forestry through the 1980s divested their timberland holdings. A new class of forest landowners has emerged during this period including Timberland Investment and Management Organizations (TIMOs) and Real Estate Investment Trusts (REITs). Because the new investments in timberland by TIMOs are relatively short term, many are less inclined to invest in silvicultural practices. However, these new forest landowners still can take advantage of many of the advances from silvicultural research to improve the productivity, profitability and sustainability of their southern pine plantations.

A major concern associated with this transition in forest land ownership in the South has been the decrease in support of forestry research. Both internal proprietary research and external cooperative research programs have declined substantially or have been entirely eliminated. Several of the university/industry research cooperatives in the South were terminated in the last 10 years, and the support for some of the remaining programs has declined to the point where their long-term survival is questionable. There also has been a significant decline in the research focused on forest productivity at southern universities and the USDA Forest Service. This is an alarming trend because we believe that additional support for research focused on forest productivity will be needed in the coming decades if we hope to continue to make the advances in plantation productivity similar to those that have occurred.

GENETICS AND RESTORATION

GRAFTING NATIVE VIRGINIA LONGLEAF PINE TO ESTABLISH A SEED PRODUCTION AREA

Nathan Lojewski and Billy Apperson, VDOF

In the last issue of the Research Review, we reported on our longleaf pine provenance study, which suggests that longleaf pine from native Virginia origins are superior in early survival and growth to those from other locations around the south. We would like to provide the native Virginia seedlings for planting in Virginia by establishing a grafted seed production area from the small number of remaining wild native Virginia trees in addition to the open-pollinated seed-origin production area we are already establishing at Garland Gray Forestry Center. Past attempts at grafting longleaf pine did not achieve acceptable grafting survival to create a seed orchard. We believe that they failed because they used potted longleaf pine rootstock, which lacked the well-developed root system and vigor required to survive grafting stress.

We hypothesized that longleaf pine could be successfully grafted in outplanted beds because the rootstock would have well-developed root systems and be vigorous. This was based on observations by VDOF personnel of longleaf pine seedlings pulled from natural stands, which have extensive root systems, sometimes extending as far as 20 feet in any direction from a two-foot-tall seedling. Historical records also indicate that longleaf pine grafting success can be obtained in beds. We also wished to test a new waxing protocol for sealing grafts, which is used by Dr.

Martin Cipollini from Berry College in Georgia. This spring, we initiated a grafting study using two-year-old rootstock planted in beds.

Specifically, we designed our experiment to answer four questions (Table 1). First, would large rootstock (greater than one foot in height) take grafts better than small rootstock (less than one foot in height)? Second, will rootstock planted directly in seedbeds take grafts better than rootstock planted into in-ground bags? Third, will scion wood and grafts sealed with traditional wax survive better than those sealed with paraffin and parafilm (Cipollini method)? Fourth, how does timing affect graft survival? We chose three grafting dates to approximate different physiologic conditions: dormancy (March 6th), pre-bud break (March 19th) and post-bud break (April 3rd).

Graft survival was evaluated June 22, 2008 (Table 2). The overall survival for the study was 38.3 percent with the single best treatment (large direct-planted rootstock grafted March 6th using the Cipollini method) reaching 80 percent survival (Figure 2). We found that large direct-planted rootstocks tended to achieve higher overall grafting success than small rootstocks or those planted in in-ground bags, but these differences were not

Figure 2. A successful longleaf pine graft (on a large direct-planted rootstock – grafted March 6th using the Cipollini method) in August 2008.

Table 1. Longleaf pine grafting study design showing the number of grafts made for each treatment. All small rootstock were less than one foot in height. Large rootstock and in-ground bag rootstock were greater than one foot in height.

Rootstock	March 6		March 19		April 3	
	Traditional	Cipollini	Traditional	Cipollini	Traditional	Cipollini
Small (direct planted)	—	10	—	10	—	10
Large (direct planted)	10	10	10	10	10	10
Large (in-ground bag)	—	10	—	10	—	10

Table 2. Grafting survival across all treatments and dates. Traditional and Cipollini refer to the waxing method used to seal grafts.

Rootstock	March 6		March 19		April 3	
	Traditional	Cipollini	Traditional	Cipollini	Traditional	Cipollini
Small (direct planted)	—	60%	—	50%	—	30%
Large (direct planted)	10%	80%	0%	50%	10%	40%
Large (in-ground bag)	—	70%	—	30%	—	30%

statistically significant (Figure 3). The traditional waxing method (6.6 percent graft survival) was statistically inferior ($p<0.05$) to the Cipollini method (56.6 percent survival). Grafting date also had a statistically significant influence ($p<0.05$) with the early dates having higher success than later dates. Graft survival across all treatments was 55 percent for March 3rd; 32.5 percent for March 16th, and 27.5 percent for April 3rd (Figure 4).

In conclusion, the longleaf pine grafting study was a success, and we can say with confidence that we can graft longleaf pine. These results tell us that to maximize graft survival, we should avoid traditional grafting wax and graft while buds are still dormant. They suggest that using two-year-old rootstock larger than one foot in height direct planted in beds is also desirable. We expect future graft survival to be 50 percent and possibly as high as the 80 percent or 90 percent if results obtained this spring can be replicated on a larger scale.

The surviving grafts from the study and other longleaf pine grafting conducted this spring now total approximately 100, and we will use these grafted trees to begin a native Virginia longleaf pine seed production area at the New Kent Forestry Center. This is exciting news for landowners in Virginia interested in restoring longleaf pine. We hope to see the new area in production in 10 years and to greatly increase the amount of native Virginia seedlings that the VDOF can supply to landowners across Virginia.

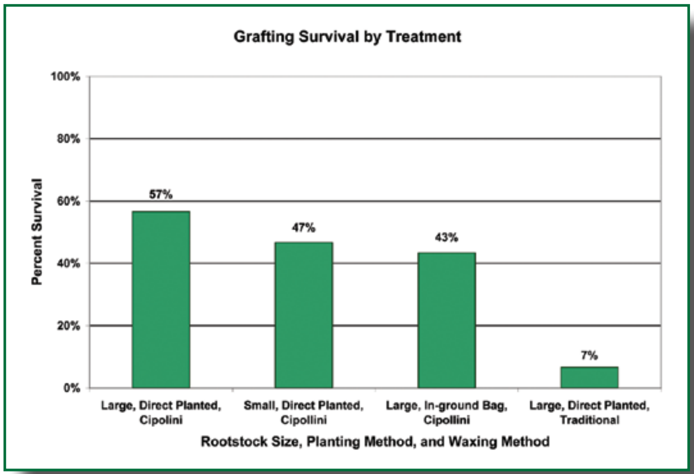


Figure 3. Large rootstock had the highest grafting survival while the traditional waxing method resulted in grafting failure. A Chi-squared test showed that graft survival across all dates was significantly ($p<0.05$) related to rootstock characteristics.

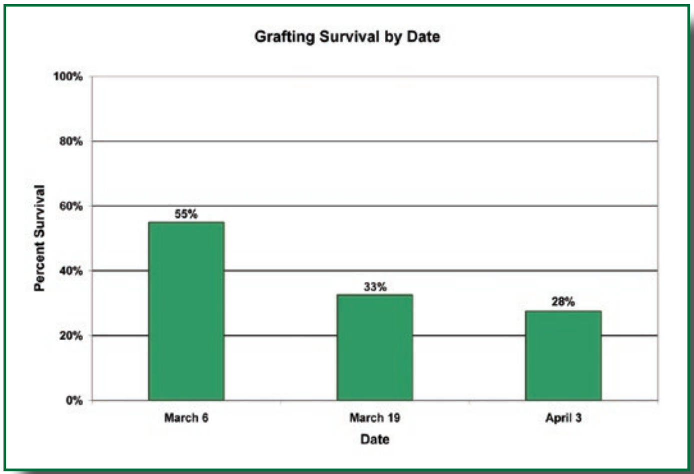


Figure 4. Early dates had the highest graft survival while survival fell at each later grafting date. A Chi-squared test showed that graft survival was significantly related to grafting date ($p<0.05$).

Shortleaf Pine Establishment

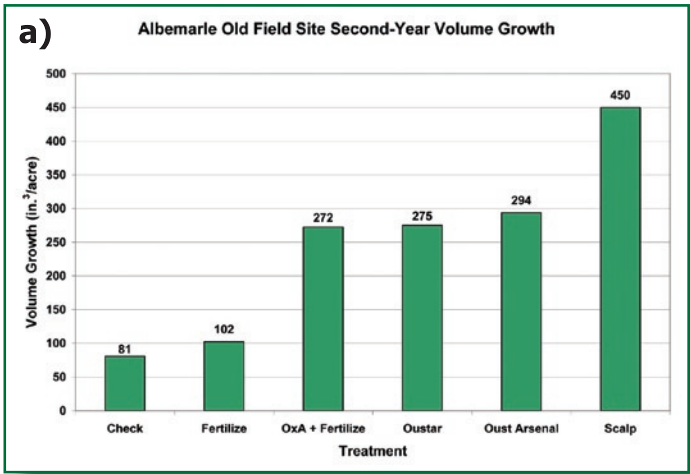
In March 2006, we installed three locations of a study to look at whether different methods of competition control with and without supplemental fertilization would affect early survival and growth of planted shortleaf pine on old field and cutover sites in Albemarle and Louisa counties. The treatments being compared include: 1) no treatment; 2) scalping using a modified fire plow pulled by a farm tractor to turn over the top 3-5 inches of sod along an approximate 2-3 foot swath; 3) fertilizer (urea x DAP) to provide approximate rates of 200 lbs./acre nitrogen and 25 lbs./acre phosphorus prior to the second growing season; 4) weed control using 4 oz. Arsenal + 2 oz. Oust (imazapyr + sulfometuron) (Figure 5); 5) weed control using 12 oz. Oustar (sulfometuron + hexazinone); 6) treatments 3 and 4 combined; 7) treatments 3 and 5 combined, and 8) fall-applied broadcast weed control using Roundup (glyphosate).

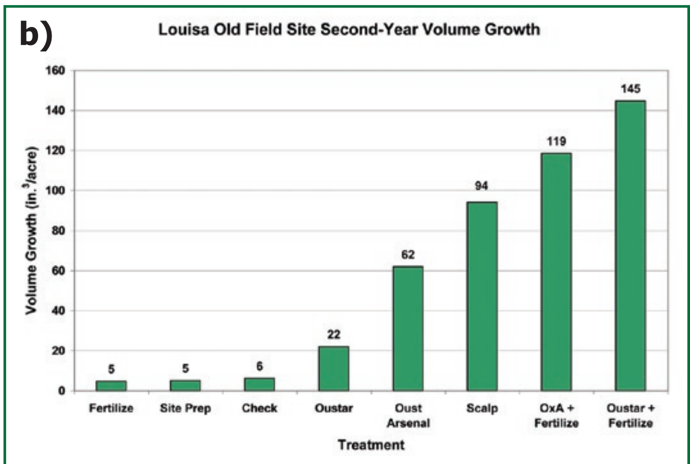
We've measured height, groundline diameter (GLD) and survival of the seedlings through two years after planting. The results are listed in Table 3, and Figure 5 a-c show the growth in volume index per acre for each location over the past year. After two years, the differences among sites and the effects of the fertilizer have become apparent. In general, survival has not been acceptable although treatments to remove competing vegetation either by scalping or applying herbicides have been helpful. Statistically, analysis of variance indicates that the differences among treatments in growth, volume index and survival are significant on both of the old field sites but not on the cutover site.

In terms of tree size and growth, fertilizer alone has not worked on old fields – probably because the fertilizer stimulated the competing vegetation more than the pine seedlings. Where herbicides and fertilizer were combined on old fields, the growth was much improved – equal to or better than that on the herbicide alone plots. Any form of competition control allowed the shortleaf seedlings to grow better, but the value of the herbicide application seemed to depend on the weed complex on the site. Scalping was consistently beneficial (for example, see Figures 6 and 7).

Table 3. Second-year results of the shortleaf pine establishment study.

Albemarle Old Field	Height (ft.)	Height Growth	GLD	GLD Growth	Survival	Volume (in.^{3})	Volume (in.^{3}/acre)
Check	1.63	0.56	0.34	0.19	30.00%	2.85	286
Fertilize	1.69	0.60	0.33	0.17	50.00%	2.50	444
Oust Arsenal	1.86	0.94	0.43	0.27	76.67%	4.52	1232
Oustar	1.90	0.79	0.44	0.28	63.33%	6.20	1467
OxA + Fertilize	1.85	1.03	0.40	0.25	70.00%	4.06	995
Scalp	2.13	0.96	0.50	0.31	86.67%	7.61	2295
Louisa Old Field	**Height (ft.)**	**Height Growth**	**GLD**	**GLD Growth**	**Survival**	**Volume (in.^{3})**	**Volume (in.^{3}/acre)**
Check	0.74	0.16	0.18	0.05	36.67%	0.4398	56
Fertilize	0.84	0.23	0.2	0.06	43.33%	0.4784	83
Oust Arsenal	1.27	0.55	0.27	0.12	66.67%	2.0284	538
OxA + Fertilize	1.50	0.72	0.34	0.17	66.67%	3.4294	796
Oustar	1.04	0.41	0.23	0.09	63.33%	1.2034	306
Oustar + Fertilize	1.56	0.74	0.37	0.21	56.67%	3.5872	634
Scalp	1.32	0.48	0.35	0.20	70.00%	3.034	716
Site Prep	1.16	0.38	0.18	0.05	16.67%	0.5713	45
Louisa Cutover	**Height (ft.)**	**Height Growth**	**GLD**	**GLD Growth**	**Survival**	**Volume (in.^{3})**	**Volume (in.^{3}/acre)**
Check	1.33	0.47	0.45	0.23	60.61%	4.14	924
Fertilize	1.78	0.72	0.60	0.32	66.67%	10.37	2746
Oust Arsenal	1.54	0.50	0.59	0.32	57.58%	8.65	1624
Oustar	1.46	0.47	0.55	0.28	66.67%	8.82	2375
OxA + Fertilize	1.81	0.73	0.60	0.33	54.55%	8.98	1751





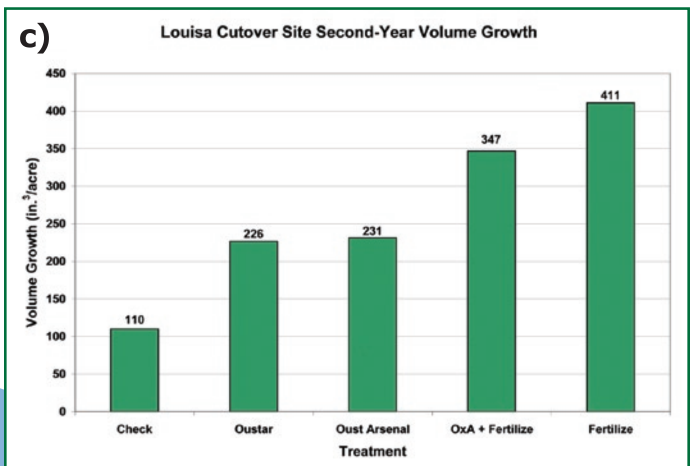


Figure 5 a-c. Volume index growth per acre during the second year on plots of the shortleaf pine establishment study. The effects of the treatments are highly statistically significant.

Figure 6. Typical shortleaf pine row (or lack thereof) in an untreated area on the Page old field site after two years.

Figure 7. Typical shortleaf pine row in a scalped row on the Page old field site after two years.

Tipmoth Control

Nantucket pine tipmoth (*Rhyacionia frustrana*) affects growth of loblolly pine throughout its range more than any other insect pest. In 2008, we became aware of two new insecticide products that are labeled for tipmoth control. Both products are systemic; they are absorbed through the tree roots and taken up into the foliage. One (SilvaShield, from Bayer Environmental Science) contains the active ingredient imidacloprid and is a tablet that is either placed in the planting hole with the seedling when planted or later inserted into the soil adjacent to the seedling. The other (PTM, from BASF) contains fipronil and is a liquid that is mixed with water and injected into the soil at the base of the seedling.

We wanted to evaluate the claims that these products can protect seedlings from tipmoth damage for two or more years, so in March 2008, we installed test plots in seven newly-planted sites around Virginia. We thank MeadWestvaco for its help and permission to use its property for four locations in Buckingham and Campbell counties. The other locations are on the Appomattox-Buckingham State Forest; on private land in James City County, and on the Camp Community College in Southampton County. At every site, we installed four replications of 25-tree row plots. Treatments included an untreated check, PTM (at all sites) and SilvaShield (at five sites). Only three of the sites (one each in Campbell, Buckingham and James City counties) have been affected by tipmoth to date, so only those sites are included in this discussion.

Figure 8 shows the results through August 2008 in terms of average percentage of seedlings infested and of shoots damaged on each plot. It's fairly clear and highly statistically significant (Pr>F of 0.01 or less at all sites) that the unprotected seedlings are showing a lot more damage (34 percent of seedlings and 14 percent of shoots) than those treated with either of the insecticides (0.51 – 1.94 percent of seedlings and 0.25 – 0.32 percent of shoots). Figure 9 indicates that survival has also tended to be better where the insecticides were used, although the effect has only been statistically significant at two sites. It is not clear whether the improvement was due to tipmoth control or to effects on other damaging insects. We plan to continue to assess tipmoth damage periodically through the end of the second growing season next year, and will also measure height and diameter growth to see whether the tipmoth protection is allowing the trees to grow more quickly. Examples of undamaged and damaged seedlings are shown in Figure 10.

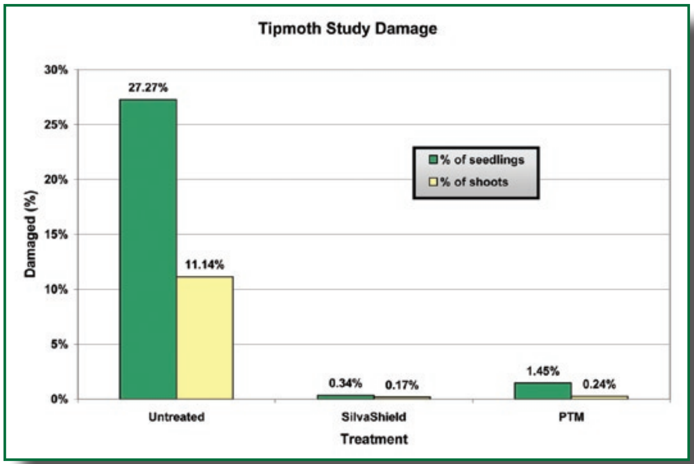


Figure 8. Seedling and shoot infestation on plots of the 2008 tipmoth study in August 2008.

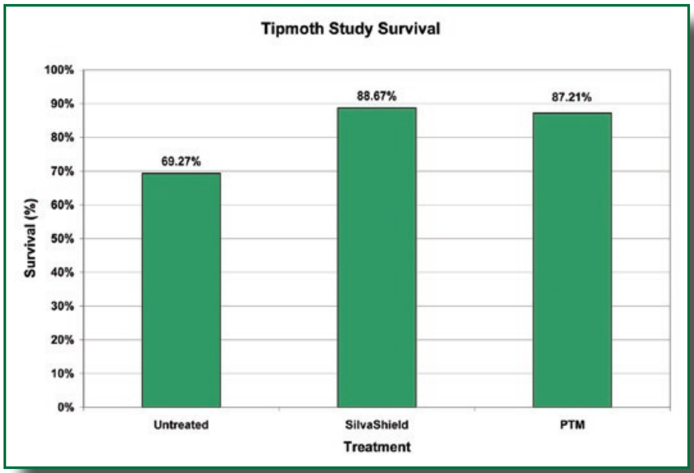


Figure 9. Seedling survival on plots of the 2008 tipmoth study in August 2008.

Figure 10. Loblolly pine seedlings undamaged (left) and damaged (right) by timpoth.

Effects of Establishment Methods and Initial Seedling Size on Early Northern Red Oak Performance

In early 2006, the VDOF installed a test of the effects of different establishment methods and initial seedling size on northern red oak survival and growth. There were two old-field locations, one in Louisa County and the other in Washington County.

The study design was described in detail in the March 2007 issue of the Research Review. Northern red oak seedlings were graded into 3 root-collar diameter classes: small (<0.2 inches), medium (0.2-0.3 inches) and large (>0.4 inches), and planted in March 2006 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 two percent glyphosate solution; 4) 4-foot Tubex tree shelter plus 2-foot radius glyphosate spot spraying, and 5) VisPore mulch mat only. After two years, all the trees are off to a very slow start (Tables 4 and 5). Even the best have grown only about 1.5 feet in height and 0.06 inches in groundline diameter (GLD).

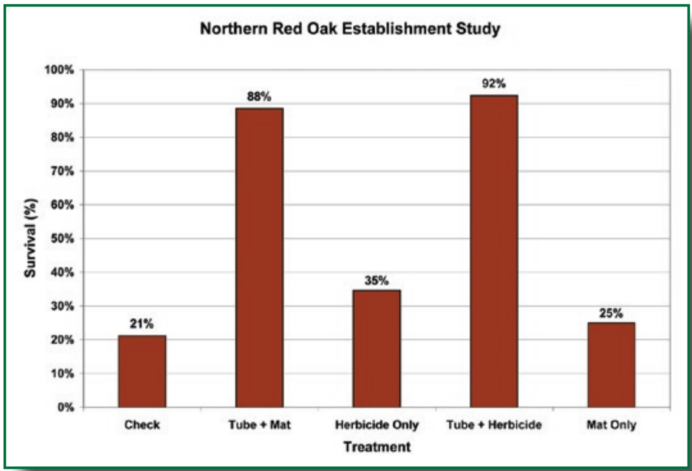


Figure 11. Comparing establishment treatments shows that the Tubex shelter was essential for survival/browse protection.

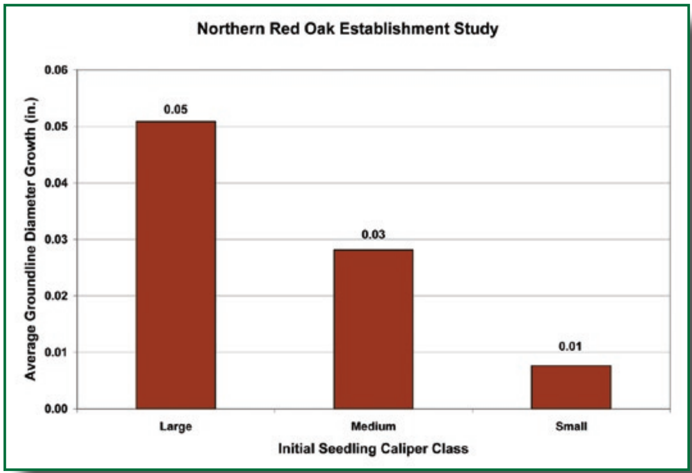


Figure 12. Although none of the seedlings have grown much in diameter, those that were larger when planted have grown more than those that were smaller.

Table 4. Two-year growth and survival of northern red oak seedlings in response to different establishment treatments (averaged across all three initial seedling sizes).

Treatment	Height (ft.)	Height Growth	GLD (in.)	GLD Growth	Survival
Check	0.85	-0.66	0.29	0.03	21%
Tube + Mat	2.60	1.34	0.25	0.02	88%
Herbicide Only	0.71	-0.85	0.34	0.06	35%
Tube + Herbicide	2.83	1.47	0.28	0.03	92%
Mat Only	0.91	-0.24	0.31	0.05	25%

Table 5. Two-year growth and survival of northern red oak seedlings of different initial diameter classes (averaged across the two establishment treatments that included tubes).

Treatment	Height (ft.)	Height Growth	GLD (in.)	GLD Growth	Survival
Large	3.76	1.59	0.38	0.05	92%
Medium	2.87	1.65	0.27	0.03	88%
Small	1.94	1.06	0.20	0.01	93%

In response to establishment treatments (Table 4), height growth has been much greater with tubes than without, and seedlings in tubes have survived well and those not in tubes have not (Figure 11). Both of these results are largely due to browse damage of the unprotected seedlings by rabbits and rodents. However, the seedlings in tubes have grown less in diameter than those not in tubes, resulting in taller but more spindly trees. The VisPore mat and spot herbicide treatment resulted in similar survival and growth.

In terms of seedling size, we looked just at seedlings that were protected inside tubes so that the browse damage would not affect the data. The seedlings that were larger initially are still larger, and have grown more in diameter than smaller seedlings (Table 5, Figure 12). There are no consistent differences between large- and medium-sized seedlings in height growth. The smallest seedlings have grown the least and survival has not varied due to initial size.

Invasive Species

Tree-of-Heaven (Ailanthus) Control Methods

Non-native invasive plants threaten natural ecosystems because they can replace diverse native plant communities with monocultures. Tree-of-heaven (*Ailanthus altissima*) – the 46th most abundant tree species in the Commonwealth – is considered by many to be the most serious non-native woody invasive plant in Virginia. VDOF initiated a series of tests in early 2006 to evaluate the effectiveness of basal bark herbicide treatments applied in the early-, mid- and late-growing season for control of Ailanthus.

All herbicide treatments in the tests involved a tank mix of triclopyr ester (Garlon 4) in a hydrocarbon / limonene oil carrier (JLB Oil Plus) at a ratio of 1:3 triclopyr: oil. The mix was applied using a Solo backpack sprayer. Individual Ailanthus trees were sprayed around their entire circumference approximately 12-18 inches above ground. The objective was to determine whether treatment effectiveness varied with season of application.

Results from the mid-season (June 5-6, 2006) application were reported in the September 2007 issue of the Research Review and showed that the treatment is highly effective (100 percent mortality with near-zero resprouting) for removing tree of heaven up to 16 inches in diameter when applied shortly after leaf expansion in the spring. The trees wilted and were leafless within weeks. There is evidence that they were dead within one week, since there was no resprouting even in the plots where the trees were cut a week after treatment.

Results of the early and late season application are shown in Figure 13. The early-season (March 28, 2007) trial was established on the Lesesne State Forest in Nelson County. Fifty-five Ailanthus ranging from 2 to 16 inches in dbh were treated. Within two months, roughly half of the trees had died while the other half had most or all of their foliage intact and healthy. Virtually all (96 percent) of them had died within 6 months. The late-season (September 12, 2007) study plots were established on the private property of Richard Helms, near Batsesville in Albemarle County, VA, where 65 Ailanthus ranging from two to 11 inches in dbh were treated. By the end of May 2008, only 40 percent of the trees were dead; the remaining 60 percent had stunted leaves on a few branches (Figure 14). By August, only 18 percent of the trees still had any leaves, and it appears likely (due to their poor condition, tiny crowns, and secondary infestations with wood boring insects) that all of them will die. At this site, we have observed a (not unexpected) relationship between tree size and the amount of time required for control. Only 30 percent of trees smaller than six inches in dbh had any leaves in May compared to more than 70 percent of the larger trees. And by August, all of the trees less than seven inches in diameter were dead, while 18 percent of those larger than seven inches still had small tufts of stunted leaves.

In summary, it appears that tree-of-heaven was consistently controlled by this treatment, but the response pattern varies depending on application timing. With a March application, about half of the trees leafed out although all were dead by the end of the growing season. After a June application, the trees were already at full leaf but wilted and were dead within one week after application. Following a September application, more than half of the trees leafed out in the spring although all of the foliage was severely stunted and very few branches had any leaves at all. By August, more than 80 percent are completely dead and indications are that none will be alive by the end of the season.

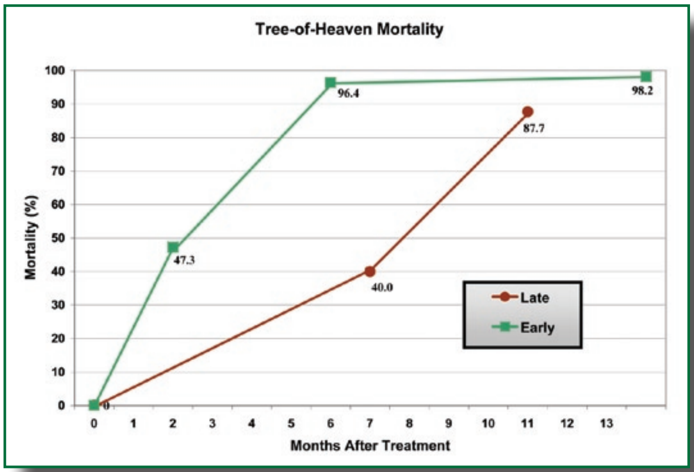


Figure 13. Mortality (percent) of tree-of-heaven sprayed with triclopy in oil basal spray in March (early) and September (late), 2007.

Figure 14. Example of stunted thin foliage of treated Ailanthus the spring following a September basal spray of triclopyr in oil.

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