Virginia Department of Forestry

Forest Research Review

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In this issue...

VDOF Research Program

Welcome to the first issue of the Virginia Department of Forestry's Forest Research Review. The VDOF has a 50-year history of scientific research related to the health and sustainability of Virginia's forests. In fact, more than 120 research reports have been published and are available on our Web site. The goal of this publication will be to periodically familiarize readers with our ongoing research projects and findings.

Jerre Creighton, research program manager

The program is divided into four primary subject areas: tree genetics and restoration; forest growth and yield measurement and projection; pine silviculture, and hardwood silviculture. Studies designed to address specific information needs or biological systems are installed and monitored across the state – often for periods of years or even decades. The program staff is assisted in these efforts by other VDOF staff in regions and counties where the studies are located, so the projects and results you will read about are truly the result of a department-wide effort.

Wayne Bowman, research forester

In addition, the research program leverages our resources through memberships in a number of regional and international research cooperatives, such as the Tree Improvement Cooperative at NC State; the Forest Nutrition Cooperative housed at Virginia Tech and North Carolina State universities; the Loblolly Pine Growth and Yield Cooperative at Virginia Tech, and the Longleaf Alliance at Auburn University. Collaborations with scientists with organizations, such as the American Chestnut Foundation, the Institute for Advanced Learning and Research at Danville, and various other universities, further enhance the overall VDOF program. Industries, such as MeadWestvaco and BASF, have also shared data, study sites and resources.

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. Please feel free to contact the research program staff at any time with any questions or suggestions you may have:

www.dof virginia.gov

Jerre Creighton, research program manager, Central Office

(434) 977-6555; jerre.creighton@dof.virginia.gov

Wayne Bowman, research forester, Appomattox-Buckingham State Forest

(434) 983-2175; wayne.bowman@dof.virginia.gov

Genetics and restoration

Longleaf Pine

When Virginia was first being settled 400 years ago, the lands south of the James River were dominated by longleaf pine forests at the northern limit of their range. These forests were extremely high in biological diversity and provided some of the most important resources needed by the early colonists: naval stores (tar and pitch) for use in ship building and lubricating wagon axles; grazing range for livestock, and high -quality timber. However, human land use practices caused the longleaf forests of Virginia to decline and virtually disappear by the mid-1800s.

The species remains in viable numbers in the sand hills of North Carolina and southward, but only 150 to 200 mature native longleaf trees remain in Virginia today. A few also exist in the northern counties of neighboring North Carolina, which together with the Virginia trees, form a remnant but potentially significant northern range seed source that could form the basis of a program to produce significant quantities of longleaf seedlings to be made available to Virginians.

In support of longleaf pine restoration, we have joined and collaborated with the Longleaf Alliance (http://www.longleafalliance.org/) in the installation of a longleaf establishment study at the New Kent Forestry Center and the planting of three study sites (New Kent and Garland Gray Forestry Centers, and Sandy Point State Forest) to test the performance of longleaf seedlings from sources ranging from Mississippi to Virginia. We are also joining forces with the Virginia Department of Conservation and Recreation (http://www.dcr.virginia.gov/) in an aggressive effort to collect all available seed from known existing native longleaf pine and use it to establish a seed production area and to restore as many acres as possible.

Figure 1. Scalping for site preparation prior to planting longleaf pine.

The establishment study tests the effects of mechanical site preparation (scalping – see Figure 1), planting depth (plug surface even with ground line or plug exposed by ½ to 1 inch), and herbicide treatment (Oustar at 8, 12, or 16 oz./acre and Arsenal + Oust at 4 + 2 oz./acre) on containerized longleaf seedling survival and early growth. After one season, survival is excellent. In particular, seedlings planted shallow (in accordance with Longleaf Alliance recommendations to leave ½ to 1 inch of the plug exposed) in scalped rows treated with Oustar at 8-12 oz./acre show excellent development (Figure 2 and 3).

Figure 2. One-year-old longleaf pine planted in scalped rows treated with Oustar at 12 oz./acre.

Figure 3. One-year-old longleaf pine planted in scalped rows treated with Oustar at 12 oz./acre.

Shortleaf Pine

Another diminished species in Virginia is shortleaf pine. In 1915, shortleaf pine's range encompassed 440,000 square miles in 24 states – more than any other pine species. In Virginia, shortleaf has declined from nearly 1.4 million acres in 1940 to just 74,000 in 2002. Once shortleaf has been removed – either in selective harvests from mixed stands or in land clearing for agriculture – loblolly is in the more favorable competitive position to seed in from non-harvested areas and grow rapidly in the early years of the stand.

Although shortleaf pine can adapt to a vast array of site and soil conditions, its growth and yield pattern is not well suited to short rotations. Within the common range of shortleaf and loblolly, old-field plantations of loblolly grow better for 40 to 50 years; beyond 50 years, shortleaf yields approach and perhaps exceed those of loblolly. Loblolly is the preferred species for shorter, pulpwood rotations.

In addition, shortleaf can suffer from littleleaf disease caused by a complex of factors, including the fungus Phytophthora cinnamomi Rands; low soil nitrogen, and poor internal soil drainage. Often, microscopic roundworms called nematodes and species of the fungal genus Pythium are associated with the disease. Affected trees have reduced growth rates and usually die within six years.

If we are interested in restoring this species in Virginia, one question that arises is how it might respond to the more intensive management options that have been applied to accelerate the growth of loblolly pine. Might it be possible to boost the slow development rate of shortleaf to make it more desirable?

In early 2006, we installed three locations of a study to look at whether different methods of competition control with and without supplemental fertilization have any effects on the early survival and growth of planted shortleaf pine in old field (Figure 1) and cutover (Figure 2) sites. The sites are in Albemarle and Louisa counties, and were planted in March. 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 (Figure 3); 3) fertilizer urea x diammonium phosphate (DAP), to provide approximate rates of 200 lbs./acre nitrogen and 25 lbs./acre phosphorous prior to the second growing season; 4) weed control using 4 oz. Arsenal + 2 oz. Oust (imazapyr + sulfometuron) (Figure 4); 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).

The study treatments are replicated three times on each site selected. The plots are 100 feet long and include 10 planted crop pines (10 x 10 ft planting spacing). Our plan is to monitor survival and growth for at least the first five years of stand development.

Figure 1. Study overview on an old field site.

Figure 2. Study overview on a cutover site.

Shortleaf Pine, continued

Figure 3. Old field site prepared by scalping.

Figure 4. Old field site treated with Oust x Arsenal (left) and Oustar (right).

American Chestnut

Prior to 1900, the American chestnut was present from Maine to Alabama. Trees were large, covering 30 to 40 percent of some forest types. Trees and their nuts were used by wildlife, livestock and humans for food. Farmers used the trees for lumber, firewood and split rail fences. In 1905, the chestnut blight was introduced into this country and spread throughout its range, infecting the native American chestnut trees.

Today many groups, such as the Virginia Department of Forestry, the American Chestnut Foundation and the American Chestnut Cooperators' Foundation, are busy trying to produce an American chestnut that is resistant to the chestnut blight. The American Chestnut Cooperators are focusing on breeding known large surviving chestnuts. The American Chestnut Foundation and the Virginia Department of Forestry are both crossing the resistant Chinese chestnut to American chestnuts in hope of bringing the resistance characteristics to the American tree. By crossing the blight resistant Chinese chestnut to surviving American chestnuts, blight resistant offspring should be produced. The only characteristic wanted from the Chinese chestnut tree is the blight resistance. Chinese chestnut trees have a poor bush-like form, while the American chestnut grows tall and single stem.

An example of the crossing:

Chinese chestnut X American chestnut ➔ ½ American chestnut

½ Chinese chestnut X American chestnut ➔ ¾ American chestnut

¼ Chinese chestnut X American chestnut ➔ ⅞ American chestnut

⅛ Chinese chestnut X American chestnut ➔ $^{15}/_{16}$ American

$^{15}/_{16}$ American X $^{15}/_{16}$ American ➔ A portion of seedlings are blight resistant

In 1969, the 421-acre Lesesne State Forest (located in Nelson County near Wintergreen) was donated to the VDOF specifically for American chestnut research. From 1969 to 1974, more than 10,000 hybrid chestnuts were planted at this site. Since the 1970s, American chestnut breeding work has been underway by VDOF personnel using the best of the first hybrids and crossing with pure American chestnut trees. We now have trees that are ⅞ American chestnut and are still working for more crosses. Other groups throughout the eastern United States are doing this same type of work. The American Chestnut Foundation now has crosses that are $^{15}/_{16}$ American chestnut. These trees will be out-planted in the near future for testing.

When the chestnuts flower each year in June and July (Figure

1), volunteers from the VDOF make the pilgrimage to the Lesesne breeding orchard – first to place paper bags over female flowers (before natural pollen matures, to prevent open pollination of the flowers – Figure 2) and then later to pollinate those flowers using pollen collected from known resistant American parent trees (Figure 3). Later in the summer, the nuts from those flowers are collected and planted at the Augusta nursery.

The following spring, the seedlings are transplanted back to the orchard at Lesesne where their blight resistance and American characteristics are evaluated. Based on observations over a number of years, they are either included in future breeding work or discarded from the program.

In 2006, we planted more than 150 new seedlings from last year's breeding program in the Lesesne orchard and a similar number at the New Kent Forestry Center. Over 250 pollen bags were placed on 24 existing crosses in the Lesesne breeding orchard, and more than 400 female flowers were pollinated.

It takes between five and eight years to raise these new seedlings from the control-pollinated seed to the point where selections and crosses for the succeeding generation of hybrids can be made. And we need hundreds of seed from each cross in order to ensure that we recover the resistant genes in at least a few of the seedlings. Our program is at the point where most of our hybrids are ⅞ American, leaving at least two more generations (10-15 years) before it is likely that our first significant numbers of blight-resistant seed will be ready for testing. Until then, we will continue the cycle of pollination, seed collection, planting, screening, and selection each year. The Lesesne program is an important part of the broader goal of preserving American chestnut adapted to a wide range of different geographic zones, all the while introducing blight resistance using the backcross breeding approach.

Figure 1. American chestnut flowers.

Figure 2. Bagging female American chestnut flowers.

Figure 3. Pollinating female flowers on backcross hybrids using male flowers from American chestnut.

Pine Silviculture

White Pine Establishment and Release

Eastern white pine is the most common and commercially important tree species planted in the mountains of southwest Virginia. In recent years, survival of eastern white pine (EWP) plantings has been variable and in some cases unacceptable. There are numerous possible reasons for seedling mortality, which may act alone or in combination to create plantation failures. Fortunately, a great deal of research has already been reported on this subject, and much of it was recently summarized in a report in "Forestry News," Spring 2006 edition.

Study #1

In a 2005 study, seedlings exposed to the elements during transportation or planting and those stored for eight weeks initiated height growth significantly later than the others. Survival ranged from 46 to 91 percent and was reduced by cold storage over four weeks, prolonged exposure to sun and air during planting, and exposure during transportation. Further, overall seedling performance was quite poor when two of these stressors were applied in combination. For example, only 17 percent of seedlings stored for eight weeks and then exposed to sun and air for 60 minutes before planting were acceptable. There was no evidence that either exposure up to two hours during grading or application of gel root dip had any substantial effects on the seedlings' performance regardless of other factors.

Based on these results and previous research, the best practices to ensure eastern white pine survival include: avoid all exposure to sun and wind during planting; protect seedlings from drying and heating during transportation; plant earlier instead of later (February through April, depending on weather); control competing vegetation and sod in old-field plantings; minimize time in cold storage; plant the largest seedlings available and practical (to accelerate height growth); and avoid root pruning at the time of planting.

Study #2

In September of 2005, a follow-up test was installed to screen potential hardwood control herbicides for application over young white pine. The plots were applied over a 4 ft. x 50 ft. band at 10 gal./acre using a boom sprayer with flat fan nozzles in early September of 2005. In addition to the planted pine, there were numerous volunteer pines (naturally seeded) of the same age in the plots; hence, probably 10-15 or more pines were sprayed in each plot. The objective was to determine whether the treatments caused any damage to the white pine.

Eight treatments were replicated three times each: 1) no treatment; 2) 8 oz. Arsenal + 24 oz. Accord without surfactant; 3) same as 2 plus Brewer TA-35 at .25%; 4) same as 2 plus EnTrée at .25%; 5) same as 2 plus Red River Forestry Oil at .25%; 6) same as 2 plus TimberSurf 90 at .25%; 7) 8 oz. Arsenal + 1 oz. Escort + TimberSurf 90 at .25%; and 8) 12 oz. Arsenal with no surfactant. Because of the 10 gallons per acre volume, small droplets and lack of hardwood canopy (no interception or pattern breakup), this probably provided more coverage of pine foliage than would be expected with a helicopter. The seedlings were re-evaluated early in the 2006 growing season and no damage of any kind was detected on any of the treatment plots.

Study #3

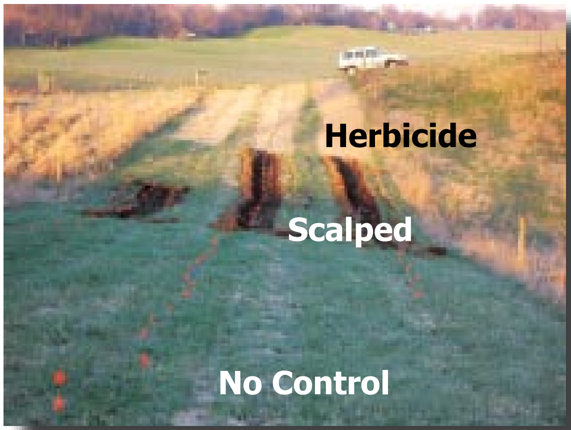
A third trial was planted in the spring of 2006 on an old field site near Glade Spring (Figure 1). This test compared seedlings stored for five, 30, 50, and 80 days after lifting; scalping, herbicide treatment, and no control of competing weeds, and seedlings showing lammas shoots versus no lammas shoots (extra whorls of branches or leader growth extension which develop late in the growing season).

The study is replicated three times in a split plot design with

White Pine Establishment and Release, continued

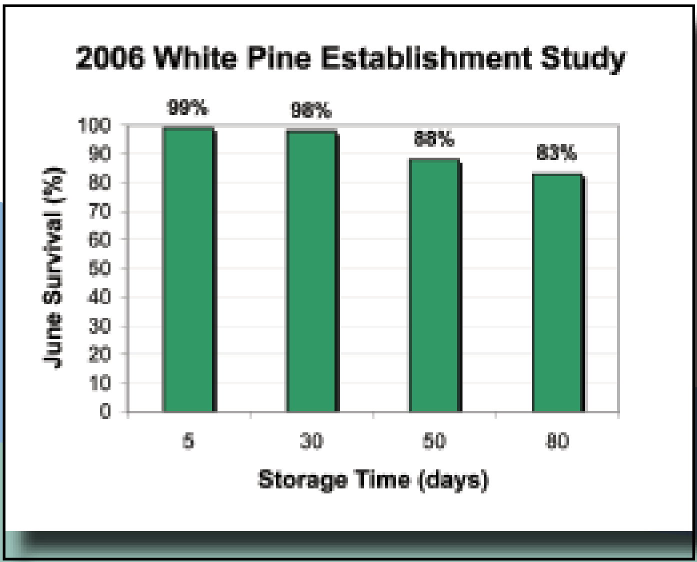
competition control treatments as whole plots and storage treatments as subplots. The subplots are 50-foot rows (10 planted seedlings at five-foot in-row spacing) spaced 10 feet apart.

Figure 1. 2006 white pine establishment trial location overview.



The first measurements (in June) indicate that the seedlings that were stored for more than 30 days either haven't started growing yet or have died (20% mortality), while the ones that were stored 30 days or less have grown 4-6 inches and look good. The seedlings with lammas shoots are doing well. So the preliminary indications are that we see problems resulting from prolonged storage (Figure 2), but not from lammas shoots. These results underscore the importance of monitoring seedling storage from the nursery bed, to cold storage, to transit to the final destination and final planting.

Figure 2. First-season survival of white pine in the 2006 establishment study.



Loblolly Pine Release Tank Mixes and Surfactants

Hardwood competition is one of the most limiting factors to the long-term productivity of loblolly pine plantations. Therefore, herbicides are often applied either before planting (site preparation) or in the first 1-5 years after planting (release) to control competing hardwoods. Historically, the most common herbicide tank mix applied for pine release in Virginia has been Arsenal (active ingredient: imazapyr) plus Accord (active ingredient: glyphosate) plus Entry II surfactant (35% ethoxylated tallow amine).

In 2004, the manufacturer of Entry II withdrew it from the market. In 2005, two alternate brand formulations of the same tallow-amine chemistry found in Entry II – EnTrée 5735 by Aqumix of Roanoke, and TA-35 by Brewer International of Vero Beach, Florida – became available. Because the effects of the surfactant chemistry on crop pine tolerance to the Arsenal x Accord tank mix in particular are very significant, it is important to identify and demonstrate safe alternatives.

Test plots were installed on the Glover Tract at the Appomattox-Buckingham State Forest in September of 2005. The stand is a 2003 harvest area planted with 2nd generation loblolly pine seedlings in March of 2004 at a target planting density of 550 trees per acre. Plots were treated using a CO^2-pressurized backpack research pole sprayer simulating a helicopter application over 30-foot spray swath over a 100-foot centerline (Figure 1). The treated plot size was 0.07 acres, and each treatment was replicated three

Figure 1. Pole sprayer application of release treatments.

times in a randomized, complete block experimental design to allow statistical testing for treatment effects on hardwood control, pine growth, and pine damage.

A total of 13 treatments were applied testing common release mixes (Arsenal alone, Arsenal at 12 oz./acre plus Accord at 32 oz./acre, and Arsenal at 12 oz./acre plus Escort XP at 1 oz./acre) with either no surfactant, TimberSurf 90, Red River Forestry Oil, Entry II, EnTrée 5735 by Aqumix, or TA-35 at 0.25% by volume.

At the end of March 2006, damage to pine trees on all the plots was assessed. In addition to scattered damage due to tipmoth and fusiform rust, most of the plots showed evidence of damage to the terminal shoot (three to six inches of dead needles and stem - Figure 2). There was no evidence of more widespread effects on branches or lower parts of the crown. The average pine height was 3.8 feet at the time of spraying, so this would affect – on average – between six percent and 13 percent of the pine stem involved. By July of the year following treatment, all of the damaged pines had recovered to the point that no damage could be seen and normal height growth had resumed. A summary of those data indicate that the damage was mostly associated with the Arsenal x Accord tank mix either with or without surfactants (Figure 3).

Figure 2. Example of terminal damage associated with the Arsenal x Accord tank mix.

In July of 2006, 10 months after treatment, competing hardwoods on the study plots were tallied and their densities compared to pre-treatment levels. All of the release treatments had significantly reduced hardwood densities, while the untreated plots (which differ slightly from pre-treatment levels) remained basically unchanged (Figure 4). Instead of 2,000-2,500 hardwoods per acre, pines on the treated plots had to compete for water, light and nutrients with only 75-400 hardwoods per acre. Previous research has proven many times that this competition control will significantly improve the yield of this stand.

Figure 3. Summary of early pine leader damage observed on the 2005 loblolly pine release plots.

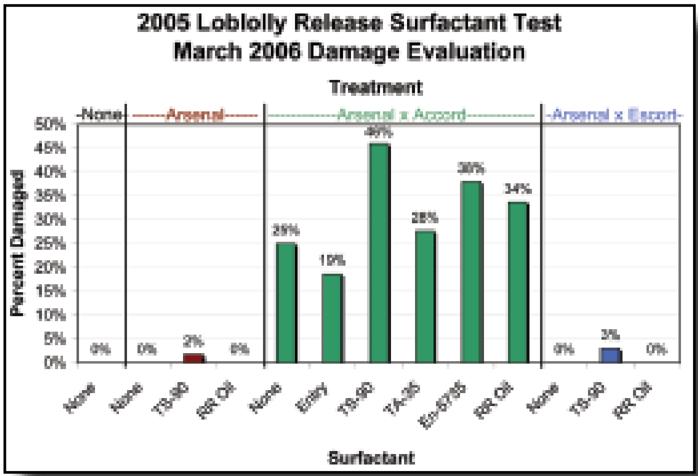
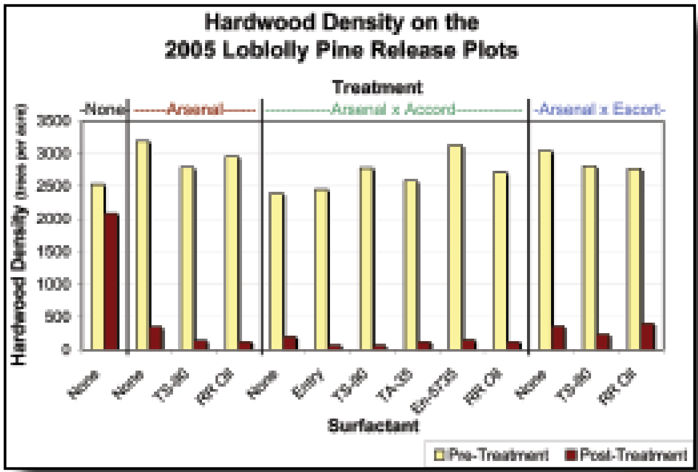


Figure 4. Summary of hardwood density before and 10 months after treatment on the 2005 loblolly pine release plots.



Treatments:

None = untreated

Arsenal = Arsenal alone

Arsenal x Accord = Arsenal at 12 oz./acre plus Accord at 32 oz./acre

Arsenal x Escort = Arsenal at 12 oz./acre plus Escort XP at 1 oz./ acre

Surfactants (at 0.25% by volume):

None = no surfactant

TS-90 = TimberSurf 90

RR Oil = Red River Forestry Oil

Entry = Entry II

TA-35 = Brewer TA-35

En-5735 = EnTrée 5735 by Aqumix

EPICORMIC BRANCHING OF WHITE OAK

Many hardwood tree species develop epicormic sprouts (water sprouts on the main stem) if sunlight and other growing conditions are favorable, particularly following disturbances, such as thinning, that allow sunlight to reach the previously-shaded tree boles. In many cases, these branches will persist for years and the small knots and defects they cause may degrade lumber value (Figure 1). At present, the only control for these branches is to mechanically cut them by sawing or allow them to be naturally pruned as the tree ages. Krenite herbicide (active ingredient fosamine ammonium) is being used by the Virginia Department of Transportation to control encroaching vegetation and lower limbs of right-of-way trees along roadways. Lower portions of trees are sprayed in the fall without apparent damage to the main tree stem, and larger limbs are killed and fall off leaving a healthy looking stem.

In 2002, we installed a test in a 34-year-old hardwood stand using herbicides chosen for their ability to kill only those parts of plants with which they come into direct contact without moving into and damaging other parts of the plant (i.e. non-translocated herbicides). These herbicides were sprayed directly onto the epicormic branches of white oaks in this study. The stand was harvested in the early 1970s and left to grow undisturbed since then. Today, it is a mixed upland hardwood stand containing white oak, hickory, red oak, yellow-poplar, chestnut oak and a few scattered Virginia pine. Most trees appear to be of single stem origin, with very few multiple stem stump sprout trees in the stand. Within this stand, a total of 105 white oak trees containing epicormic branches were located and individually tagged.

Figure 1. Epicormic brances on white oak.

On September 2, 2002, the trees were measured and then sprayed using a backpack sprayer equipped with an adjustable nozzle that allowed for a straight stream application to cover branches up to 20 feet from the ground. All leaves on the epicormic sprouts were covered with the spray. Two non-translocated herbicides, Krenite S and Derringer F, were applied at different rates separately and as a mix on the test. Treatments consisted of Derringer at 2%, Derringer at 5%, Krenite at 2%, Krenite at 5%, Derringer at 2% plus Krenite at 5%, Derringer at 5% plus Krenite at 2%, and unsprayed controls. Each treatment was repeated on 15 white oaks.

All herbicide treatments had 100% control of epicormic branches the next May following leaf out (Figure 2). Control plots had 2% mortality through natural processes. New epicormic branches have sprouted over time in all treatments, with significantly fewer on trees treated with the 5% Krenite solution. After

Figure 2. Summary of epicormic branching occurrence following various herbicide treatments.

Treatment	Average Number of Epicormic Branches per Tree		
	Before Treatment	After 9 Months	After 32 Months
Control	9.0	8.8	8.4
Derringer 2%	9.8	0	6.8
Derringer 5%	10.0	0	7.5
Krenite 2%	9.2	0	7.0
Krenite 5%	9.1	0	2.0
Derringer 2% + Krenite 5%	10.5	0	8.3
Derringer 5% + Krenite 2%	10.1	0	5.5

examining dead epicormic branch stems, no defects or off color can be seen on the main tree bole where the dead treated branch occurred. No apparent damage can be seen on the main bole (Figure 3). Unsprayed foliage shows no herbicide effects.

Figure 3. White oak with no surviving epicormic branches.

This study has demonstrated that certain herbicides sprayed on tree foliage can kill existing epicormic branches without harming the tree bole. The result also would lead us to recommend the 5% solution of Krenite as the best long-term control measure for epicormic branches of those tested in this study.

Hardwood Establishment AND Survival Trials

Hardwood trees may be planted to reforest abandoned agricultural land; establish manageable plantations; enhance the species composition of harvested areas, or for mitigation of riparian areas. These efforts are often hampered by seedling quality, competing vegetation, or predation by insects or mammals. In early 2006, we installed a trial at two locations to test different establishment methods for one commercially-valuable species – Northern red oak. The objective is to compare survival and growth of different sized northern red oak seedlings following different establishment treatments.

The study sites are near Boswells Tavern (Louisa County) and Glade Spring (Washington County). They 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) - graded at the Augusta Forestry Center on February 16, 2006. They were planted 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% glyphosate solution; 4) 4-foot Tubex tree shelter plus 2-foot radius glyphosate spot spraying, and 5) VisPore mulch mat only (Figure 1). Treatment two is the current standard recommendation for CREP plantings. These treatments were applied to 10 seedlings of the small and medium classes and six

Figure 1. Hardwood establishment methods study site showing VisPore mulch mats (foreground) and Tubex tree shelters (background)

seedlings in the large class. The study is a completely randomized design using individual-tree plots (Figure 2). The seedlings were planted at an approximate 10 x 10 foot spacing in holes drilled using a 12-inch auger. Within two months of planting, some of the larger seedlings had already grown above the tops of the 4-foot Tubex shelters (Figure 3). We will continue to monitor survival and growth of these trees to try and develop recommendations for the most cost-effective establishment methods.

Figure 2. Overview of hardwood establishment methods study site.

Figure 3. Northern red oak seedling emerging from a 4-foot tree shelter two months after planting.

Virginia Department of Forestry
900 Natural Resources Drive, Suite 800
Charlottesville, VA 22903