



United States Department of Agriculture
Natural Resources Conservation Service

“Tree and Shrub Establishment Guidelines”

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TREE AND SHRUB ESTABLISHMENT GUIDELINES



INTRODUCTION

Establishing trees and shrubs successfully takes careful planning and consideration. Not all trees or shrubs can be planted using the same methods. Special attention is needed for woody plant establishment. The choice of what to plant depends on the purpose of the planting, the site and soil conditions and the availability of the seed, seedlings, or cuttings. There are many factors to consider before, during and after tree and shrub planting which requires attention to several key elements including proper species selection, seedling quality, proper planting technique, and short- and long-term control of competing vegetation. A successful establishment depends on considering all these factors.

Refer to Virginia NRCS Plant Establishment Guide (PEG) at <http://efotg.sc.egov.usda.gov/treemenuFS.aspx> for information about choosing and planting native trees and shrubs, plant characteristics, species selection, planting rates, dates for establishment, planting methods, techniques and uses.

Plant tree species listed in the Soil Survey Interpretations – Woodland Suitability, for Individual Soil Series can be found on the Web Soil Survey: <http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>

The Virginia Department of Forestry and the Virginia Department of Game and Inland Fisheries as well as private consulting foresters can provide species recommendation for landowner’s objectives.

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SITE EVALUATION

A field site evaluation by a professional forester is an essential first step to successful tree establishment. USDA programs require a written forest management or site plan for each planting along with the appropriate job sheet for the practice specification. Virginia Department of Forestry (VDOP) Form 75 (Forest Management Plan) or an NRCS Conservation Activity Plan (CAP 106) will suffice for the written management plan if it includes site information including but not limited to:

- Description of existing conditions and vegetation (herbaceous and woody, extent, species)
- Recent management activities and present use of site
- Adapted tree/shrub species and quality
- Planting stock type and quantity
- Planting methods
- Site preparation specifications
- Tree density - Row spacing (between and within)
- Vegetation control and maintenance

Recommendations should include the site preparation method, tree species and number of trees to plant per acre, tree spacing, companion planting (if needed), tree shelters (if needed), and operation and maintenance with emphasis on controlling competing vegetation. If a herbicide site preparation application is recommended, the forester will identify the possible herbicides, rates, and time of year to apply. A map showing species to plant, trees per acre, spacing and location shall be attached to the plan.

SITE PREPARATION

Before planting, most sites need site preparation treatment to remove woody and herbaceous competition and decrease vole and mice habitat. In open fields, by creating more bare soil, site preparation may increase the likelihood of natural hardwood regeneration, including invasive species. Refer to the Virginia Conservation Practice Standard Site Preparation (Code 490) for more complete information about site preparation.

Site preparation will vary according to the species to be planted, type of ground cover, soil type, slope, and other site factors. The objective is to reduce competition without removing or destroying topsoil and organic matter. Without effective weed control during establishment and ongoing maintenance early in the life of the planting, tree establishment may never be successful. Effective weed control reduces competition (increases tree growth), reduces cover from pests such as meadow voles, and makes it easier to properly inspect and maintain the trees. The best time to begin weed control is the season prior to planting the trees. Having weeds under control in the fall prior to late winter/early spring tree planting provides the best control of perennial species, and makes planting much easier. This is especially true where tree planting are to be established in existing cool-season grass pastures or hay fields (particularly fescue dominated grass fields).

It has been shown that weed competition and fescue dominated pastures can lead to reduced growth and mortality of hardwood seedlings through shading, moisture stress and associated allelopathic effects. Replacing fescue dominated pastures with an appropriate ground cover will provide competition control from weed seed germination but allow natural regeneration of trees and shrubs to establish. See Planting Hardwood and Shrub Seedlings section for a list of companion plantings and the Virginia Plant Establishment Guide (PEG) on the Virginia Field Office Technical Guide (FOTG)

at <http://efotg.sc.egov.usda.gov/treemenuFS.aspx> for methods for conversion of fescue dominated pastures.

Some special considerations for site preparation are as follows:

Herbicide Application

- Herbicides can be used for individual stem treatment or broadcast over extensive areas.
- Herbicides should only be applied by a certified applicator and per label instructions to control vegetation that will compete with planted trees.
- For open fields, herbicide can be broadcast, band (min. width of 4 feet), or spot spray (3-5 ft. radius around tree)
- A second application may be required for hard to control species.
- Be aware of the potential for invasive species that may invade sprayed sites.

Mechanical

Open Field Sites

- Disking or tilling can be effective at reducing sod and breaking up hard soil; multiple passes may be needed.
- Sub-soiling or ripping can be effective in breaking up hard plow pan layers or heavy sod and to lay out planting rows.
- Scalping can be effective in removing sod and may provide early season freedom from competition and can be done using tractors, or scalping spots with hand planting tools to remove grass roots. It will not provide long term control of grasses or weed competition.
- Close mowing or pre-planting grazing can make the site easier to plant but will not provide competition control.

Note: With any soil disturbing practice, consider potential for soil movement, slope, proximity to water and increased potential for invasion by non-desirable species. Perform these practices well in advance of planting, so that soil will adequately settle prior to planting.

Timber Harvested Sites

- Mechanical site preparation in harvested areas is being used less due to the improvement of timber harvesting equipment, techniques and better wood utilization,
- Mechanical site preparation should remove only the logging debris that impedes the tree planting operation while leaving as much of the top soil in place as possible.
- Whenever possible, the windrows, continuous piles of logging debris, should follow the contours of the land to lessen soil erosion and provide breaks for the water runoff.

Prescribed Burning

- May be used to reduce vegetation and create better planting conditions.
- Burning may not provide long term control of grasses or natural tree sprouting but may improve habitat conditions for certain birds and wildlife.
- Consider using burning in conjunction with herbicide treatment.
- Prescribed fire is a valuable supplement to some forms of mechanical or chemical control of competing vegetation. Other benefits are improved access and visibility that increase efficiency and safety of planting operations.

Site Improvement

- Water control and fertilization often can improve growth on wet and other low quality sites. Water control should be designed to maintain optimum water table. In the bottomlands, pines grow best when the water table is at least 18 inches but less than 36 inches below the surface.
- Bedding is used to improve drainage and make planting easier. It has improved survival and initial growth of loblolly pine. Pines planted on beds in wet areas benefit from improved nutrition and soil aeration.

TREE SPECIES SELECTION

Selection is based on landowner and project objectives, select the best species or best mix of species suited for the site and with the highest probability of success. Refer to Virginia NRCS Plant Establishment Guide (PEG) on the Field Office Technical Guide (FOTG) at <http://efotg.sc.egov.usda.gov/treemenuFS.aspx> for information about choosing and planting native trees and shrubs, plant characteristics, species selection, planting rates, dates for establishment, planting methods, techniques and uses. Trees already present on or near the site will aid in this selection process as well as matching the best species for the soil. If a strong seed source (particularly light wind borne seeds) for an individual species is present, then planting that species may not be necessary. Site characteristics must be taken into full consideration when selecting species not naturally occurring on the site. Species are to be selected by a professional forester, not the planting contractor. Contractors have discretion over where the seedlings are purchased but the professional forester is responsible for selecting proper species based on site characteristics and management objectives or program criteria. The forester needs to communicate the location where each species is to be planted both verbally and on the site map. Review and select trees based on the silvicultural characteristics of the species. If consistent with objectives, choose species with aggressive growth characteristics that will quickly occupy the site, outgrow or suppress competing or invasive species and create the benefits of a forest environment. Rapid site occupation by planted trees of the proper species may reduce the need for future site maintenance.

Use of conifer “Nurse or Trainer” trees for hardwood establishment: Inter-planting of conifers can be useful in hardwood stand establishment to encourage vertical development, shade competition, ameliorate soil conditions, foster root development and create forest conditions more quickly. Use conifer species that are best-adapted to the site conditions and with growth rates that are consistent with the hardwood species being planted. Interplanted conifers should be species that are best adapted to the site and evenly spaced between planted hardwoods. Consider diminished conifer species like shortleaf pine, as well as white pine. . These may be removed when they have achieved their desired purposes, and when practical to do so.

On sites subject to wet soil part of the year, use appropriate wet soil adapted species, not upland oaks. Northern red oak should only be planted on well drained, northern or eastern aspects on the middle to lower slopes. White oak grows best on north and east-facing lower slopes and coves and grows well on moderately dry slopes and ridges with shallow soils.

Reminders:

- Select stocking/density and spacing levels appropriate to management or program objectives and species characteristics.
- Be careful when planting near power lines, entrance roads, fences, gates etc. Leave room for ingress and egress. Use shrubs or small trees in areas where power lines are overhead.

Leave at least 15 feet from the center of roads, 20 feet from the dripline of existing trees, and 10 feet off of fence lines.

- Do not plant shade intolerant species under the canopy or within 20 feet of larger over-story tree driplines.
- Where an abundance of natural seedlings are expected, but supplemental planting is desired for species diversity or specific program guidelines, plant a lower stand density.
- Refer to the Virginia Plant Establishment Guide for a complete list of native/suitable Virginia species.

GENERAL SEEDLING CARE

Successful plantations depend so much on the care of planting stock that every effort should be made to keep the seedlings in good condition. Experience has shown that tree seedlings can be kept in better condition in bales/bags as they come from the nursery than in field heel-in beds. This is particularly true where the stock will be planted in two to three weeks.

The following additional precautions should be taken in storing bundles/bags:

- Keep in a cool, protected place with air circulation between the bundles.
- Protect bundles/bags from rain, wind and freezing.
- Most bare root seedlings are treated with a clay slurry or watery jell at the time of packaging. This coating should keep the moisture in the roots until planting. Do not wash the coating off the seedlings by excessive watering or placing the seedlings in a bucket of water.
- Stack bundles/bags on sloping racks to ensure air circulation, easy watering, and drainage of excess water, if watering is necessary.

Stock must be kept cool and protected from “heating”. Heating is a condition where seedlings break dormancy thereby using up stored water and energy resources. The survival rate for seedlings planted after heating is very low. Stock that is well watered, protected from direct sunlight, and properly aerated usually will not heat. Seedlings that have been subjected to heating should not be planted.

It should be remembered that the sooner seedlings are planted after being lifted from nursery beds, the better the chances for survival and normal growth. Loose seedlings, those not baled or bagged, should be “heeled in” immediately upon arrival.

Ideal planting days are cool and cloudy with little or no wind. If possible, avoid planting on warm, windy days. The soil should be moist. Make sure the roots are never allowed to become dry. Bare root seedlings should be carried in a waterproof bag or bucket with plenty of moist material packed around the roots to keep them damp.

While planting, take the following precautions:

- Seedlings that are not being planted should be rewrapped and put in a shady or cool area out of direct sunlight. If no shade is available, they should be covered by a white or reflective tarp. When hand planting, one seedling should be selected at a time and immediately planted.
- At the end of each day, repack loose seedlings in the bundles and wrap them tightly.

Tree and shrub establishment can be highly successful when done correctly. By paying attention to the purpose of planting the trees, carefully considering the species, and deciding whether to hand or machine plant, will ensure that seedling survival will be high and a healthy forest will be established.

PLANTING RECOMMENDATIONS

Seedlings should be planted during the dormant season, generally from December through March. (The season can be extended from two to four weeks by placing dormant seedlings in cold storage.) Avoid planting when ground is frozen or dry or excessively wet and sticky. Planting when soil is in poor condition results in low survival, poor planting production, misplanted seedlings, and poor growth.

Plant loblolly pine seedlings slightly deeper (1" to 2") than they grew in the nursery in all soils except deep sands where they should be planted 2 to 4 inches deeper than they grew in the nursery, exercising due care not to cover the terminal bud. One exception is longleaf pine which should be planted with the terminal bud slightly above or at ground level after the soil has settled. All other pine species should be planted with the root collar (where the seedling stem meets the roots) at the same level as existing ground level.

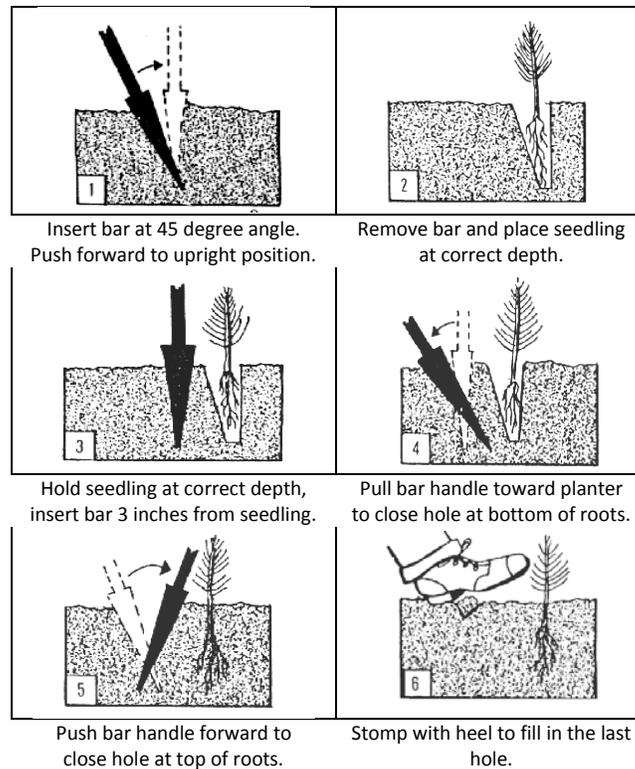
Seedlings may be planted by hand or with a planting machine. Machine planters are effective where logging debris or steepness of slope does not prohibit their operation. Seedlings should be planted with their roots straight down not "L" or "J" rooted, plant holes should be free of debris and have only one seedling per hole. The seedling should be set in the ground with no air pockets or voids and within 30 degrees of vertical.

Soil must be packed firmly around the planted seedlings with no air pockets around roots. For pines, test firmness by grasping 2 or 3 needle tips and pull. If seedling comes out of the ground, the trees have not been packed firmly.

Hand Planting Bare Root and Plugs

Hand planting using, hoedads, dibble bars, shovels, augers, or machines can be done successfully if the planting hole is large enough to allow the roots to spread out and deep enough to plant with the root collar at ground level without "L" or "J" rooting. Hand planting is used when the planting area is too small or the slope of the land is too steep to drive with a tractor. It is also used when there is too much debris on the ground and on wet sites. Refer to Figure 1 for procedures for hand planting (Dibble bars should not be used with hardwoods because they do not make an adequate hole for many hardwood seedling roots). Planting is more efficient if a shoulder bag is used to hold the seedlings. Hardwood roots need more care in planting. Larger seedlings are used, at least 1/4-inch diameter at the root collar or 18", and it is very important to keep the roots straight and not twisted or doubled over.

Figure 1. How to use a dibble bar to hand plant tree seedlings



Container Plantings

Plant by hand or using an auger that is larger in diameter than the container. Handle plants by moving the container, not by grasping the stem. Remove plants from containers before placing in the ground. Straighten or cut all encircling roots to avoid future girdling problems. Place plants at the same depth as in the nursery and firmly pack soil around roots to eliminate air pockets. Water if needed.

Balled and Burlapped Plantings

Dig holes $1\frac{1}{2}$ times as big as the rootball. Handle plants by moving the rootball, not by grasping the stem. Remove any rope, wire, or plastic twine from the tree. Pull back burlap around trunk and gold once in the hole. Straighten or cut all encircling roots to avoid future girdling problems. Place plants at the same depth as in the nursery and firmly pack soil around roots to eliminate air pockets. Water if needed.

Machine Planting Bare Root

If the site is several acres or more in size and the ground is fairly even with no obstructions such as stumps, leave trees, or heavy brush planting machines, pulled by a farm tractor, can be very effective and efficient, particularly with higher seedling densities and may be more suitable in Piedmont and Coastal Plain soils. Care must be taken to assure proper depth and avoid “L” or “J” rooting.

Figure 2. Machine planting tree seedlings.



Natural Regeneration

Regeneration of a site can also be accomplished through natural means. This method works best with native pines, cottonwoods, and yellow poplar (tulip poplar) and most hardwoods, if fire, grazing and competition are eliminated. Before considering this method, inventory the site to ensure that an adequate seed source, called seed trees, are present. Naturally regenerated pine stands may need release from competing vegetation and overstocked stands may need pre-commercial thinning. See Virginia Conservation Practice Standard *Forest Stand Improvement (Code 666)* for more information about tree release.

Natural regeneration may be an adequate method for tree establishment where there is an adequate natural seed source. The tree planting plan developed will include justification for use of natural regeneration. Natural regeneration may be used under any of the following conditions:

- Local reports or a site inspection indicate that the site is flooded, subject to swift currents, or too wet for planting equipment in both spring and fall of the typical year.
- The site is inaccessible to planting equipment (islands or other remote sites).
- There is existing mature trees suitable to the planting area, preferably including at least 2 hard mast tree species, within 100 feet of the entire planting site or evidence of existing seedlings.

With natural regeneration, it is anticipated that the available seed source will fully occupy the site to provide canopy closure. Where an abundance of natural seedlings are expected, but supplemental planting is desired for species diversity or specific program guidelines, plant a lower stand density. In order to ensure success of natural regeneration, it is critical to have an available seed source present and to control weed competition and fescue dominated pastures. Fescue dominated pastures can lead to reduced growth and mortality of hardwood seedlings through shading, moisture stress and associated allelopathic effects. Replacing fescue dominated pastures with an appropriate ground cover will provide competition control from weed seed germination and to allow natural regeneration of trees and shrubs to establish. See Planting Hardwood and Shrub Seedlings section for a list of companion plantings and the Virginia Plant Establishment Guide (PEG) on the FOTG at <http://efotg.sc.egov.usda.gov/treemenuFS.aspx> for methods for conversion of fescue dominated pastures.

General maintenance mowing throughout the buffer with natural regeneration is not a management activity since it will impede natural regeneration. Natural regeneration will result in the pioneer tree species becoming establish so if planting any trees within the natural regeneration area, favor hard mast producing species for wildlife resources.

PLANTING CONIFER SEEDLINGS

There are many different methods and procedures used to plant trees and shrubs. Table 1 provides several methods to plant pine trees based upon traditional site preparation methods.

Table 1. General Prescriptions for Pine Tree Plantings.

Pine seedlings are planted in timber harvested sites and some open field conditions. Alternatives are listed according to their effectiveness for establishing successful tree plantings. Research has shown that Alternative 1 site preparation method creates the best conditions for seedling survival and growth.

	Site Preparation	Number of Trees per Acre	Tree Spacing	Post Planting Management
Alternative 1	Herbicide Application	363	8' x 15'	No release needed
		484	9' x 10'	
Alternative 2	Prescribed Burn	363	8' x 15'	Herbicide release 1-2 yrs. after planting
		484	9' x 10'	
Alternative 3	Drum chop & Prescribed Burn	363	8' x 15'	Herbicide release 1-2 yrs. after planting
		484	9' x 10'	
Alternative 4	Bulldoze & Pile	363	8' x 15'	Herbicide release 1-2 yrs. after planting
		484	9' x 10'	
Alternative 5	None	363	8' x 15'	Herbicide release 1-2 yrs. After planting
		484	9' x 10'	

Seedling Quality and Care

A quality seedling is disease-free, root collar diameter no less than one-eighth inch, stiff and woody, with secondary needles present, maximum top length 14 inches and a root system no less than five inches nor more than 9 inches long. Seedling roots must be kept moist at all times. Seedlings (especially the roots) should not be exposed to the sun, wind, heating, drying, or freezing at any time from lifting at the nursery until planted. No roots should be exposed to the sun or wind for more than 10 minutes. If cold storage is not available, keep seedlings packed in bales after delivery. They should not be stored in bales longer than 2 weeks.

Conifer Spacing

Proper spacing of seedlings ensures a high survival rate, maximum growth and efficient use of space. Spacing controls competition between the seedlings and takes into account future operations such as thinning, release and harvest. Spacing recommendations are highly dependent on site characteristics and landowner's objectives. Table 2 lists the most important pine species for Virginia. Consult with a forestry professional for specific spacing recommendations.

Table 2: Recommended Conifer Species for Reforestation and A forestation by Region*

Species	Coastal Plain	Lower Piedmont	Upper Piedmont	Mountains
Loblolly Pine	X ¹	X	X	
Longleaf Pine	X ²			
Shortleaf Pine ³	X ¹	X	X	X ⁴
Virginia Pine ⁵			X	X
Eastern Redcedar	X	X	X	
Eastern White Pine ⁶			X	X
Frasier Fir ⁷				X
Red Spruce ⁷				X

1 Not recommended on sands over 30" in depth.

2. Best species for sands over 30" in depth.

3. Adapted to dry, infertile soils.

4. Recommended up to 2,500 feet elevation.

5. Adapted to severely eroded soils and disturbed sites.

6. Should not be planted on heavy clay soils or wet sites.

7. No lower than 2,000 ft. elevation, preferably above 4,500 ft. elevation.

Planting Follow-up for Pines

- Livestock should be restricted from all tree and shrub plantings until the trees are large enough to resist damage.
- The pine planting should be inspected once at the time of planting and then re-inspected after the first growing season. A professional forester should perform field re-inspections to determine seedling survival, condition, and to evaluate competition.
- Assess the need for competition control, particularly vertical, or overtopping competition and non-native or invasive species. Foliar herbicide spraying with approved herbicides according to label can be effective if planted seedlings can be located and protected.

PLANTING HARDWOOD AND SHRUB SEEDLINGS

- Site preparation must be such that the soil is not eroded or compacted. A sufficient A-horizon is desired when planting hardwood seedlings. Also, compaction and ponding occurs when equipment is run over wet soils. These conditions can result in planting failure.
- The newly planted seedlings need to grow without severe competition. This requires intensive site preparation and proper follow-up to control competing vegetation.
- Tree tubes (shelters) are necessary to protect the seedlings from browsing by deer, mice and other animals; they also protect the seedling from weed competition, excessive winds and sunscald.
- Plantations must be carefully monitored. Hardwoods and shrubs are killed or injured by light fires; grazing cattle and deer can destroy them, and they are sensitive to herbicides.
- Tree planting along with shelters should be completed prior to April 15th in the coastal plain and piedmont, and by May 1st in the mountains.
- Soil augers can be useful when planting larger seedlings and for efficiency. Use care when in heavy clay soils where augers could create a smooth hard wall that will restrict water and roots. To account for soil settlement augered holes should be left for several weeks so the soil can "settle" before planting the trees. Tree shelters should be set and buried 2-3 inches below ground surface. Any soil removed by the auger or machine should be placed back into the hole to secure the seedling at ground level and prevent the seedling from settling below ground level.

There are many different methods and procedures used to hardwood plant trees and shrubs. Table 3 provides different proven techniques to plant hardwood trees depending on the level of site preparation that is needed.

General Prescriptions for Hardwood Tree Plantings in Open Fields.

Alternatives are listed in table 3 according to land use and their effectiveness for establishing successful tree plantings. Effective competition control (tall fescue and weed pressure) is a key to the success of hardwood tree plantings as competition can lead to reduced growth or mortality of hardwood seedlings through shading, moisture stress and chemical inhibition. The use of tree shelters is recommended for all of the alternatives. Planting hardwood seedlings on harvested sites is not recommended under most circumstances because the natural hardwood regeneration will likely outcompete the planted seedlings.

Table 3. Alternatives for Establishing Hardwood Trees

	Land Use	Site Prep	Companion Planting	Available Seed Source on Site	Number of Trees per Acre	Operation & Maintenance Sprayings
Alternative 1	Pasture/ Hay	Spraying entire field to kill weeds & fescue ³	Yes ⁵	Yes ¹	Natural Regen +25 (40'x40' spacing)	Post emergent spraying for at least 2 years following planting as needed ⁶
Alternative 2	Pasture/ Hay	Spraying entire field to kill weeds & fescue	Yes ⁵	No	300 (12'x12' spacing) ²	Post emergent spraying for at least 2 years following planting as needed
Alternative 3	Pasture/ Hay	Strip or circle sprayings for tree planting	No	Both Yes and No	300 (12'x12' spacing) ²	Required spraying for at least 2 years following planting around tree shelters to reduce competition
Alternative 4	Cropland	Spraying entire field to kill weeds & fescue	Yes ^{4,5}	Yes ¹	Natural Regen +25 (40'x40' spacing)	Post emergent spraying for at least 2 years following planting as needed ⁶
Alternative 5	Cropland	Spraying entire field to kill weeds & fescue	Yes ^{4,5}	No	300 (12'x12' spacing) ²	Post emergent spraying for at least 2 years following planting as needed

Notes:

1. Natural regeneration will likely occur where there is an available seed source at the planting site and will fill in the gaps to provide canopy closure. The 25 planted trees per acre recommended for sites with natural regeneration is to favor hard-mast producing trees for diversity since areas adjacent to tree lines or woodland will favor wind-blown soft-mast species. The 25 planted trees should be of larger stock trees or tree whips to allow for a more rapid growth of the tree.
2. Up to 50% of the recommended trees per acre can be of pine species. These trees will not have tree tubes installed and will be inter-planted to act as nurse or trainer trees. These trees should favor Longleaf Pine, Short Leaf Pine, and White Pine species.
3. Total area spraying is required for the natural regeneration alternative on pastureland due to the competition from fescue effecting artificial regeneration.
4. Cropland generally has the least amount of weed competition due to residual weed control, however, due to the land being open with no cover a companion planting is necessary to prevent weed competition in the future.
5. Companion plantings are required where there is total area spraying to control fescue and weed competition or where there is a potential erosion concern. Poorly degraded pasture sites also require companion plantings as these sites are the most vulnerable to weed pressure.
6. General maintenance mowing throughout the tree planting is not a recommended management activity since it will impede natural regeneration.

Companion Plantings for Tree/Shrub Establishment.

A companion planting is the practice of planting a herbaceous cover that will occupy the site in combination with the tree planting, but not compete with the trees seedlings. Preventing weed problems before they occur is key to successful control of competition with trees. The use of a companion planting effectively limits weed development and encourages natural regeneration. The use of a companion planting is a preferred method of establishment with trees and shrubs to reduce weed competition and eliminate fescue dominated pastures or unmanaged non-fescue pastures. It has been shown that weed competition and fescue dominated pastures can lead to reduced growth and mortality of hardwood seedlings through shading, moisture stress and associated allelopathic effects. Replacing fescue dominated pastures with an appropriate ground cover will provide competition control from weed seed germination but allow natural regeneration of trees and shrubs to establish. The following companion planting mixes should be used if a companion planting is needed for the site preparation prescription.

Companion plantings should provide significant ground coverage as quickly as possible to prevent weed seeds from establishing, grow less than 3 to 4 feet in height to minimize shading and lodging effects, possess no known allelopathic effect on the trees and pose no invasive threat to adjacent sites. Table 4 is a selected list of acceptable companion plantings for establishing trees and shrubs. The use of mix of one small grain to provide quick ground coverage and one perennial to provide continuous coverage is a preferred companion planting but not always conducive for riparian areas due to site limitations on the use of a drill or disk as an establishment method. Broadcasting (frost-seeding) clover may be the only acceptable alternative for a companion planting in some locations.

Table 4. Companion Plantings

Companion Planting Mixtures for Tree/Shrub Plantings		
Species	Seeding Rate	Establishment Method
Winter Wheat	1-2 bu./acre	Drill or Disk and Cultipack
Fescue; Creeping Red, Chewing's, Sheep, Hard	8-10 lbs./acre	Drill or Disk and Cultipack
Red Top	8-10 lbs./acre	Drill or Disk and Cultipack
Virginia Wild Rye	10-15 lbs./acre	Drill or Disk and Cultipack
White Clover	2-3 lbs./acre	Broadcast (frost-seeding)

Prescriptions and Timing of Hardwood Tree Plantings

This section is designed to assist in the selection of a prescription for hardwood tree planting in open fields and details on how to implement the selected alternative. The alternatives in table 5 are listed according to land use and their effectiveness (from most effective to suitable) for establishing successful tree plantings.

Table 5. Pastures and fescue-dominated fields.

Fescue Replacement – One Growing Season Prior to Planting	
Spring Year 1	<ul style="list-style-type: none"> Two to three weeks prior to herbicide spraying, bush hog as close to ground as possible. Double mow if heavy build-up of cover. Allow grass to develop new foliage (6-10 inches) in April through early May and broadcast spray entire planting area with post-emergent herbicide.
Fall Year 1	<ul style="list-style-type: none"> Survey planting area in early fall (Late August - September) for any presence of competition and spot spray or spray entire field a second time with post-emergent herbicide. Seed companion planting in late fall (September into October).
Late Winter/ Early Spring Year 2	<ul style="list-style-type: none"> Plant trees directly into groundcover. Scalp an area at least 6 inches by 6 inches directly where tree is being planted and tree shelter is installed.
Year 2	<ul style="list-style-type: none"> Survey planting area in mid-summer/early fall to determine if competition control is needed. Generally the established groundcover will provide adequate control. Spot spray any noxious or invasive weeds that may be present.
Year 3	<ul style="list-style-type: none"> Survey planting area to determine if competition control is needed. Generally the established groundcover will provide adequate control. Spot spray any noxious or invasive weeds that may be present.
Fescue Herbicide Control Only – Strip or circle spraying	
Year 1	<ul style="list-style-type: none"> Problem weed species should be treated on site prior to any planting recommendations.

	<ul style="list-style-type: none"> • Two to three weeks prior to herbicide spraying, bush hog as close to ground as possible. • Double mow if heavy build-up of cover. • Allow grass to develop new foliage (6-10 inches) in when actively growing (Late-August into September) and spray strips a minimum 4 foot wide or circles a minimum of 3-5 foot radius around the tree with a post-emergent herbicide where trees are to be planted.
Late Winter/ Early Spring Year 2	<ul style="list-style-type: none"> • Plant trees directly into the sprayed strips or circles. • Scalp an area at least 6 inches by 6 inches directly where tree is being planted and tree shelter is installed.
Fall Year 2	<ul style="list-style-type: none"> • Spray a post-emergent herbicide on a 4 foot band or 3-5 foot radius circle around tree tubes in September to provide competition control. • Spot spray any noxious or invasive weeds that may be present.
Year 3	<ul style="list-style-type: none"> • Spray a post-emergent herbicide on a 4 foot band or 3-5 foot radius circle around tree tubes in April or in September to provide competition control. • Spot spray any noxious or invasive weeds that may be present.

Note: Cropland fields generally have a minimal amount of weed competition due to residual weed control and cultivation. Weed competition in these areas will come from seed deposited directly prior to and after the tree planting. Due to the land being open with no cover a companion planting is recommended to prevent weed competition in the future and minimize any erosion concerns. Spraying a pre-emergent herbicide on a 4 foot band or 3 to 5 foot radius circle around tree tubes may be needed for 2 years following planting. Generally the established groundcover will provide adequate control. Spot spray any noxious or invasive weeds that may be present.

Seedling Quality and Care

Use hardwood seedlings that have a root collar diameter of at least 1/4" or greater and a height of at least 18". Inspect seedlings for any injury, and for general condition. Musty smelling or moldy seedlings should be avoided. Choose seedlings produced from seed sources at or near the same latitude as the planting site. Handle and store seedlings carefully by planting them promptly, storing them in a cool dark place, out of the sun, wind, and high temperatures. Avoid freezing.

Hardwood and Shrub Spacing

Spacing for special purpose plantings such as program requirements, wildlife, beautification, aesthetics, and sound and visual barriers, carbon sequestration or waste treatment will be done in consultation with an appropriate professional forester from the Virginia Department of Forestry, Virginia Department of Game and Inland Fisheries, or a consultant forester.

In general, a minimum of 300 trees per acre for hardwoods is recommended. However, since spacing is dependent on soil characteristics, site conditions and landowner's objectives, it is best to consult with a professional forester to determine species and spacing.

Table 6 illustrates the connection between different spacing patterns and the number of trees per acre required to fill the area. These spacing patterns are used mostly for poles, pulpwood, lumber and veneer objectives.

Table 6. Number of Trees Required Per Acre at Various Spacing

5' x 5' = 1,742	6' x 9' = 807	8' x 8' = 681	9' x 10' = 484
6' x 6' = 1,210	6' x 10' = 726	8' x 10' = 544	12' x 12' = 302
6' x 8' = 908	7' x 10' = 622	8' x 12' = 454	20' x 20' = 109

Using container, balled and burlapped stock, or tree whips is capable of rapid height growth, allowing them to keep up with fast-growing, light seeded bottomland pioneer tree species. Rapid early height growth may be important when establishing forested buffers and windbreaks. If natural regeneration is expected to fill in between tree whips, plant 25 trees per acre (approximately 40' x 40'). Adequate fill in natural regeneration is likely to occur on frequently flooded sites with an upstream floodplain dominated by woody vegetation or where a mature forest stand is within 200 feet of the planting site.

Seedling Protection Recommendations

The use of tree shelters can aid in survival, early growth (through micro-environment effect), and protection from predation by voles, mice, deer, and livestock. They aid in locating and maintaining seedlings and offer protection when spraying nearby competition. Carefully consider costs and benefits of shelters and mats when making prescriptions. Be aware that costs, contractor preferences, and landowner preferences are not acceptable technical reasons or justifications for using shorter tubes or less seedling protection. The Department of Forestry field foresters are available to make the final planting decisions.

Following are recommendations related to this system:

- A 4' tree shelter is recommended. Shorter or taller shelter sizes are available and may be used but the forester must provide technical justification as to why a different size shelter is specified. The tract management plan (VDOF Form 75) dictates tree shelter size. Tree shelters should be double walled, biodegradable with a perforated line and should stay in place for at least 5 years to provide protection against deer, voles and mice. If the tube is not perforated, the landowner must understand the added expense of removing the shelters after the tree reaches a diameter of 2 to 3 inches. Flat packaged shelters must be rolled to overlap the ends providing a fully enclosed tube around the seedling.
- Tree shelters should be installed with the flared end up and must be 2-3 inches below the ground surface to reduce rodent entry and wind chimney effects.
- Shelters should be tied securely using releasable cable ties.
- Stakes shall be a 1" by 1" (7/8" minimum) white oak heartwood or treated pine or oak stake. Bamboo stakes, steel rebar or other non-biodegradable material may not be used.
- Bird nets shall be used on 3 or 4 foot shelters and installed leaving a small opening, about the size of a quarter, in the top.
- Flood waters can knock down shelters. Shorter shelters could be considered where flooding is likely and deer damage is expected to be light. Install stakes on the upstream side of tubes if flooding is expected. If taller shelters are used, use longer stakes and install them deeper.

Planting Follow-up for Hardwoods and Shrubs

- Livestock should be restricted from all tree and shrub plantings until the trees are large enough to resist damage.
- The hardwood planting should be inspected once at the time of planting and then re-inspected after the second and third growing season. A professional forester should perform field re-inspections to determine seedling survival, condition, and to evaluate competition. Consider and record natural hardwood seedling stocking, species, and desirability. This will affect decisions regarding competition control.
- Check to see if there is a live seedling. For future reference, it is helpful to mark shelters, which do not have a live tree. They may re-sprout the second year.
- Consider replanting if seedling survival is poor (<70%). Surviving plants should be evenly distributed over the planting area. Desirable natural regeneration may be substituted for planted material when equivalent to desired species and planned purpose. Inter-planting or replacing seedlings in close proximity to surviving seedlings is not recommended. However, if there are large spaces between surviving seedlings, replanting in these areas can be considered. Carefully assess the condition of the site. Further site preparation or competition control will likely be necessary to ensure survival of replanted trees.
- Natural regeneration sites will be replanted if recruitment and survival after 3 growing seasons is less than 250 evenly distributed seedlings per acre.
- Mowing or disking may be considered to retard competing vegetation or to reduce sod and thatch that may provide vole and rodent habitat. However, regular mowing will promote sod-grasses instead of natural vegetation.
- When the tree is within six inches of the top of the shelter the bird net should be removed. If shelters do not degrade and split, they must be removed when the tree is 2 to 3 inches in diameter. Biodegradable shelters with a perforated line will split off with normal stem growth.
- The landowner should check the site annually for broken stakes or invasive species. Efforts should focus to control and prevent invasive species from developing in hardwood plantings. The landowner should anticipate having to replace up to 10% of the stakes by the fifth year. Remove wasp nests from inside of the tree shelter. Nests can get large enough to block the growing seedling.
- Grass or weeds inside the shelter should be removed during the first 3 years. Do not pull up the clump of grass, since that can pull up the tree or damage tree roots. Raise the shelter, leave the soil in place and cut off the weeds or grass at ground level, then replace the shelter and seat it 2 to 3 inches deep.
- A weed free area and competing grass species will continue to be controlled for at least 2 feet in all directions from planted trees and/or shrubs will be maintained for at least the first 2 full growing seasons following planting.
- All noxious and invasive weeds will be controlled in accordance with Federal and State laws.

PLANTING WITH CUTTINGS

Cottonwoods, Alders, Willows and Sycamores can all be planted from a cutting. A pointed steel rod, approximately ¾" in diameter and of convenient length (36"- 42"), may be used. The rod is inserted vertically in the soil to a depth of approximately 12". The rod is withdrawn, a cottonwood cutting 20" long is placed in a hole to a depth of 15", and the soil is then firmed around the cutting. Cottonwood cuttings of various lengths up to 40" may be planted. In such cases, the cuttings are planted to depths, which will permit 4" to 5" to extend above the surface of the ground.

INTERPLANTING

Interplanting pine species with the hardwoods is allowable to act as “trainer trees” and force the hardwood trees to grow straighter. Shortleaf, longleaf, or white pine should be favored because their growth is slower than other pine species such as loblolly pine. Seedling stocking and survival can be determined a year after planting by taking 1/100 acre randomly sampled plots in the plantation. The radius of a 1/100-acre plot is 11.75'. Sufficient plots are needed to give a good representation. Replacement plantings should be made within 2 years of the original planting.

Interplanting is used when a stand failure has occurred in an original planting. New seedlings are interplanted in between the surviving seedlings. It is important to remove or control trees, shrubs, and vegetation of unwanted species that overtop or compete with interplanted seedlings and trees already established. Use the best-suited method described in the Virginia Conservation Practice Standard *Forest Stand Improvement (Code 666)* to release the surviving trees. This release work should be done in the spring to assure better survival and faster growth. Then plant new seedlings where the failures occurred. The objective of interplanting young stands is to attain an average stocking of at least 300 well distributed trees per acre by the time the trees are 5 to 6 inches dbh (diameter at breast height). The average distance between the trees should be 10 to 12 feet apart.

INSECT, DISEASE AND OTHER PROBLEMS

- Pales weevil is the most serious insect pest for pine seedlings on recently cutover pinelands. In susceptible areas, use chemically treated seedlings. Another preventive measure is to delay planting for one season following harvest cutting. The greater the volume of slash and number of stumps, the higher the population of pales weevil will be.
- Fusiform rust is the most important disease of loblolly pines. In localities where fusiform rust incidence is high, consider planting rust resistant stock or species less susceptible to rust (longleaf, shortleaf, and white pine).
- Damping off disease is caused by many types of fungi but is especially associated with *Rhizoctonia sola*, and species of *Pythium*, *Fusarium*, and *Phytophthora*. Both pines and hardwoods are affected. This disease is common in nurseries and infected seedlings can be delivered to planting sites. The fungi are more active in sites that are excessively wet and the pH is above 5.5. It is best to avoid sites that have these conditions or wait until the site is drier.
- Problems other than insects and diseases can hamper tree and shrub establishment. Deer, mice, voles, and other mammals chew on the seedlings often killing them. Acres of hardwoods can be damaged from these animals. To combat this destruction, tree shelters, stakes and mats are used to protect the trees. Figure 3 shows a planting protected from animal damage with tree shelters.

Figure 3. Hardwood Trees Protected Using Tree Shelters



Refer to the publication “Hardwood Planting Guidelines” from the Virginia Department of Forestry for more information.

SAFETY TIPS FOR TREE PLANTERS

Wear protective gloves and use care when handling seedlings treated with chemicals. Wash hands thoroughly and change clothes if they become soiled with chemicals. Provide first aid kit and see that tree planters wear proper work clothing.

REFERENCES

1. NRCS, Virginia Field Office Technical Guide, Sections II and IV.
2. “Forestry Best Management Practices for Water Quality” in NRCS, Virginia Field Office Technical Guide.
3. Stringer, Jeffrey W., Clatterbuck, Wayne, Seifert, John, Site Preparation and Competition Control Guidelines for Hardwood Tree Plantings, The University of Tennessee, Institute of Agriculture, Extension PB1783.
4. NRCS, *Plant Establishment Guide for Virginia*. Virginia Field Office Technical Guide, Section II.
5. Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. *Silvics of North America: 1. Conifers; 2. Hardwoods*. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC., NRCS, Virginia Field Office Technical Guide, Section I.

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