



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. A successful establishment depends on considering all these factors.

Refer to Virginia Department of Forestry *Seedling Catalogue* for information about choosing and planting native trees and shrubs, plant characteristics and uses.

Some trees to plant and manage are listed in the Soil Survey Interpretations – Woodland Suitability for Individual Soil Series in Section II of the Virginia Field Office Technical Guide.

The NRCS *Plant Establishment Guide for Virginia* lists native trees and shrubs for erosion control, wildlife and water quality.

The Virginia Department of Forestry and the Virginia Department of Game and Inland Fisheries as well as consultant or professional 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 management or site plan for each planting. VDOF Form 75 (Forest Management Plan) will suffice if it includes site information including but not limited to:

- Soil description and condition (type, depth, drainage class)
- Aspect and position on slope or topographic feature
- Existing vegetation (herbaceous and woody, extent, species)
- History of, and present use of site
- Existing trees and available seed sources (wind, water, animal dispersed)
- Flood potential
- Deer, vole and other mammal potential
- Size of openings (Openings within established stands of trees should not be planted unless they are wide enough to permit direct sunlight to reach the ground for several hours each day. The openings should be at least twice as wide as the height of the surrounding trees.)

Recommendations should include site preparation method, shelter height (if needed), companion planting (if needed) and spacing. If herbicides are recommended, state the name, rate, and time of year to apply. A map showing species and number to be planted and location shall be attached.

There are many different methods and procedures used to plant trees and shrubs. Table 1 provides several different proven techniques depending on what level of site preparation is desired.

Table 1. General Prescriptions for Tree/Shrub Plantings. The use of tree tubes are recommended for all of the alternatives. Alternatives are listed according to their effectiveness for establishing successful tree plantings. Alternatives 1 and 2 are preferred because they are proactive in managing weeds and fescue competition; alternative 5 and 6 should only be used when the participant chooses not to use chemicals to treat the fescue or weed competition. If heavy deer pressure is predicted for the site, favor tree species not attracted by deer (see VA Plant Establishment Guide).

	Site Prep	Companion Planting	Available Seed Source on Site	Number of Trees per Acre	Tree Mats	Post Emergence Spraying
Alternative 1	Spraying to kill weeds/fescue	Yes ²	Yes	110 (20x20 spacing) ¹	No	Only if heavy weed/fescue pressure remains
Alternative 2	Spraying to kill weeds/fescue	Yes ²	No	300 (12x12 spacing)	No	Only if heavy weed/fescue pressure remains
Alternative 3	Strip or circle spraying for tree planting	No ²	Yes	110 (20x20 spacing) ¹	No	Required spraying around tree shelters to reduce competition
Alternative 4	Strip or circle spraying for tree planting	No	No	300 (12x12 spacing)	No	Required spraying around tree shelters to reduce competition
Alternative 5	Scalping fescue/weeds	No	Yes	110 (20x20 spacing) ¹	Yes	Only if heavy weed/fescue pressure remains
Alternative 6	Scalping fescue/weeds	No	No	300 (12x12 spacing)	Yes	Only if heavy weed/fescue pressure remains

¹Natural 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.

²General mowing throughout the buffer is not a preferred management activity since it will impede natural regeneration.

Table 2. Companion Plantings for Tree/Shrub Establishment. The following companion planting mixes can be used if a companion planting is needed for the site preparation prescription. The use of companion plantings 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.

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. The following is a selected list of acceptable companion plantings for establishing trees and shrubs. The mix will contain one small grain to provide quick ground coverage and one perennial to provide continuous coverage.

Companion Planting Mixtures for Tree/Shrub Plantings	
Species	Seeding Rate lbs/acre pure live seed "PLS"
<i>Select one of the following small grains:</i>	
Wheat	1-2 bu/acre
Rye	
Oats	
<i>And add one of the following perennials:</i>	
Virginia Wild Rye	2-3 lbs/acre
Clover; Ladino or Red	
Red Top	
Orchardgrass	
Fescue; Creeping Red, Sheep, Hard	

SITE PREPARATION

Before planting, most sites need site preparation treatment to remove woody and herbaceous competition and decrease vole and mice habitat. 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, degree of erosion, and other site factors. The objective is to reduce competition without removing or destroying topsoil and organic matter. Many areas will not require site preparation where pine species are being planted

Some special considerations for site preparation are as follows:

Chemical

- Chemicals can be used for individual stem treatment or applied to extensive areas.
- Use approved herbicide per label instructions by certified applicator to control vegetation that will compete with planted trees.
- Broadcast, band (min. of 4 feet), or spot spray (3-5 ft. radius around tree)
- Second application may be required for hard to control species.
- Be aware of the potential for invasive species that may invade sprayed sites.

Mechanical

- 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.
- Ordinarily, pine plantations do not require cultivation. However, cultivation of pine seedlings planted on old fields, abandoned farms, and pastures has resulted in appreciable increase in early growth as compared to normal growth of seedlings on untreated areas. The “cost versus benefit ratio” may help the landowner make his decision in this matter. If cultivation is needed, a light disking to reduce grass competition during the first year usually will suffice.
- 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.
- 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.

Burning

- May be used to reduce vegetation and create better planting conditions.
- Burning does not provide long term control of grasses but may improve habitat conditions for certain birds and wildlife.

- Consider using burning in conjunction with herbicide treatment (before burning, or the spring following burning).
- Prescribed fire is a valuable supplement to some forms of mechanical or chemical control of competing vegetation. Drum chopping and fire, used in combination, is one of the most effective and least destructive methods of intensive site preparation. Other benefits are improved access and visibility that increase efficiency and safety of planting operations.

Site Improvement

- Water control and fertilizer 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, but may increase future logging costs. Pines planted on beds in wet areas benefit from improved nutrition and soil aeration.
- Fertilization is generally not used when planting trees. Contact the Virginia Department of Forestry for more information.

SPECIES SELECTION

Selection is based on landowner and project objectives, select the correct species or mix best suited for the site and with the highest probability of success (Table 3). Trees already present on or near the site will aid in this selection process. 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 acting 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. 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 will reduce the need for site maintenance.

Use of “Nurse or Trainer” trees: Inter-planting of conifers can be useful in hardwood stand establishment to encourage vertical development, shade competition, ameliorate soil conditions and 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 evenly spaced between planted hardwoods. Consider diminished conifer species like shortleaf pine, as well as white pine. Plant only enough to meet site needs. These may be removed when they have achieved their desired purposes, and when practical to do so. (USDA program guidelines limit to 200 tpa for white and shortleaf pine and 50 tpa for loblolly pine).

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 density and spacing 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 overstory 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. More intensive site preparation and maintenance can be expected to establish and keep these trees in the stand.
- Refer to the Virginia Plant Establishment Guide for a complete list of native/suitable Virginia species.

Table 3. Suggested Hardwood and Shrub Species for Reforestation and Aforestation by Region and Soil Characteristics*

Coastal Plain Characteristics

Species	Well Drained Deep, Rich (River Terrace)	Heavy, Somewhat Wet Soils (Mineral Soils)	Very Poorly Drained Permanently Wet Soils w/ Clay Base Muck or Peat	Shallow, Sandy Loamy Soils Over Clay Base (>6" Topsoil)
Ash				
Black Ash				X
Green Ash	X	X		X
White Ash	X			
Bald Cypress		X	X	X
Beech	X			
Black Gum (Tupelo)		X	X	
Black Walnut	X			
Black Willow		X	X	
Cedar				
Atlantic White Cedar			X	
Chokecherry		X	X	
Common Buttonbush	X	X		
Cottonwood	X			
Dogwoods	X			
Hazel Alder	X	X		
Hickories				
Mockernut	X	X		
Pignut				
Indigobush	X	X		X
Oaks				
Red				
Black Oak	X	X		
Northern Red Oak	X			
Cherrybark	X			
Pin Oak		X	X	
White				
Overcup Oak	X	X	X	X
Water Oak	X	X		
White Oak	X	X		
Willow Oak	X	X		
Persimmon	X			
Red Maple	X	X	X	
Red Mulberry	X			
River Birch	X	X		
Service-berry		X	X	X
Sweetgum	X	X		
Swamp Tupelo				X
Sycamore	X			X
Waxmyrtle (Bayberry)		X	X	
Yellow Poplar	X	X		

Piedmont Characteristics

Species	Loamy, Clayey, Red, Droughty, (Eroded)	Upland Slopes & Ridges; Deep, Loamy Soil (Little Erosion)	Small Stream Bottom (Variable)	Major River Bottoms (River Terraces)
Ash				
Green Ash			X	X
White Ash		X		X
Beech			X	
Black Gum (Tupelo)			X	
Black Walnut		X		
Black Willow			X	X
Common Apple		X		
Common Buttonbush			X	X
Cottonwood			X	X
Dogwoods		X		
Eastern Redbud		X	X	
Eastern Red Cedar	X	X		
Hackberry			X	
Hazel Alder			X	X
Hazelnut			X	X
Hawthorne		X	X	
Hickories				
Mockernut	X	X		
Pignut	X	X	X	
Indigobush	X		X	
Oaks				
Red				
Black Oak	X	X		
Cherrybark Oak			X	X
Chestnut	X			
Northern Red Oak		X		
Pin Oak			X	X
Southern Red Oak		X		
White				
Overcup Oak			X	X
Water Oak			X	X
White Oak		X	X	X
Willow Oak			X	X
Persimmon	X	X	X	
Red Maple	X	X	X	X
Red Mulberry			X	
River Birch			X	X
Service-berry			X	X
Sweetgum		X	X	X
Sycamore		X	X	X
VA-70 Lespedeza	X			
Yellow Poplar		X	X	

High Piedmont & Lower Mountains Characteristics

Species	Upland Ridges, Rocky, Eroded (Less than 3" topsoil)	Upland Ridges, Deep Soil (less than 50% Rocks)	Coves, Valleys	High Plateau
Beech			X	
Black Gum (Tupelo)			X	
Black Locust		X	X	
Black Walnut			X	
Black Willow			X	
Cherry		X	X	
Common Apple		X		X
Cottonwood			X	
Crab Apple			X	
Dogwoods			X	
Eastern Redbud	X	X		
Eastern Red Cedar	X			X
Hackberry			X	
Hazelnut			X	
Hawthorne			X	
Hickories				
Mockernut		X	X	
Pignut	X		X	X
Indigobush	X		X	
Oaks				
Red				
Bear Oak	X			X
Black Oak		X	X	
Chestnut Oak	X			
Northern Red Oak		X	X	
White				
Bur Oak	X			
White Oak		X	X	
Persimmon	X			
Red Maple	X	X	X	
Red Mulberry			X	
Sycamore			X	
VA-70 Lespedeza	X			X
White Ash			X	
White Walnut (Butternut)		X	X	
Yellow Poplar		X	X	

DIRECT SEEDING

Seed Quality

Seed should be ordered from a reliable commercial seed dealer. Lots should contain no more than 10% cull by number and moisture content should be 10% or less. Impurities should be 2% or less by weight.

Seed Treatment

Seed stratification and repellent coating are essential for all pines except longleaf. Stratification will hasten germination after sowing, which in turn will reduce the period of exposure to predators and the elements. After stratification, the seed must be coated with a chemical repellent.

The repellent coating is the same for all Southern pine species. It usually consists of one chemical to repel birds and another to repel rodents and many insects. It also includes a substance that sticks the repellent to the seed, plus an aluminum powder to lubricate the seed so they flow through a seeding machine.

Timing and Rates

Seed should be sown about the time of the last killing frost. However, if longleaf seeds are used, November or February are the preferred seeding time. For broadcasting, the rate for most species, both pines and hardwoods, should be 10,000 to 15,000 seed per acre. In terms of weight, used often for pines, the following pounds per acre are recommended:

Longleaf	3.0
Loblolly	1.0
Shortleaf	0.4
Virginia	0.3
White	0.6

With the hand-operated cyclone seeder, about 15 acres can be sown per man-day. This machine is efficient on tracts of up to several hundred acres.

Leaf litter must be burned if it is deep enough to prevent seed from reaching mineral soil. If the tract cannot be burned, use the spot sowing method as follows:

Using a hoe, rake leaves from a spot about one-foot square and drop six seeds on the exposed soil. Press them lightly into the soil. The leaves should be scattered, rather than piled, around the edge so they won't blow back over the bare spot and smother seedlings. Seedling 1,000 spots per acre, one man can cover 2 to 4 acres daily.

Release Seedlings

One advantage of direct seeding is that overtopping hardwoods do not hamper the operation; they offer shade to the seed during germination time and while the seedlings are getting established. The hardwoods should be killed by the middle of the following summer. Otherwise, they will compete for moisture and growing space.

Direct seeding should not be used on slopes which are steep and eroded because seed can easily be washed away. Also deep, sandy soils should be avoided because they dry out too fast for good seed germination. For direct seeding to work on such sites, the seed have to be covered with ½ inch of soil – a very time-consuming operation.

GENERAL SEEDLING CARE

Successful plantations depend so much on the care of planting stock that every effort should be made to keep it in good condition. Experience has shown that stock can be kept in better condition in bales/bags as it comes 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 bales/bags:

- Keep in a cool place. Avoid heated rooms.
- Protect bales/bags from freezing.
- Water at least once each week to keep roots and packing moss moist.
- Stack bales/bags on sloping racks to ensure air circulation, easy watering, and drainage of excess water.

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.

While planting, take the following precautions:

- Water, wet moss, or wet burlap should be kept around the seedling roots.
- When hand planting, one seedling should be selected at a time and immediately planted.
- At the end of each day, “heel in” the loose seedlings or repack them in wet moss and wrap tightly with waterproof paper.

Heeling

To ensure adequate survival of seedlings, it is imperative to keep the roots of the seedlings moist. Seedlings should not be allowed to dry out from the moment they are lifted from the seedbed at the nursery to the time they are planted. Seedlings should be planted the day they are delivered. If this is not possible, protect the seedlings by “heeling” them in.

Heeling Instructions:

1. Select a well-drained and slightly sloping spot with some shade.
2. Dig the trench 2 to 4 inches deeper than the seedlings’ roots are long. One side of the trench should be smooth and slightly sloping.
3. Place a shallow layer (less than 3 inches) of seedlings against the sloping side of the trench and cover the roots and 1 or 2 inches of the stem with soil.
4. Water the soil thoroughly and repeat as necessary in order to keep the soil moist at all times.
5. Keep seedlings covered while hauling and protect them from the sun and wind prior to planting.

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 SEEDLINGS

Seedlings should be planted during the dormant season. (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 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. An exception is longleaf pine which should be planted with the terminal bud at ground level after the soil has settled.

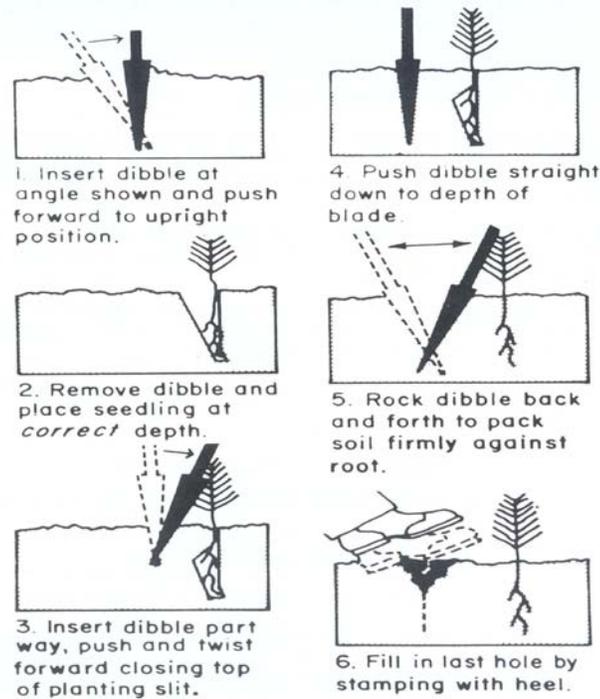
Seedlings may be planted by hand or with a machine transplanter. Machine transplanters are effective where logging debris or steepness of slope does not prohibit their operation. In some cases, planting is not needed at all since existing "seed trees" will provide the seedlings. Trees should be planted with the root collar (where the seedling stem meets the roots) at the same level as existing ground level. Seedlings are not to be "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 4 or 5 needle tips and pull. If seedling comes out of the ground, the trees have not been packed firmly. If the needles come loose, it is packed too firmly.

Hand Planting

Hand planting using, hoedads, 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. If roots are too long for the planting hole, they can be trimmed to the length of the hole. Hand planting of pines is less tedious than hand planting hardwoods. Pines are less sensitive to errors in planting than hardwoods, therefore many more acres of pines can be hand planted in a day than hardwoods. Hardwood roots need more care in planting. Larger seedlings are used, at least 3/8-inch diameter at the root collar, and it is very important to keep the roots straight and not twisted or doubled over.

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



Machine Planting

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

Seeding a site can also be accomplished through natural regeneration. This method works best with native pines, cottonwoods, and yellow poplar (tulip poplar) and most hardwoods, if fire and grazing are eliminated. Before considering this method, inventory the site to ensure that an adequate seed source, called seed trees, is present. Because the growing seedlings will be severely over-stocked, it will be necessary to release the young trees from competing vegetation and undesirable species. See Virginia Conservation Practice Standard *Forest Stand Improvement (Code 666)* for more information about tree release.

Table 4. Minimum Recommended Number of Seed Trees/Acre for Pines in Virginia

DBH*	Shortleaf Pine	Loblolly Pine	Longleaf Pine	White Pine
10	20	12	55	12
12	14	9	38	9
14	12	6	28	6
16+	12	4	21	4

*DBH is Diameter at Breast Height

PLANTING CONIFER SEEDLINGS

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 plantbeds 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. For instance, in Virginia, to be considered for Land Use Assessment for tax relief a minimum of 400 trees per acre is required. Table 5 lists the most important pine species for Virginia. Consult with a forestry professional for specific spacing recommendations.

Table 5: Recommended Conifer Species for Reforestation and Aforestation 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 HARDWOOD AND SHRUB SEEDLINGS

- Logging and site preparation must be such that the soil is not eroded or compacted. Organic soil is desired when planting hardwood seedlings. Also, compaction and ponding occurs when equipment is run over wet soils. These conditions result in planting failure. As a general guide, the site should have a pine site index of 90 feet or more at 50 years if hardwood plantations are to be considered as a satisfactory crop.
- 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 shelter and mat installation (if needed) 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 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.

Seedling Quality and Care

Use hardwood seedlings that have a root collar diameter of at least 3/8" or greater. 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.

Care of hardwood and shrub seedlings are similar to conifer seedlings with the following additions:

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 forestry specialist or from the Virginia Department of Forestry, Virginia Department of Game and Inland Fisheries, consultant forester or professional forester.

In general, a minimum of 300 trees per acre for hardwoods is recommended for timber production, 110 per acre for wildlife habitat establishment. 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 Spacings

5' x 5' = 1,742	6' x 9' = 800	8' x 8' = 675	10' x 10' = 435
6' x 6' = 1,225	6' x 10' = 728	8' x 10' = 545	12' x 12' = 300
6' x 8' = 870	7' x 10' = 622	8' x 12' = 450	20' x 20' = 110

*From 400 to 500 well-distributed trees/shrubs per acre is an adequate stand for trees of minimum pulpwood size (5 or 6 inches diameter at breast height, dbh). From 1,000 to 1,200 trees/shrubs per acre is an adequate stand for 5-foot to 8-foot high Christmas trees. About 110 trees or shrubs per acre are recommended for wildlife planting.

Seedling Protection Recommendations

The use of 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.

Following are recommendations related to this system:

- **A 4' tree shelter is recommended.** Shorter shelter sizes are available and may be used but the forester must provide technical justification and confirm the absence of significant deer-damage potential elsewhere on the property and/or by consulting with the local Game and Inland Fisheries biologist. The tract plan (VDOP 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** stake. Bamboo stakes, steel rebar or other non-biodegradable material may not be used. **The stakes should be installed on the north side of the shelter.**
- **Bird nets shall be used** on 3 or 4 foot shelters and **installed leaving a small opening in the top.**
- Flooding 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 downstream side of tubes if flooding is expected. If taller shelters are used, use longer stakes and install them deeper.

PLANTING WITH CUTTINGS

Cottonwoods, Alders, Willows and Sycamores can all be planted from a cutting. A pointed steel rod, approximately 3/4" 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.

PLANTING FOLLOW-UP FOR ALL TREES AND SHRUBS

- Livestock should be prevented from all tree and shrub plantings until the trees are large enough to resist damage.
- The planting should be inspected twice a year for the first 3 years and once per year after that. A forester should perform field reinspections to determine seedling survival, condition, and to evaluate competition. This should be completed by the late summer/early fall of the second growing season. 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 (<50%). Inter-planting or replacing seedlings in close proximity to surviving seedlings is not recommended. However, if there are large spaces between surviving seedling, 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.
- 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. Spraying over seedlings prior to bud-break may be an option, but only with labeled herbicides over labeled species.
- 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.

INTERPLANTING

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. As a rule, if 300 or more well-established seedlings survive per acre, it will not pay to replant. Replacement plantings should be made within 2 years after 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 tubes. 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. Virginia Department of Forestry *Seedling Catalog, Virginia Trees for Virginia’s Landowners*.
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. vol.2, 877 p. These volumes can be accessed at: http://www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

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