

Riparian & Wetland Tree Planting Pocket Guide for North Carolina

4th Edition



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Cover Photo: A restored reach of the Linville River at Gill State Forest in Avery County, shown about 1 month after completion. In addition to post-construction erosion control groundcover, the riparian vegetation restoration included a mix of live stakes, bare-root seedlings, and transplants. The NCFS operates the Mountain Training Facility here, which is available to rent for workshops and classes while offering on-site sleeping dorms and meal service. Learn more in the [Statewide Contacts](#) >> [Training Facilities](#) section at www.ncforestsservice.gov, and visit the [Water Quality](#) >> [Stream Restoration](#) section to learn about this and other restoration projects involving the NCFS.

Forward

Investments in restoring and enhancing stream, wetland and riparian areas have substantially increased over the last two decades.

Re-establishment of appropriate, site-suited permanent forest or shrub vegetation often is overlooked or taken for granted once water resource engineering and construction work is completed.

It is the goal of this guide to offer recommendations and guidelines based upon the collective knowledge and research of the N.C. Forest Service and its cooperators, having been successfully regenerating forests for nearly 100 years in North Carolina.

The basis for successful vegetation growth lies within the soil. This is particularly true when soils are compacted by heavy equipment during restoration, or a waterway is subject to major soil disturbance, as is often required for restorations. Carefully planned and executed soil/site preparation, tree seedling handling, and proper planting will go a long way in ensuring successful reforestation of the riparian zone.

How To Use This Pocket Guide

This Pocket Guide:

- Focuses on bare-rooted, containerized (plugged) forest tree seedlings, and live stakes.
- Outlines a process for establishing a forested riparian area in support of stream or wetland restoration.
- May be used to plant trees in existing stream corridors or on wet-natured sites.
- ***IS NOT ACCEPTABLE FOR USE ON COST-SHARED TREE PLANTING.*** The information in this guide is for reference purposes only and must not be considered as standards, specifications, policies or requirements.

Notable Revisions in this 4th Edition:

-Added a table to determine the number of seedlings needed to establish a 100-foot long stream buffer, of variable widths.

- Updated websites and reference links.

1: Understanding the Site and Soil

1.1 - Climate and Seed Source

Species and seed sources should originate within their native climate range and match the project area to be planted. In all cases, seed should be obtained from local sources. The nursery from which seedlings were obtained should have the information on the source of the seed for each species grown. Climate consideration becomes most important when selecting a seed source from a different frost hardiness zone or using a subspecies that is not native to the area to be planted.

NOTE: Nonnative species should not be used.

1.2 - Soil and Site Factors

Examine the soil and site conditions:

- Type of soil (mixture of sand, clay, loam).
- Amount of organic matter in the soil.
- Hardpans or other limiting soil layers.
- Soil moisture and/or degree of saturation.
- Depth to water table.

Amount of mottling in the soil:

- Dull bluish, gray colors indicate prolonged saturation and a wet site.
- Brighter browns, reds, and oranges indicate drier soils and infrequent saturation.

Elevation and aspect of the site:

Some tree species are adapted for growth according to elevation and the resulting micro-climate:

- South and West-facing aspects are warmer and drier.
- North and East-facing aspects are cooler and more moist.

Layout of the site:

Specifically gullies, swales, or other drainage features of the landscape that often have moist soils.

Existing vegetation onsite or nearby:

- Native, existing vegetation can be a guide.
- Investigate for any invasive species.
- Understand if control of undesirable vegetation will be needed either before or after restoration. Refer to Chapter 4 for methods.
- A website is available to help identify invasive plants and offer native plant replacements:
www.ncsu.edu/goingnative

1.3 - Soils Information

After making an on-site examination, additional information may be available in a soil survey.

These surveys often include or describe:

- Soil type and composition.
- Expected average soil productivity.
- Drainage capability.
- Historical aerial photos.
- Recommended forest tree species.

Soil Survey books are no longer printed, but some copies can still be found. Soils information can also be obtained from the Internet at:

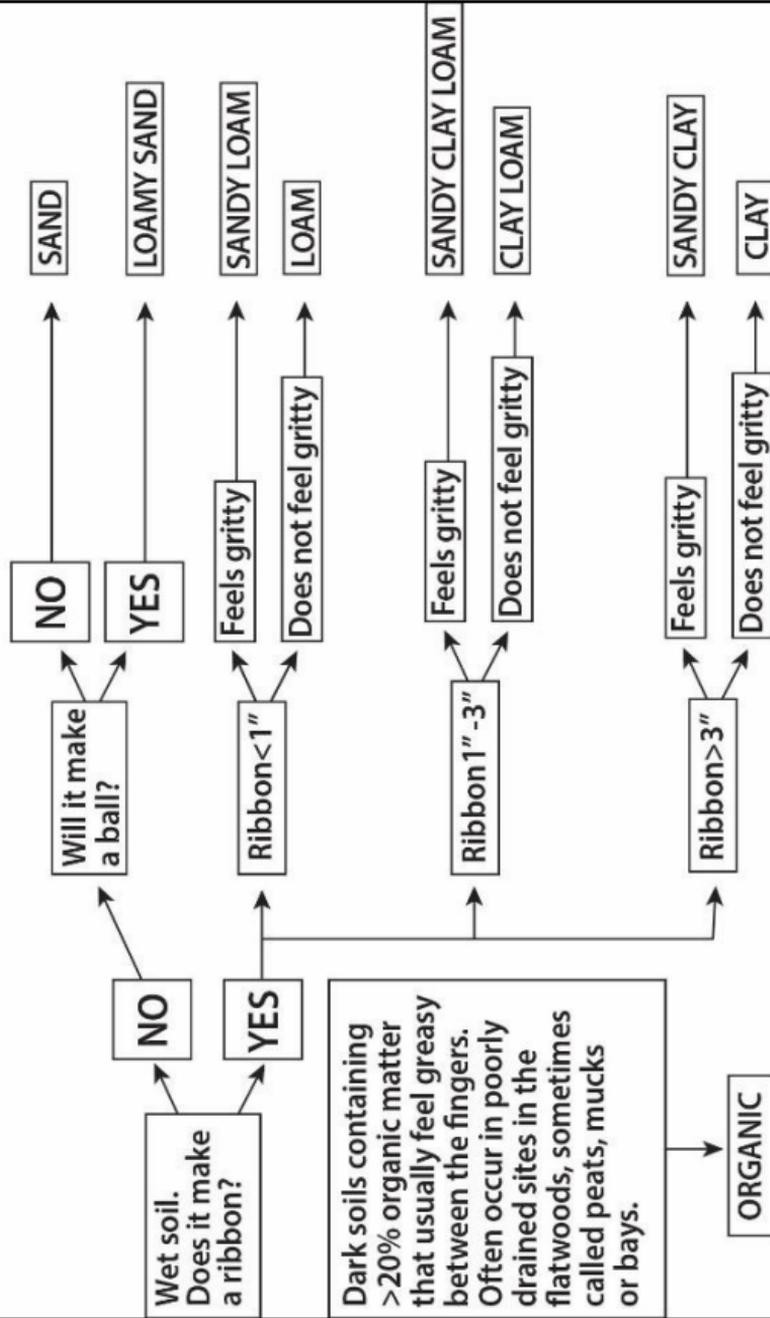
<http://websoilsurvey.nrcs.usda.gov>

1.3.1 - Soil Identification

Use the flow chart on the following page to help determine the category of soil on a site, according to how the soil feels.

- Clay soils generally drain very poorly, yet when soil is dry, become very hardened.
- Loam soils are often found in floodplain and riparian zones and drain well.
- Sandy soils drain well, but often do not retain enough moisture and can easily dry out.

Soil Texture



1.3.2 - Soil Nutrients and Amendments

The primary nutrients are nitrogen (N), phosphorus (P) and potassium (K). Fertilizer amendments sold at stores usually contain some combination of these three primary nutrients.

Forest tree seedlings generally perform well under a broad range of soil nutrient conditions. However, on very wet sites with prolonged saturated soil, the amount of available phosphorous (P) can be limited, which may stunt tree growth significantly. Other minor constituent nutrients may play a factor in tree growth, especially on sites where mining occurred or where there is runoff from mined lands. A soil analysis test is vital for projects that are conducted in a unique soil, or are outside of the 'norm.'

On soils/sites that were used for grazing or agriculture, there is often an abundance of residual nutrients within the topsoil, so amendments may not be needed. Limiting soil layers (hardpans) often exist on pasture and croplands. This hardpan may need to be tilled for tree growth

If this topsoil is removed during restoration, you can expect an accompanying loss in residual nutrients.

1.3.3 - Soil Testing

In addition to the information found in a soil survey, a soil analysis test will describe the specific soil nutrition characteristics found on a site. If there is concern over the productivity of the soil, the acidity of the soil, or what nutrients (amendments) may be limiting vegetation growth, a soil sample can assist. You can obtain the soil sampling package kit at a N.C. Soil & Water Conservation District office, www.ncagr.gov/swc, or N.C. Cooperative Extension Service office www.ces.ncsu.edu/.

1.3.3 - Soil Acidity (pH)

The level of acidity is measured by pH, with the scale ranging from 0 to 7 for acidic, and 7 to 14 for basic. Generally, North Carolina's soils are somewhat acidic. Growth and survival, especially for hardwood tree species, is strongly affected by pH, so take the time to match the species mix to the site. The following table outlines pH ranges for commonly planted wetland tree species.

Table 1A: Soil pH range of select tree species

Common Name	Scientific Name	pH Range
Alder, tag	<i>Alnus serrulata</i>	4.0 - 7.0
Ash, green	<i>Fraxinus pennsylvanica</i>	3.6 - 7.5
Baldcypress	<i>Taxodium distichum</i>	4.6 - 7.5
Birch, river	<i>Betula nigra</i>	4.5 - 6.0
Blackgum, swamp	<i>Nyssa biflora</i>	4.6 - 7.0
Cedar, Atlantic White	<i>Chamaecyparis thyoides</i>	3.5 - 5.5
Cottonwood, swamp	<i>Populus heterophylla</i>	3.6 - 7.5
Elm	<i>Ulmus</i> spp.	5.2 - 8.0
Hickory, water	<i>Carya aquatica</i>	4.5 - 5.5
Maple, red	<i>Acer rubrum</i>	4.4 - 7.5
Oak, cherrybark	<i>Quercus pagodafolia</i>	4.5 - 6.2
Oak, laurel	<i>Quercus laurifolia</i>	3.6 - 5.6
Oak, overcup	<i>Quercus lyrata</i>	3.6 - 5.5
Oak, pin	<i>Quercus palustris</i>	6.0 - 7.0
Oak, Shumard	<i>Quercus shumardii</i>	4.4 - 6.2
Oak, swp. chestnut	<i>Quercus michauxii</i>	3.6 - 6.2
Oak, water	<i>Quercus nigra</i>	3.6 - 6.3
Oak, willow	<i>Quercus phellos</i>	3.6 - 6.3
Persimmon	<i>Diospyros virginiana</i>	4.4 - 7.0
Pine, loblolly	<i>Pinus taeda</i>	4.5 - 6.0
Pine, longleaf	<i>Pinus palustris</i>	4.5 - 6.0
Pine, pond	<i>Pinus serotina</i>	4.1 - 6.0
Sugarberry	<i>Celtis laevigata</i>	5.0 - 7.5
Sweetbay	<i>Magnolia virginiana</i>	4.0 - 5.0
Sweetgum	<i>Liquidambar styraciflua</i>	3.6 - 7.5
Sycamore, American	<i>Platanus occidentalis</i>	4.4 - 7.5
Tupelo, water	<i>Nyssa aquatica</i>	3.6 - 5.6
Willow, black	<i>Salix nigra</i>	4.6 - 7.5
Yellow-poplar	<i>Liriodendron tulipifera</i>	4.5 - 7.0

2: Bottomland & Riparian Forest Types

Knowing which species to plant is not only based upon the soil/site factors, but can be linked to the ecological history of that site. You can often narrow your choice of species options by observing what forest trees would, or should have, been growing in that area by observing a reference forest area.

Be aware that due to landscape hydrology alterations (dams, berms, levees, ditches), or centuries of intensive land use (grazing, agriculture, or mining), poor forestry practices, and disease or insects, the species found today may not accurately represent the site's greatest potential for species diversity and growth performance.

North Carolina is fortunate to have a comprehensive reference guide describing its major eco-regions, including vegetation. This reference is the *Guide to the Natural Communities of North Carolina, Fourth Approximation (2012)*, produced by the N.C. Natural Heritage Program. This guide is available at www.ncnhp.org. As a quick-reference, the following table and sections describe some of the more frequently observed bottomland forest sites in North Carolina.

2.1 - Bottomland Hardwood Forest Site Types

For each forest site type, the following quick reference indicators are listed below its name:

- Typical hydrologic regime.
- Typical Forest Tree Indicator Species.

Muck ('Deep') Swamp

- Flooded 10 to 12 months.**
- Bald / Pond Cypress; Water / Swamp Tupelo.**

Very poorly drained, usually has standing water. Found on broad areas between tidewater and upstream runs, along black rivers and branch bottoms. Predominant trees: Cypress, Tupelo, some Green and Pumpkin Ash; Elm; Hackberry; Sweetgum.

Red River Bottom

- Flooded in Winter and Spring.**
- Sycamore; Sweetgum; Cherrybark Oak.**

Floodplains of a major river system with headwaters originating in the Piedmont or Mountains. Oxbows and sloughs often found. If large enough, with enough accumulated organic matter, can be typed as Muck Swamp. On the outer reaches are the First and Second Bottoms that are successively higher in elevation. First Bottoms flood often and are stocked similar to Muck Swamps but include Water Hickory; Red Maple; Laurel Oak; Water Oak; Willow Oak; Overcup Oak. Second Bottoms are more upland and flooding can be rare. Soils range from clay loams to sandy loams. Species in the Second Bottom include Swamp Chestnut Oak; Cherrybark Oak; White Oak; and Yellow-poplar.

Black River Bottom

--Flooded in Winter and Spring.

--Water Tupelo; Swamp Blackgum.

Floodplain of a major river system with headwaters originating in the Coastal Plain. Very similar in structure to Red River Bottom except on a more compact scale. Black Rivers derive their name from their dark-colored water stained by a high level of dissolved tannins. Trees often include a higher percentage of Cypress; Swamp Blackgum; Red Maple; Water Tupelo; Sweetbay.

Branch Bottom

--Boggy Throughout the Year.

--Swamp Blackgum.

Flat alluvial land along minor drainage systems, subject to minor overflow. Water Oak; Willow Oak; Laurel Oak; Swamp Blackgum; Sweetgum; and Green Ash occupy heavier soils. Lighter soils support Cherrybark Oak; Shumard Oak; Swamp Chestnut Oak; White Oak; Yellow-poplar; and Loblolly pine.

Carolina Bay

--Seasonally to Permanently Flooded Throughout Year.

--Pond Cypress; Pond Pine; Atl.White Cedar; waxy shrubs

Isolated inland depressions characterized by a sandy rim on the southeast perimeter. Bays can be either peat-lined, sand-lined or clay-lined. Most soils are organic. Species are usually Pond pine; Swamp Blackgum; Atlantic White Cedar; Sweetbay; Redbay; Titi; and various waxy-leafed understory shrubs. Along the sandy rim, Longleaf pine and Loblolly pine predominate.

Piedmont Bottomland

--Flooded in Winter.

--Yellow Poplar; Sweetgum.

Identical to Red River Bottoms except that upstream in the Piedmont, first bottoms are not found and are replaced by an expanded and well-drained Second Bottom. Species include American Sycamore; Yellow-poplar; Green Ash; Water Oak; Willow Oak; Loblolly pine and others.

Mountain Cove

--Seasonally High Water Table in Depressions.

--Sugar Maple; Beech; Yellow Poplar; Birch; Basswood.

A mixed mesophytic forest containing a diverse and rich mixture of tree species. Tree species develop best in well-drained, moist, upland sites. The dominant species are Sugar Maple; American Beech; Yellow-poplar; White Basswood; Yellow Buckeye; Northern Red Oak; and White Oak. Minor species that exist in smaller numbers are Sweet Birch; Yellow Birch; Black Cherry; White Ash; Red Maple; Blackgum; Black Walnut; Bitternut Hickory; and Shagbark Hickory.

Terrace Alluvial Site

--Periodically Intermittently Flooded Throughout Year.

--Sycamore, Ash, River Birch.

Floodplain ridges and terraces other than active levees adjacent to river channels in the upper piedmont and lower mountains. These systems may include small areas of frequently flooded land. High natural fertility and available moisture have made them excellent farmland and intact forest sites are rare. Species include Sycamore; River Birch; Green Ash; Red Maple; Elm.

2.2 - Bottomland Conifer Forest Types

Pond Pine

Occurs on soils that range from sandy to heavily organic, with a high water table. Pond pine is usually the overstory pine species in pocosins and Carolina Bays. The species has excellent growth potential on mineral soils that are not continuously saturated, even though it is not usually found on such sites in the wild. It is very tolerant of acidic and infertile conditions. Can be found in pure or mixed stands with other pines or mixed with hardwoods associated with Muck Swamps.

Longleaf Pine

Native to a wide variety of sites ranging from poorly drained wet flatwoods and savannas, to dry sand ridges. It can outperform other southern yellow pines on deep sands that are low in organic matter, infertile and are strongly acidic, as well as on deep clays that have poor internal drainage. It can form pure or mixed pine stands, or can be found with associated hardwoods, depending on the frequency and intensity of fire on the site. Associated hardwoods in wetlands settings include Water Oak, Sweetgum and Persimmon. Understory plants include Titi, gallberry, Sweetbay and blueberry.

Atlantic White Cedar

Atlantic White Cedar grows on wet ground or organic swamps and bogs. The organic layer can range from a few inches to several feet thick. These soils have a pH of 3.5 to 5.5. They usually form pure stands but sometimes other species can be found growing along with it, including Swamp Blackgum, Red Maple and Loblolly Bay. Understory plants include fetterbush and high-bush blueberries.

2.3 - Tree Tolerance to Flooding / Inundation

The following general guide provides information on the general tolerance of common forest tree species to water inundation. You should consider that flood tolerance depends not only on the duration and season, but also the depth of inundation and number of events.

Continuous Inundation

January to May

Green Ash
Water Tupelo
Swamp Tupelo
Red Maple

January to June

Cypress
Overcup Oak
Water Hickory
Water Tupelo
Swamp Tupelo

Periodic Inundation

Jan. to Mar.

Cherrybark Oak
Sw. Chest. Oak
Green Ash
Swamp Tupelo
Red Maple

Jan. to Apr.

Sycamore
Cottonwood
Green Ash
Swamp Tupelo
Red Maple

Jan. to May

Sweetgum
Water Oak
Willow Oak
Green Ash
Swamp Tupelo
Red Maple

Occasional Inundation

May tolerate short duration, dormant-season inundation.

--Yellow Poplar
--Black Walnut

3: Species Mix and Tree Spacing

3.1 - Tree Species Mix

Creating the desired mix of tree species requires control of competing, undesirable vegetation and planning for the natural succession process that determines forest tree species mix. Pioneering tree species thrive on freshly-disturbed soil with ample sunlight. Successional species are more adapted to growing in soil and shade conditions that result several years after initial forest establishment. Most tree species are adapted to grow in either type of shade, given adequate soil conditions and minimal competition.

Table 3A: Shade Needs for Select Tree Species

<u>Pioneering (sun) trees</u>		<u>Succession (shade) trees</u>	
Pine	Ash	Beech	Persimmon
River Birch	Sweetgum	Hemlock	Red Bay
Yellow Poplar	Locust	Witchhazel	Dogwood
Black Cherry	Water Oak	Mulberry	Redbud
Black Willow	Sycamore	Blackgum	Sugarberry
Swamp Chestnut Oak		American Holly	
Bitternut Hickory		Pignut Hickory	

- Establish a suitable mix of tree species.
Avoid establishing 'monocultures' of vegetation.
- Select tree species that will more readily regenerate, for long-term sustainability.

- Consider staggering the time of planting if you wish to re-create a more natural regeneration cycle by first planting pioneering species, then planting other species the following year.

3.2 - Understory Shrub Mix

Understory shrubs and native herbaceous vegetation are often needed to complete a restoration. A wide diversity of plant species may exist within sub-canopy layers.

Reference sources of information:

--*Guide to the Natural Communities of North Carolina, Fourth Approximation*: www.ncnhp.org.

--*Silvics of North America*:

V.1, Conifers: www.fs.usda.gov/treesearch/pubs/1547

V.2, Hardwoods: www.fs.usda.gov/treesearch/pubs/1548

- Use native species.
- Understory species may need shade to grow and flourish. Therefore, a multi-phased planting schedule may be needed, to allow the overstory trees time to produce adequate shade.
- Species may not be readily available from a commercial nursery. Nurseries may need 1 to 3 years to acquire local seed and grow the species needed for your project.

- Consider planting shrubs and herbaceous vegetation in groups or clusters. Doing so will allow these species to become better established and multiply to occupy more of the site in a shorter amount of time.
- Most understory plants are grown in containers varying in size from plugs to pots. A shovel or power auger are often the best tools for planting.

Table 3B: Partial List of Problem Plants in N.C.

<u>Common Name</u>	<u>Scientific Name</u>
Autumn Olive	<i>Eleagnus umbellata</i>
Bamboo	<i>Phyllostachys</i> spp.; <i>Bambusa</i> spp.
Mimosa or Silktree	<i>Albizia julibrissin</i>
Bicolor (Shrubby) Lespedeza	<i>Lespedeza bicolor</i>
Princess Tree, Paulownia	<i>Paulownia tomentosa</i>
Chinese (Sericea) Lespedeza	<i>Lespedeza cuneata</i>
Japanese Honeysuckle	<i>Lonicera japonica</i>
Japanese or Chinese Privet	<i>Ligustrum</i> spp.
Japanese stiltgrass	<i>Microstegium vimineum</i>
Tree-of-heaven	<i>Ailanthus altissima</i>
Wisteria (Chinese/Japanese)	<i>Wisteria sinensis</i> or <i>Wisteria floribunda</i>

Additional Information on Problem Plants:

Native Plants and Identification of Invasives in N.C.:

www.ncsu.edu/goingnative/

USDA-Forest Service: *A Field Guide for Identification of Invasive Plants in Southern Forests*. 2010. GTR-SRS-119.

<https://doi.org/10.2737/SRS-GTR-119>

USDA-Natural Resources Conservation Service:

<http://plants.usda.gov/>

3.3 - Spacing of Seedlings

Several factors determine spacing of seedlings, including the site's productivity potential, the landowner's objectives and the restoration criteria.

Hardwoods exhibit much more variability in spacing based on species, seedling quality, quality of planting, planned maintenance (if any), and desired objectives of the planting.

Seedlings with a larger root-collar-diameter should be favored. Some seedling mortality and wildlife-browse should be expected when selecting species and spacing. Understory (shrubby) tree species are often planted at much higher density. Once the planting objectives have been known, the following chart may be used to determine the planting spacing.

Cluster Group Planting:

To mimic natural growth patterns, consider planting trees and shrubs in multiple groups of 5 to 10 seedlings, instead of spacing each tree exactly the same distance apart from each other. Establish clusters in depressions.

Streamside Edge Planting:

In most stream restoration projects, your priority should be to establish permanent tree or shrub vegetation along the immediate streamside edge, to stabilize the bank and provide shade over the water.

Table 3C: Ranges of Tree Density per Acre

Species	Minimum per Acre	Maximum per Acre
Average for hardwoods	200	400
Average for pines	300	600
Cypress	300	700
Atlantic White Cedar	500	1,000

Table 3D: Number of Trees per Acre by Spacing, on a Grid Pattern Layout

Trees per Acre	Spacing (ft X ft)	Trees per Acre	Spacing (ft X ft)
222	14 X 14	622	7 X 10
300	12 X 12	681	8 X 8
363	10 X 12	726	6 X 10
403	9 X 12	807	6 X 9
436	10 X 10	908	6 X 8
519	7 X 12	1,037	6 X 7
544	8 X 10	1,089	5X8 or 4X10
605	8X9 or 6X12	1,210	4X9 or 6X6

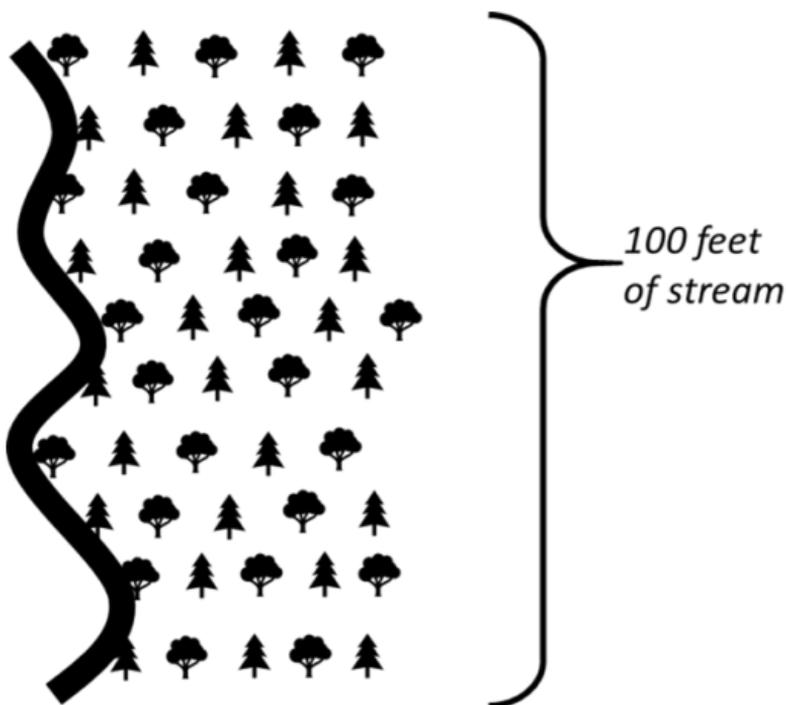
Reminder: 1 acre = 43,560 square feet.

Table 3E: Approximate Number of Trees Needed for Planting One Side of a 100-Foot Long Stream Buffer

Spacing*	30ft Buffer	40ft Buffer	50ft Buffer
4 X 4	234	286	364
6 X 6	108	144	162
8 X 8	70	84	112
10 X 10	44	55	66

* This assumes the first tree is planted at the streambank edge, and the buffer measurement starts there; And, that the 100-foot distance starts at the first perpendicular row of trees. See illustration below.

Remember: *If you are planting both sides of the stream, then you will need (x)2 number of seedlings!*



3.4: Seedling Survival

Survival is influenced by seedling quality; the quality of the planting job; availability of site and soil resources; and damaging agents. Plan for natural mortality by planting seedlings at a slightly denser spacing than the desired final amount, but no more than 100 trees/acre greater than the desired final amount.

4: Vegetation & Weed Control

Control competing vegetation and invasive plants before and after the planting to improve seedling survival and growth.

Methods to control vegetation include chemical herbicide treatment; and/or mechanical treatment with machinery or soil-disturbing tools.

4.1 - Control Before Planting

Seedling survival and growth are usually most enhanced, often at the lowest cost, when controlling vegetation before planting. This is because:

- You often have more choices of treatments.
- Herbicides can be more effective and efficient, because a broader spectrum of plants can be treated at one time.
- Herbicide applications are not hindered by the height of established seedlings.

- Mechanical control can be more complete since desirable seedlings are not in the way.
- Work is usually not as labor intensive as controlling afterwards, and is less expensive.

4.2 - Control After Planting

Controlling vegetation after planting can still be effective, but requires extra precautions to minimize damage on the desired plants. Controlling vegetation after planting may be needed when:

- Undesirable vegetation (trees, vines, grasses) invades the site or overtop the tree seedlings.
- Seedling survival is jeopardized from competition by undesirable plants.

Some options to consider at the time of planting:

- Installing tree tubes or tree shelters around seedlings can block browse access by deer and rodents. Refer to Chapter 9 to learn more.
- The use of ‘tree mats’ around individual seedlings will help reduce the amount of competing vegetation. These mats give control for the first few years before bio-degrading.

4.3 - Maintenance After Planting

Monitoring and maintaining the site after planting is crucial to promote long-term vegetation growth.

Animals and unwanted competing vegetation can impact seedling survival and early growth.

- Control undesirable vegetation before planting, soon after planting if needed, and four to five years after planting, or until the desired species attains an average height of 5 to 6 feet.
- Methods to maintain or control vegetation:
Manual: Axes, machetes, brush hooks, chainsaws and other hand-tools.

Mechanical: Mowers, bush-hog, weed-trimmer/brush saw, disking. If a tractor is used, seedlings should be planted wide enough apart and clearly marked (flagged) so the tractor can operate without damaging the desirable plants. Tractor work should be done when soil is dry and in the first growing season for best effect.

Chemical: Use a herbicide that is labeled to apply over water. Also, use herbicide that will selectively target the undesirable vegetation while not harming desirable plants. Application can be done manually with a backpack sprayer or by tractor-mounted spray-rigs. Seek a licensed pesticide applicator for assistance and application.

5: Construction & Equipment Management

Restoration work often requires a significant re-contouring of the land, including alteration of the stream channel and adjoining floodplain areas. This work often includes soil excavation and movement. To promote rapid recovery of vegetation on the disturbed site, these practices are encouraged:

- Use adequate erosion & sedimentation control measures, “Best Management Practices” (BMPs).
- Remove nutrient-laden topsoil and leafy organic matter (“duff”) from areas that are to be excavated and stage this material for re-application later.
- Keep vehicle and heavy equipment traffic within designated traffic pathways. Avoid unnecessary passes of equipment or vehicles.
- Avoid crossing the stream. If a crossing is needed, use portable temporary bridgemats.
- Do not operate on the site during wet soil conditions. Avoid rutting, compacting or other alterations to the soil structure.
- After restoration work, but before site prep, re-apply and incorporate the salvaged topsoil and organic matter to disturbed soil areas.

6: Soil & Site Preparation

Site prep creates suitable growing conditions for regeneration, either for seeds or seedlings. Site prep can mitigate soil compaction; enhance soil drainage to avoid excessive ponding; and reduce undesirable or competing vegetation. Areas on a restoration site that warrant special attention for site prep include:

- Streamside equipment traffic pathways.
- Crossings through the stream corridor.
- Soils with crusty, hardened surfaces.
- Areas where topsoil was removed.
- Invasive, nuisance or undesirable plants.

NOTE: When doing site prep work, install appropriate erosion & sedimentation control Best Management Practices (BMPs) to keep sediment out of nearby bodies of water.

Common site prep practices include disking; bedding; ripping/subsoiling; furrowing; and scalping.

Consult with a forestry specialist to learn more about applying these practices. Each site prep practice is explained in detail within the N.C. Forestry BMP Manual and multiple *Forestry Leaflets*, available from the N.C. Forest Service at, www.ncforestservice.gov.

7: Seedling Quality, Storage & Handling

7.1 - Chilling Hours for Dormancy

The term “Chilling Hours” refers to the number of hours that seedlings are exposed to temperatures between 32°F and 46°F. Chilling hours are recorded and can be obtained from the nursery.

NOTE: You should never store or “freeze” seedlings below 32°F. This will kill the seedlings.

7.1.1 - Dormant Bareroot Seedlings

Most planting of bareroot seedlings is done with dormant seedlings. Once bareroot seedlings receive more than 400 chilling hours, they are considered dormant and can be packaged for extended cooler storage.

7.1.2 - Non-Dormant Bareroot Seedlings

Storage time for non-dormant seedlings is limited. In cases where early planting of non-dormant seedlings is required, seedlings should be stored in a refrigerated cooler with temperatures set no higher than 50°F. Planting non-dormant seedlings is often called “hot planting.”

NOTE: Do not plant non-dormant seedlings on “Severe Days.” (See Chapter 8.)

Storage Time of Non-Dormant Seedlings

<u>Chilling Hours</u>	<u>Max. Storage Time</u>
0 - 200	24-hr refrigeration.
200 - 350	2 weeks refrigeration.
350 - 400	3 weeks refrigeration.

7.1.3 - Containerized Seedlings

These seedlings are grown in a soil-like media. This media is planted along with the seedling. By planting an intact “plug”, the root system is not disturbed, enhancing survival and growth. Though the size of the containers vary, some common sizes are 6 to 10 cubic-inch plugs for conifers and 16 cubic-inch plugs up to 1-gallon or larger pots for hardwoods.

Planting of containerized seedlings allows the expansion of the planting window outside the normal time frames since seedling dormancy is not a limiting factor.

Weather conditions have few detrimental effects on containerized seedlings as long as the site’s soil is moist at the time of planting and drought conditions do not prevail after the planting operation.

NOTE: Containerized seedlings should have a balanced root:stem ratio, good root development, and a moist soil-media plug that remains intact when removed from its tray.

7.2 - Seedling Size

Two important measurements are used to evaluate and grade the size (and associated quality) of forest tree seedlings:

RCD: Root Collar Diameter

This is the diameter of the seedling's main stem measured at the root collar, expressed in fractions of an inch. *A larger RCD is better.*

FOLR: First-Order Lateral Roots

This is the number of large 'first order' lateral (side) roots branching off from the taproot. Typically, a FOLR is at least 1mm diameter. *A higher number of FOLR is better.*

7.2.1 - Hardwoods and Baldcypress

Bareroot Seedlings

- Preferred RCD is 3/8-inch.
- Avoid seedlings smaller than 1/4-inch RCD.
- There should be from 2 to 6 FOLR, depending on species (see Table 6.2.1A).

Containerized Seedlings

- Minimum size generally 1/4-inch RCD.
- Limited research has been done on the preferred RCD of containerized hardwood seedlings.
- Ample root development and a good balance between root and stem may be more important.

Table 7A: Range of Acceptable Hardwood and Cypress Seedling Sizes

Species	Preferred RCD (inch)	Preferred FOLR (#)	Minimum RCD (inch)
N.Red Oak	3/8 to 1/2	4 to 6	1/4 to 3/8
White Oak	3/8	2 to 4	1/4 to 3/8
Sw.Chestnut Oak	3/8 to 1/2	2 to 4	1/4 to 3/8
Cherrybark Oak	3/8 to 1/2	2 to 4	1/4 to 3/8
Laurel Oak	3/8	2 to 4	1/4 to 3/8
Water Oak	3/8	2 to 4	1/4 to 3/8
Willow Oak	3/8	2 to 4	1/4 to 3/8
Green Ash	3/8 to 1/2	2 to 4	1/4 to 3/8
Sycamore	3/8 to 1/2	4 to 6	1/4 to 3/8
Sweetgum	3/8 to 1/2	4 to 6	1/4 to 3/8
Yellow poplar	3/8 to 1/2	4 to 6	1/4 to 3/8
Black Walnut	3/8 to 1/2	4 to 6	1/4 to 3/8
Water Tupelo	3/8	2 to 4	1/4
Swp. Blackgum	3/8	2 to 4	1/4
Overcup Oak	3/8	2 to 4	1/4 to 3/8
Shumard Oak	3/8 to 1/2	2 to 4	1/4 to 3/8
Red Maple	1/4 to 3/8	4 to 6	1/4
Baldcypress	3/8	2 to 4	1/4 to 3/8

Refer to the sizing guide in the back of this booklet.

7.2.2 - Conifers

7.2.2.1 - Atlantic White Cedar

Containerized Seedlings

- Minimum RCD of 1/8-inch.
- Minimum stem height of 6 inches.

7.2.2.2 - Pond Pine and Loblolly Pine

Bareroot Seedlings

- Minimum RCD of 3/16-inch.
- Minimum stem height of 10 to 12 inches. If larger, the seedling should have a root-to-stem ratio not to exceed 1:2.5 (root:stem).
- Minimum taproot length of 4.5 inches.
- Fibrous lateral roots with abundant mycorrhizae.

Containerized Seedlings

- Minimum RCD of 1/8-inch.
- Minimum stem height of 8 inches.

7.2.2.3 - Longleaf Pine

Bareroot Seedlings

- Minimum RCD of 4/10-inch (.40 inches).
- Minimum taproot length of 6 inches.
- At least 5 FOLR.

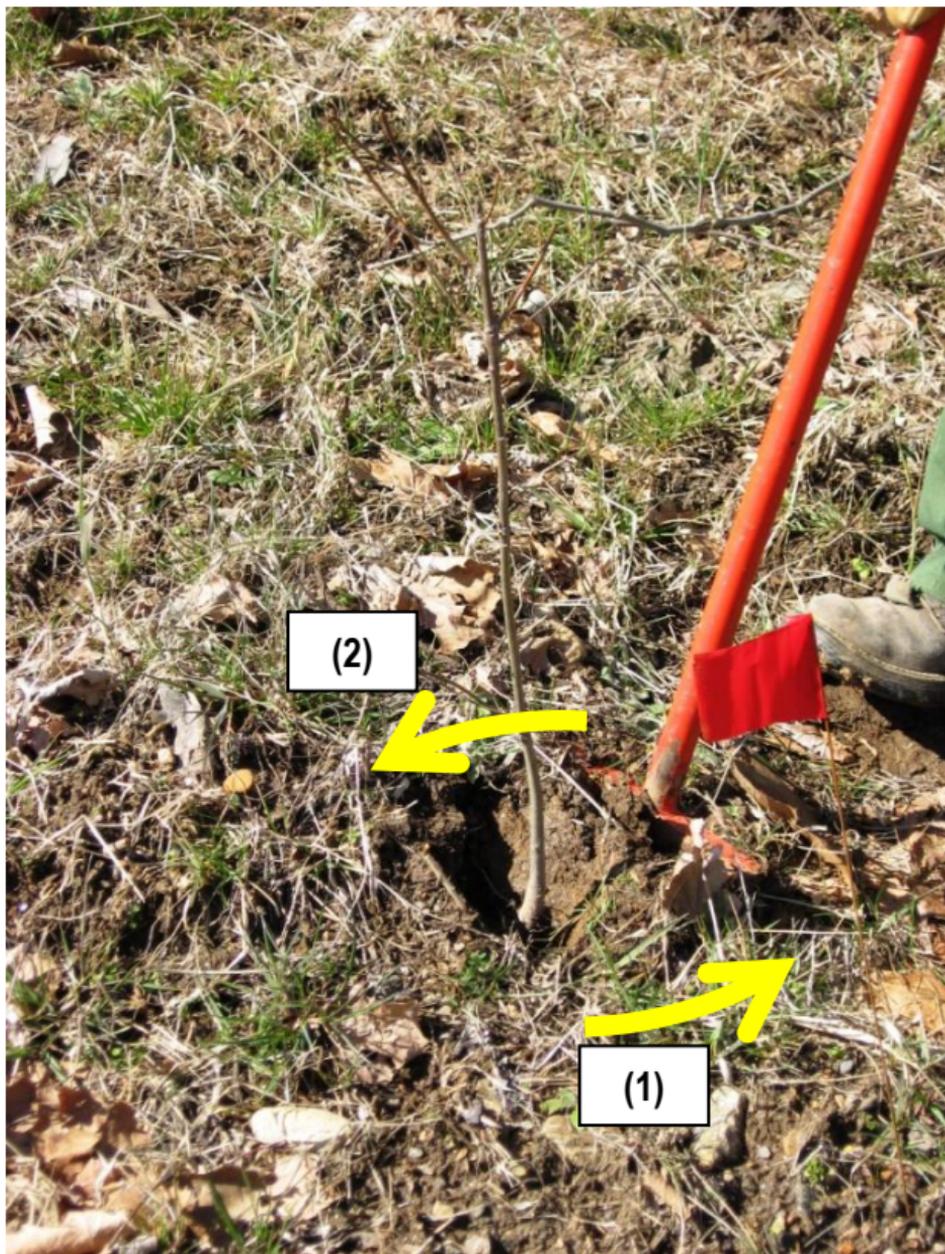
Containerized Seedlings

- Minimum RCD of 2/10-inch (.20 inches).
- Minimum needle length of 6 inches.



Planting Seedlings with Dibble Bar:

A planting hole created with a dibble bar. Dibble bars are suited for conifers and small hardwoods.



(1) Insert the bar behind the seedling, then pull back to close the bottom of the hole. (2) Re-insert the bar, push forward to close the top of hole.



Pack the soil with your foot after closing off the hole.



Live Stakes:

Drive a metal rod into the soil to create a hole suitable for installing a live stake.



Gently drive the live stake into the hole created by the metal rod. Note rubber-headed mallet.



Live stake installed. Snip-off the tip of the live stake once installed to remove damage from hammering. Leave 4 to 5 inches of the stake exposed.



*Live stakes with new sprouts,
about 2 months after installation.*



Transplanting / Salvage Planting:
A salvaged alder about 1 month after installation.



Same transplanted alder with 2 years of growth.



*Juncus shown soon after transplanting
along a recently restored stream.
Also note the small clumps of
Juncus transplanted on the opposite bank.*



Tree tube shelters installed on a restoration site.



A tree shelter that was installed around a seedling when planted. Shown after 2 growing seasons.

7.3 - Seedling Quality & Condition

Seedlings should be carefully inspected at the time of pickup/delivery and again immediately before planting to determine their condition.

Indicators of seedling deterioration:

NOTE: If any of these conditions are found, contact the source nursery before planting.

- × Sour smell or fermentation.
- × Brittle or “brashy” stems.
- × Yellow needles on conifers.
- × Black leaves firmly attached on hardwoods.
- × Trees warm to the touch.
- × Mold developing.

Indicators of dead seedlings:

NOTE: Do not plant if these conditions exist.

- × Bark slips off easily, especially on roots.
- × Cambium layer has turned brown.
- × Mold present on most of seedlings.
- × Trees too hot to touch.
- × Seedling roots are powder dry.

7.4 - Seedling Transport

- Leave seedlings in the box or bag supplied by the nursery. Use a light-colored cover to shade and protect seedlings while in transport.
- Allow for at least 12 inches of air space between the top of the bags/boxes and the shade cover so as to avoid heat build-up.
- Repair torn bags or boxes immediately by sealing the torn / ripped spot with tape.
- Do not leave vehicle in direct sunlight. If exposed to sunlight for more than 45 minutes, determine seedling condition before planting.
- If heat build-up is of concern during transport, immediately unload the seedlings upon arrival.

- Avoid stacking bags/boxes to the point of crushing. Install spacers between bags/boxes to allow air circulation .
 - On *Satisfactory* Days, stack up to 3 deep.
 - On *Marginal* Days, stack up to 2 deep.

- For transport in non-refrigerated vehicles:
 - Do not exceed 1 hour on *Marginal* Days.
 - Do not attempt on *Severe* Days over 85°F.
 - Protect from freezing when air temperatures are 32°F or below.

7.5 - Seedling Storage: Inside Structure

Once obtained from the nursery, store seedlings in a climate-controlled building, a shed, a basement, or other structure that will protect seedlings from freezing, heating and direct sunlight.

Ideal storage temperature range: 35°F to 38°F.

- Usually maintained only with refrigeration.
- Bags/boxes/bundles should be stacked on pallets no more than two deep unless spacers are used to allow air circulation between layers.
- Sealed bags stored under ideal conditions can be kept at least 3 months (sometimes longer).
- Bareroot Longleaf pine should be planted *within 2 days* of pickup from the nursery and stored for as little time as possible (*less than 10 days*).
- If hardwood seedlings are packaged with exposed leaves, inspect seedlings frequently and add water to keep seedlings moist.

If storage temperatures are 38°F to 50°F:

- Typical example is a crawlspace or basement.
- Sealed bags may be stored up to *3 or 4 weeks*.

If storage temperatures are 50°F to 75°F:

- Remove seedlings within *3 to 5 days*.

NOTE: Do not allow seedlings to freeze. Do not store seedlings at 32°F or below. If trees have been frozen less than 36-hours, thaw seedlings slowly and determine condition before planting. If frozen more than 36 hours, do not plant. Containerized seedlings will suffer severe mortality if the root plug temperature drops to 22°F.

7.6 - Seedling Storage: Onsite/Outside

Only unload the quantity of seedlings you will need for that day of planting. Minimize exposure of seedlings to outside weather conditions and keep overall handling of seedlings to a minimum.

- **At all times, keep seedlings shaded from sunlight and sheltered from wind.**
 - If no shade is available at planting site, construct a temporary shelter such as a lean-to made of tarp, canvas or wood with a 1-foot air space between bags/boxes and shelter. A "heat shield" is preferred.
- Repair torn bags/boxes immediately.

- Keep roots visibly moist at all times.
 - If roots begin to dry out, dip them in rooting gel, or kaolin clay slurry or muddy water.
 - However, “sloppy wet” seedlings will mold very quickly at warm temperatures. When using water, lightly shake off excess.

- Keep opened bags closed tightly by folding flap over bag and laying flap-side down or by placing a band or cord firmly around bag.
 - If opened bags of seedlings must be kept for more than 2 days, roots should be dipped and bag tightly closed or heel-in seedlings (See Section 6.6.1).

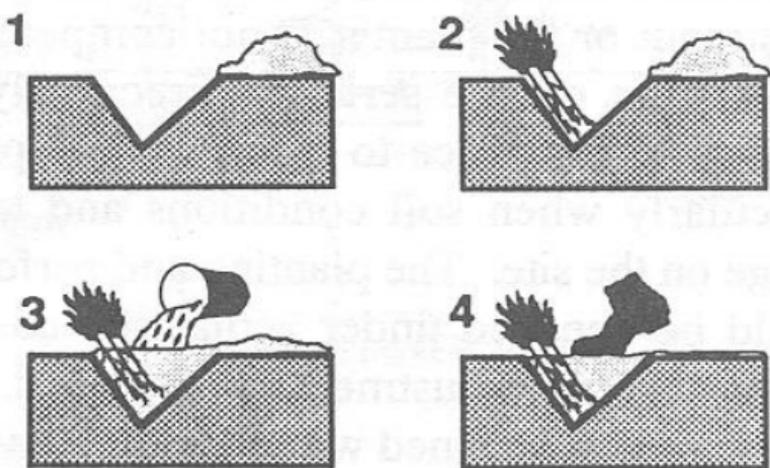
- Bags/bundles should not be stacked in layers more than two-high without spacers. Heat builds up even at low temperatures when seedlings are stored in direct sunlight or without air circulation, especially in sealed bags/boxes.

- Store trays and boxes of containerized seedlings in shade and keep root plugs moist until seedlings are planted.

NOTE: If severe weather conditions exist, seedlings should not be stored at planting site unless sheltered in a building, shed, trailer, etc. that will protect them from weather conditions.

7.6.1 - Seedling Storage: Heeling-In

Heeling-in can provide on-site short-term storage of seedlings. If opened bags of seedlings must be kept for more than 2 days or if a bag is damaged beyond repair, the seedlings can be heeled-in.



1. Dig a V-shaped trench in a **moist shady** place.
2. Spread out the seedlings evenly in the trench.
3. Backfill the trench to completely cover the root system of the seedlings.
4. If possible, water the soil then firm the soil with feet.

8: Tree Planting

8.1 - Classification of Weather Days

Seedlings are living organisms that continue with physiological activity while in the bag/box. Seedlings can build excessive heat in the package even on a cold day if storage temperatures are high or the vehicle is parked in the sun and seedlings are tightly packed, preventing air circulation. Exposure of seedlings to the weather, especially bare root seedlings, can cause rapid deterioration or death.

The North Carolina Forest Service (NCFS) has, for many years, successfully used a system of classifying daily weather conditions to determine the level of care that should be employed by anyone undertaking the handling and planting of seedlings. As conditions exceed Satisfactory to Marginal or even Severe, a greater level of care and shorter exposure times are warranted. An inexpensive weather 'kit' is available to assess on-site weather or you may contact the local NCFS office to obtain the daily classification for tree planting during the winter months.

Table 8A: Classification of Weather Days

Satisfactory Day

Air Temperature:	33°F to 75°F
Relative Humidity:	50% +
Winds	Less than 10 mph
Soil Moisture:	Moist to touch

Marginal Day

Air Temperature:	76°F to 85°F
Relative Humidity:	30% to 50%
Winds	10 to 15 mph
Soil Moisture:	Upper 1-inch dry

Severe Day

Air Temperature:	32°F or below, <i>or</i> 85°F+
Relative Humidity:	30% or less
Winds	15 mph or stronger
Soil Moisture:	Upper 3-inches dry, <i>or</i> ground is frozen

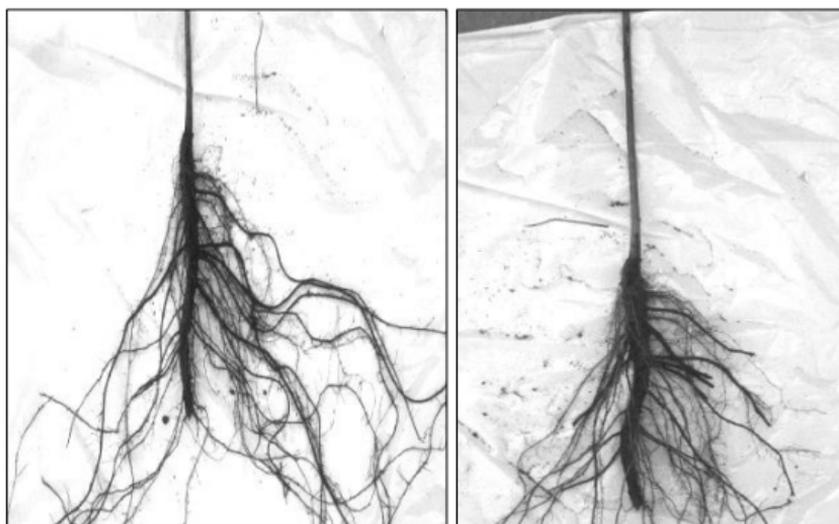
NOTE: Do not plant trees if weather forecast indicates cold temperatures that will freeze the ground for several days following planting.

8.3 - Seedling Culling

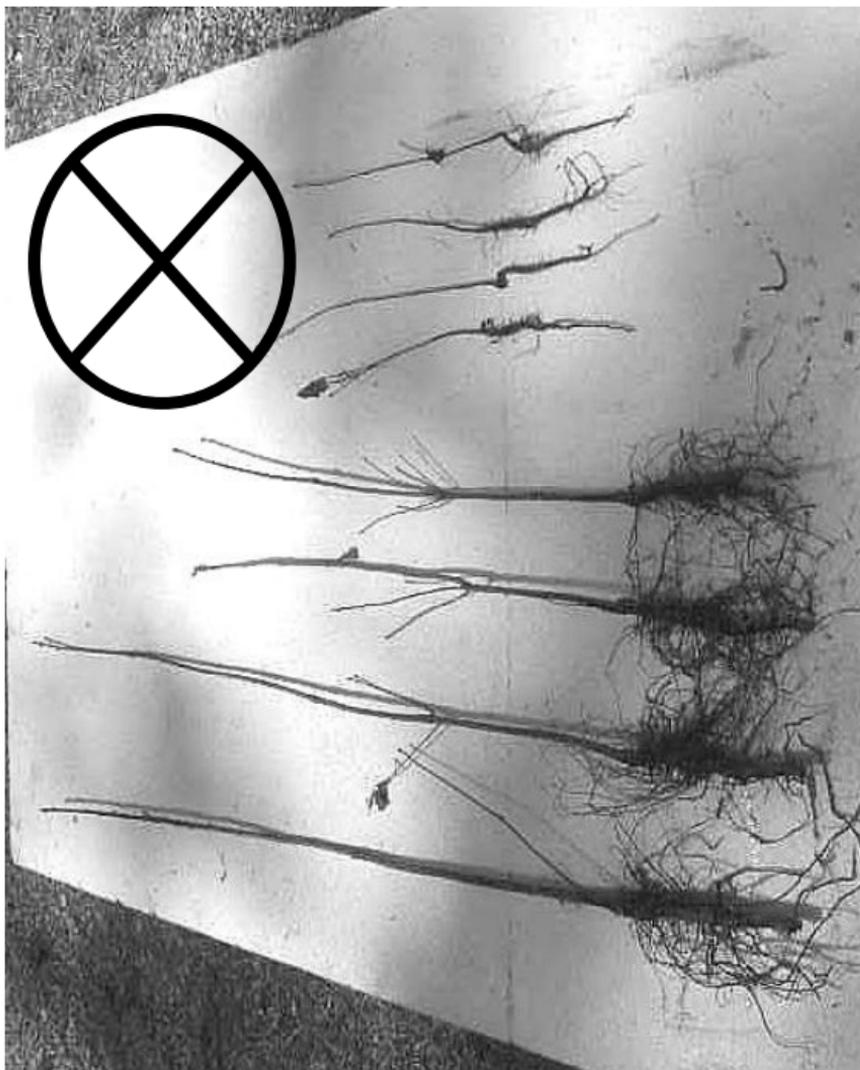
Culling is the process of examining seedlings before planting and discarding ones that are not of satisfactory quality.

- Assign one person to perform all culling to assure consistency and proper handling of seedlings.
- Perform work in a sheltered area away from sunlight and wind.
- Only open one bag/box at a time, do not leave container open for more than a few minutes.
- Only remove a handful of seedlings each time.
- Keep roots visibly moist.
- Avoid damaging, tearing, scraping or pulling of roots and tissue when separating seedlings.
- Discard seedlings that do not meet the size or quality guidelines.

NOTE: If you must prune roots, use very sharp snippers and only prune roots that impede planting.



Left: Un-pruned roots. Right: Properly pruned roots.



**Examples in the variability of hardwood seedlings.
The four seedlings on the right are too small and
should be culled out (discarded).**

8.3.1 - Handling Treated Seedlings

Some conifer seedlings are treated with a chemical spray at the nursery for protection from Pales Weevil and/or browsing by deer.

Safety Precautions

- Wear rubber gloves when handling, culling and planting treated seedlings.
- Do not rub eyes when handling treated seedlings.
- Keep hand washing soap and water at the planting site or any other area where treated seedlings are handled.
- Thoroughly wash hands with soap and water after handling treated seedlings, and prior to eating, drinking, smoking or chewing.

NOTE: The pesticides used to treat seedlings are not highly toxic to humans. However, as when handling any chemical, the above precautions should be followed at all times.

8.4 - Planting Seedlings by Hand

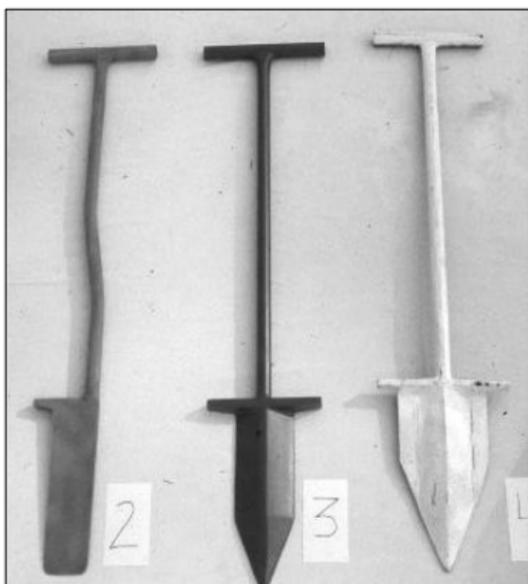
Seek onsite advice and oversight from a qualified professional. Prior to planting, train all planting workers by demonstrating proper techniques using each of the tools. Designate a crew-leader for every 5 to 6 planters for oversight, making quality control checks and to help deliver seedlings to the planters.

Acceptable Planting Tools:

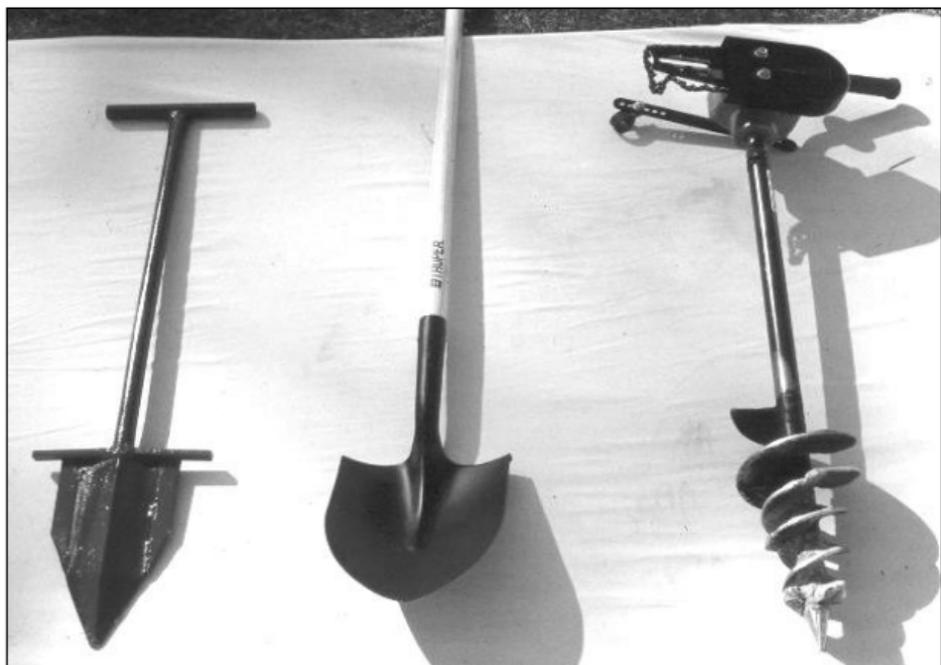
- **Round point shovel, or spade shovel.**
- **Power auger .**
- **KBC or Modified KBC Bar.**
- **Dibble Bar (also called OST Bar).** *Best suited for planting conifer seedlings, not hardwoods.*

Keys to Success:

- ✓ **Limit exposure of seedlings to the elements.**
- ✓ **Dig hole large enough to entirely contain the seedling roots, including lateral (side) roots.**
- ✓ **Do not prune roots or leave lateral roots exposed above the soil.**
- ✓ **Make the hole deep enough to avoid J-root or L-root of the seedling's taproot.**



Planting bars, from left to right: Dibble Bar, 3" wide blade. KBC Bar, 4" wide blade. Modified KBC Bar, 6" wide blade.



*Preferred tools for planting hardwood seedlings:
Modified KBC Bar, shovel, power auger.*

8.4.1 - Hand Planting Recommendations

- Avoid planting in areas of loose soil or large air pockets that cannot be closed against the roots.
- **All planting should STOP on Severe Days.**
- Protect the seedling roots by carrying the seedlings loosely in a canvas bag or bucket. Keep the seedling roots visibly moist.
Do not carry the seedlings in-hand.
- Dig the hole before removing the seedling from the bag. *Only remove one seedling at a time.*
 - Use a shovel or power auger (10 to 14 inch diameter bit) to plant hardwood seedlings that have a large or wide spreading root system.
- Make a fairly straight hole, at least 8 to 10 inches deep, and 3 to 4 inches wide.
- Plant seedling vertical.
Do not exceed 30 degrees from vertical.
- Insert the seedling roots to the bottom of the hole, and then gently lift-up the seedling to set it at the desired depth. *Keep taproot straight.*

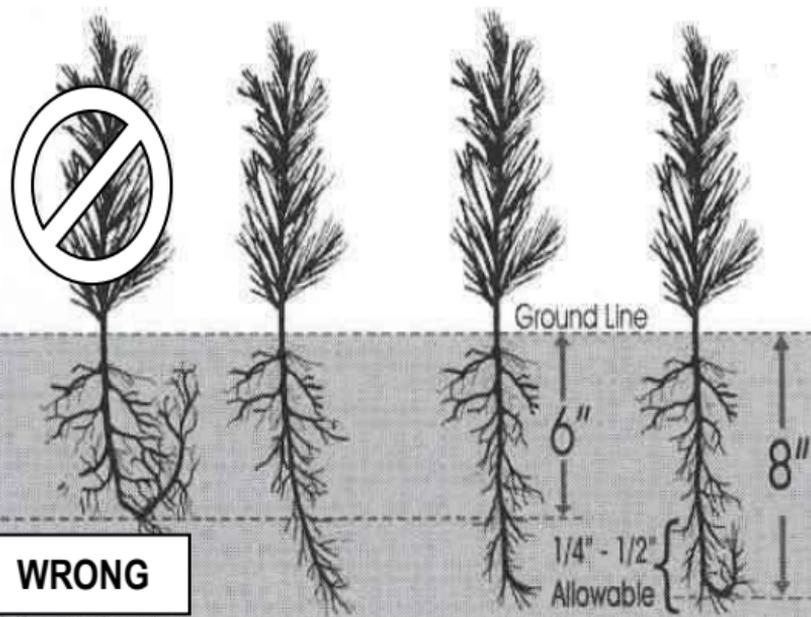
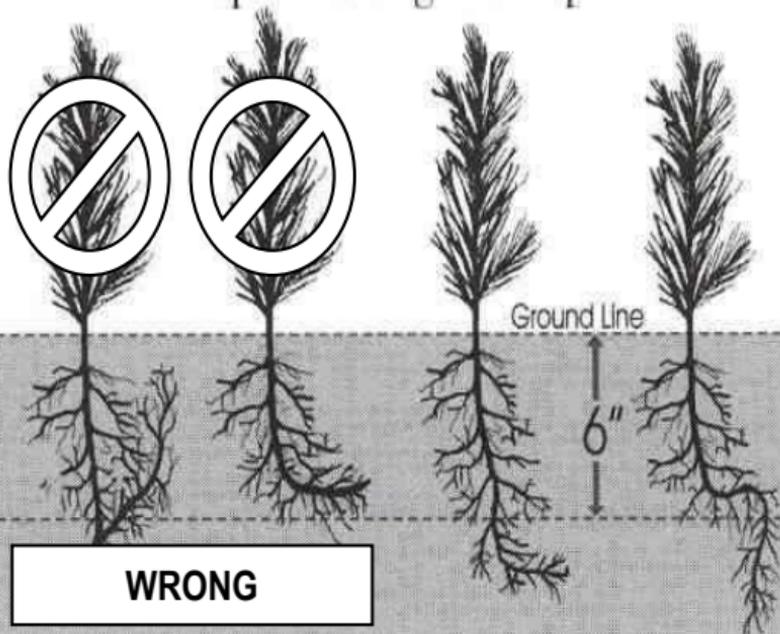
- **Avoid making L-roots within 6-inches of the surface, or that result in any broken or ruptured root tissue.**
- **Avoid making J-roots unless within $\frac{1}{4}$ to $\frac{1}{2}$ inch from bottom of 8-inch-deep hole.**

Adjust planting depth for site or species:

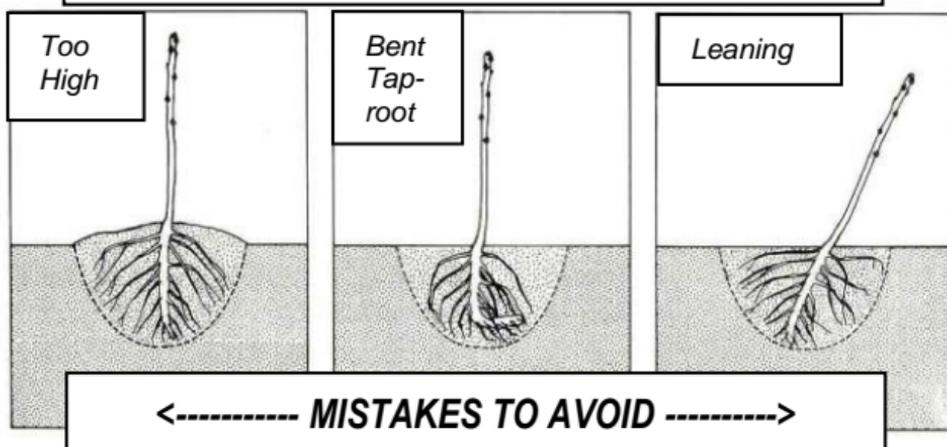
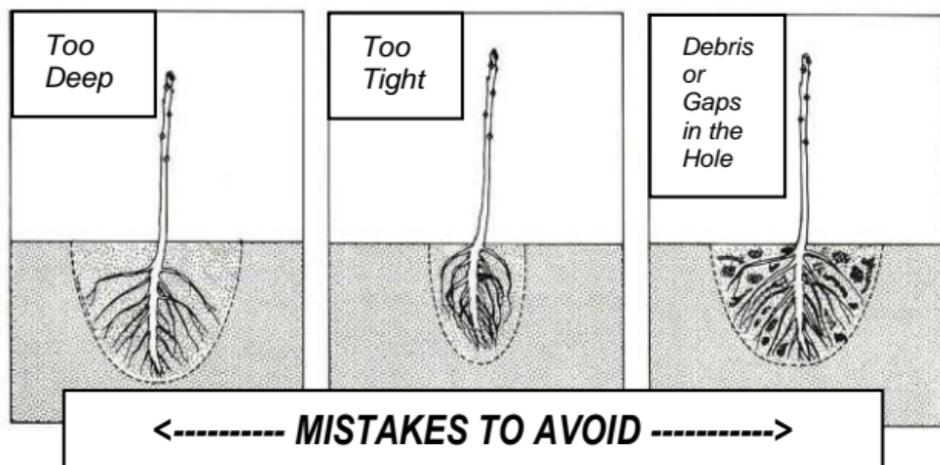
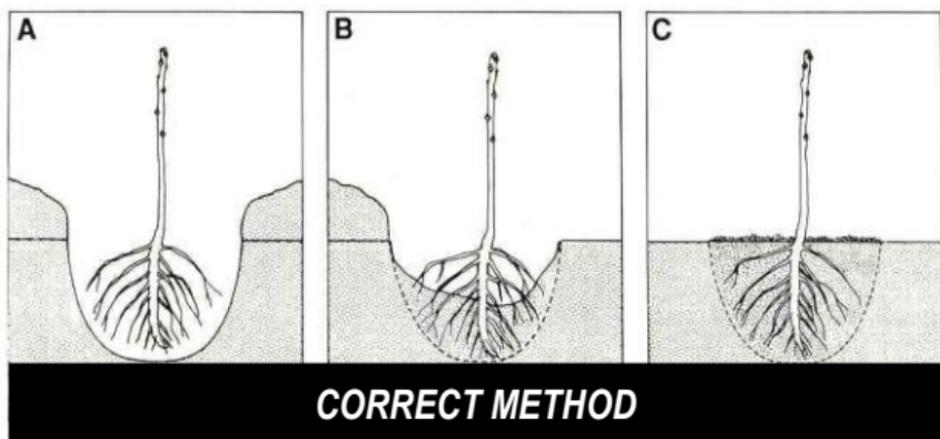
- On well-drained soil: Set the root collar 2 to 3 inches below ground line.
- On poorly drained soil: Set the root collar 1 inch below ground line.
- When planting bareroot Longleaf Pine:
Set the base of the bud at the ground surface, and the root collar just below the soil.
- When planting containerized Longleaf:
Set the root collar at or no higher than 1/4-inch above the soil. ***Do not cover the bud.***
- Close the hole tightly, but do not damage the roots.

Bottomline: Make the hole big enough to fit the roots, do not force them into the hole.

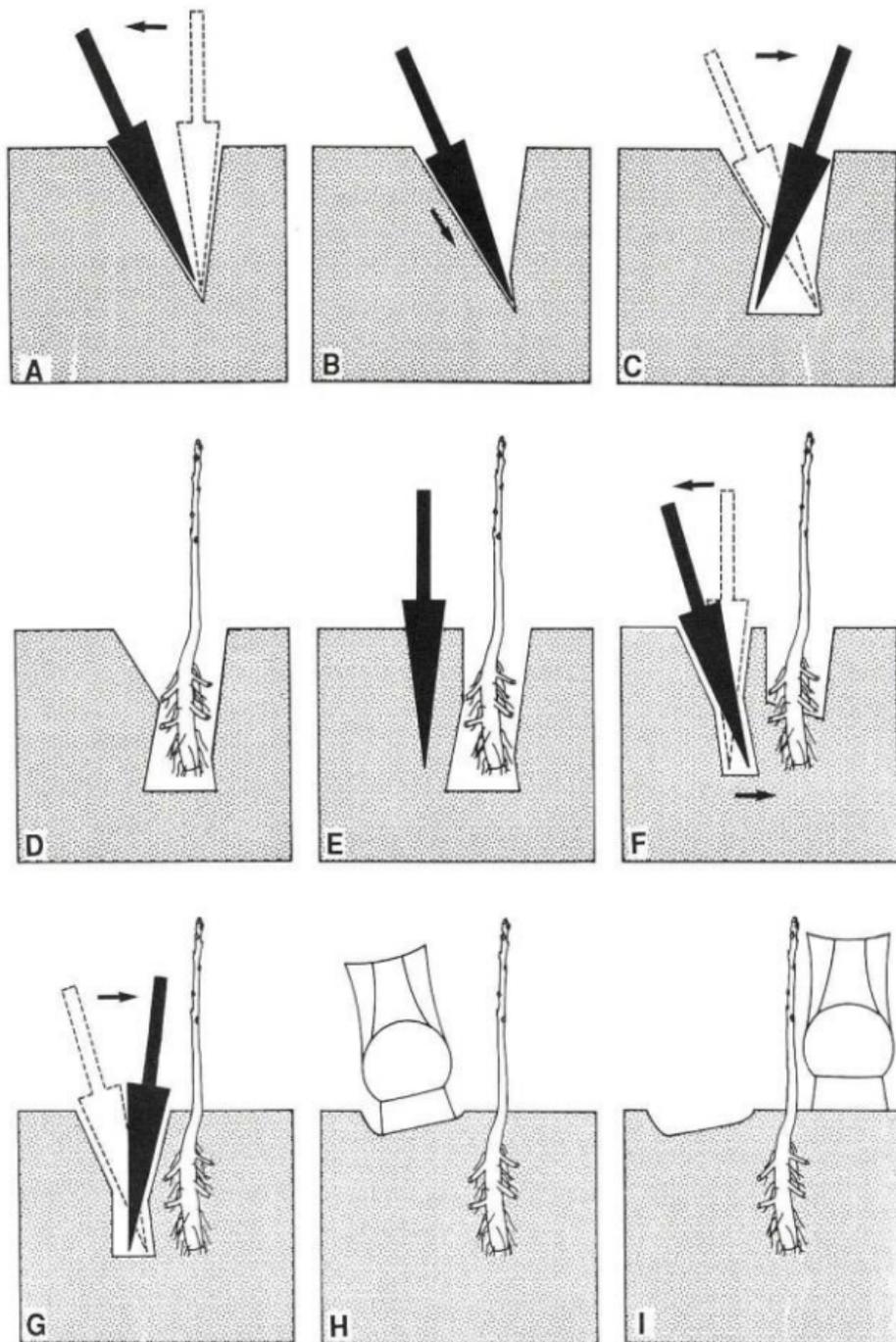
Proper Planting Techniques



8.4.2 - Hand-Planting Hardwood Seedlings with Spreading Root Systems



8.4.3 - Process for Using a Planting Bar



Process for Using a Planting Bar:

- Step A. Insert bar straight down. Pull Backwards.
- Step B. Push down tip of bar into the hole.
- Step C. Push bar forward (away from you), slightly past vertical to widen out the hole.
- Step D. Remove bar. Insert seedling in center of hole.
- Step E. Insert bar straight down about 2 to 3 inches behind the seedling.
- Step F. Pull bar backwards (towards you) to close-off the bottom of the hole.
- Step G. Keeping the bar in the hole, now push the bar forwards (away from you), to close-off the top of the hole.
- Steps H and I. Lightly pack down soil around seedling with boot heel.

9: Tree Shelter Tubes

Protecting seedlings immediately after planting is vital to assure survival and prevent damage from wildlife. Wildlife are naturally drawn to riparian areas. Deer, rabbits, beaver, and other rodents can inflict serious damage and kill seedlings by eating (“browsing”) the leaves, buds, bark, or roots. Many companies sell tree protection tubes, also called tree shelters. They come in different sizes and materials, but generally they are about 3 to 4 feet tall and made of flexible plastic. Install the shelter immediately after the seedling is planted. The shelter will be much easier to install when the seedling is small and dormant (with no leaves on it). In most cases, a wooden stake will be required to support the tree shelter upright.

NOTE: Do not attach the shelter tube directly to the seedling. Do not tie the stake to the seedling.

The tree shelter should remain installed until the tree has grown to about 6 to 7 feet tall (about head-high). This height is generally beyond the reach of most deer, assuring that uppermost leaves and buds will be available for new seasonal growth, even if lower-hanging branches are browsed by the wildlife.

Refer to the photos in this guide to see examples of tree shelters installed on a stream restoration project.

Installing Tree Shelter Tubes

Step 1: Drive a wooden stake into the ground, about 2 or 3 inches next to the planted seedling. Make sure the wooden stake is standing firmly, with no wiggle. Use a 4-foot (or taller) wooden stake.

Step 2: Staple one side edge of the shelter onto the wooden stake. The wooden stake should be ‘inside’ the completed tube shelter.

Step 3: Wrap the shelter around the seedling, and meet the two side edges of the shelter together along the wooden stake. Some shelters have tabs and slots to connect the two edges together.

Step 3A: The bottom of the tree shelter should be snug against the ground, to prevent rodents from burrowing underneath and eating the seedling bark or roots. You may need to partially bury the shelter into the ground.

Step 3B: The top of the tree shelter should extend well above the upper tip of the seedling, to protect the terminal bud from being browsed.

Step 4: Staple the remaining free end of the shelter onto the wooden stake. Do not leave any gaps between the two side edges of the shelter; this could allow wildlife to enter the shelter.

Step 5: Make sure all seedling branches are inside the shelter. Check that branches are not deformed, pushed downward, or broken. Cleanly cut any broken branches down to the next lateral bud.

The finished opening of the tree shelter should be less than 6 inches wide. If it is wider, a deer might be able to reach inside and browse the seedling.

10: Live Staking

The live staking planting method uses dormant, living woody stem cuttings of species that can root quickly from the cutting. Common suitable species include willow (*Salix* spp.), silky dogwood (*Cornus amomum*), viburnums, and elderberry (*Sambucus canadensis*). Live staking is suitable on streambanks of moderate slope (4:1 or less) and in original, loose soil (not compacted fill). It is most effective in pockets or mounds that remain wet.

Step 1: The live stakes should be large enough in diameter and long enough to be driven into the ground as stakes. A good range of size is 0.5 to 2 inches in diameter, and 18 to 36 inches long.

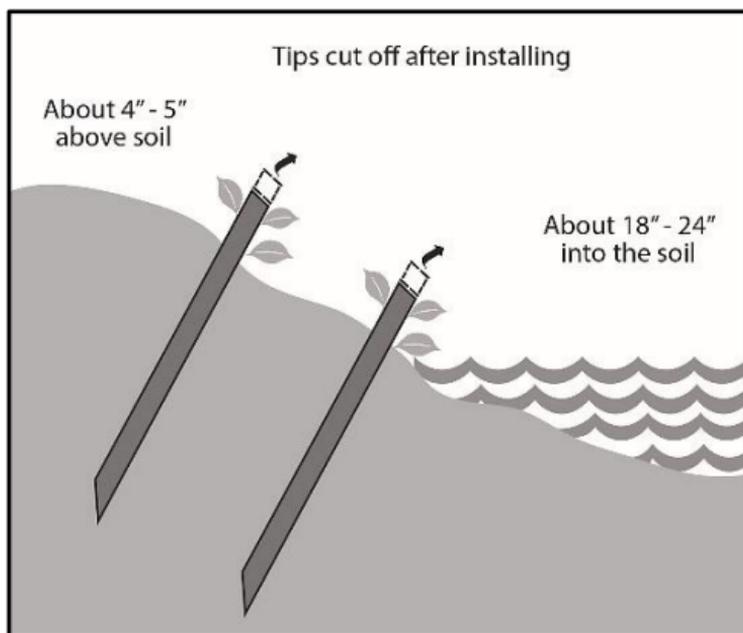
Step 2: Keep live stakes wet. Do not allow to dry out. Cleanly trim off side branches. Do not scrape off the bark. Cut off the top level-across, to make a flat surface

to hammer. Cut off the bottom of the live stake at a 45° angle to help penetrate the soil.

Step 3: Create the staking hole by driving a metal rod into the ground to the desired depth. The hole should be at right-angle to the ground slope. Ideally, the bottom of the hole should reach the seasonal low-water table. Spacing between live stakes should range from 12 to 24 inches apart.

Step 4: Remove the metal rod and insert the live stake. Orient the live stake with leaf buds facing upward. Gently hammer the live stake into the hole. It's best to use a rubber-head mallet. There should be at least two leaf buds exposed above the soil after installation.

Step 5: Gently pack the soil around the live stake, and snip off the uppermost tip of the live stake to remove tissue damaged from hammering. Leave 4 to 5 inches of the live stake sticking out of the ground.



11: Stick Planting

This method is similar to live staking. The main difference is that ‘stick planting’ uses a nursery-grown, bare-root tree seedling instead of a cutting. This method works best in saturated soils, where a planting hole cannot be established.

Demonstration trials of stick planting have shown to be effective in perennially wet, mucky wetland soils typically found in bottomland swamps. Tree species that have been tried and may be considered include:

- Carolina ash (*Fraxinus caroliniana*).
- green ash (*Fraxinus pennsylvanica*);
- water tupelo (*Nyssa aquatica*); and
- bald cypress (*Taxodium distichum*);

Plantings with bald cypress have shown the most success in demonstration trials across the Eastern US. In most studies, installing tree shelter tubes proved important to protect the seedling from wildlife browse damage, especially beaver.

NOTE: Stick planting has not been widely practiced, so you should proceed with caution. Do not rely upon this method as your primary way to establish vegetation. It has shown the most success in permanently saturated soils.

- Use seedlings that have a larger root collar diameter.
- If needed, clip the taproot to be no more than about 9 inches long.
- Cleanly clip off lateral roots. It is acceptable to leave a short stub ($\frac{1}{4}$ -inch or less) of lateral root.
- Insert the main taproot of the seedling straight into the soil, up to the root collar.
- Stick planting seems to work best if the seedling is inserted into soil that is saturated, or nearly saturated, and is likely to remain wet throughout the growing season.
- If planting in flooded areas, be sure that at least 50% of the tree crown (branches and leaves) will remain above water and exposed to sunlight.
- Ideally, insert the seedling in spots next to standing water, or where water level is expected to be at, or slightly below, the root collar of the seedling. For example, do not necessarily insert the seedling in the center of a water-filled depression. Instead, plant the seedling near the water's edge, but in a place that is likely to remain saturated for much of the year.

12: Transplanting (Salvage Planting)

Salvaging and transplanting existing small trees, shrubs and clumping grasses/sedges during the restoration construction is another option for re-vegetating the riparian area. Experience from stream restoration projects hosted by the N.C. Forest Service has shown that transplanting works well for alder, maple, ferns, and *Juncus* species.

Step 1: On woody shrubs, cut the branches before removing the plant. Retain about 3 feet of the main stems exposed off the root collar ball.

Step 2: Excavate the new hole 2 to 3 times the root ball width, down to the same depth as the root ball.

Step 3: Excavate and gently remove the salvaged tree/shrub. Retain ample soil, lateral roots, and root ball when removing the plant.

A good rule of thumb is to have a root ball width, measured in feet, that is the same number as the diameter of the main stem, as measured in inches.

For example, a 2-inch diameter tree stem should have a 2-foot wide root ball removed and transplanted.

When transplanting herbaceous plants, generally a 1-gallon jug size root ball is sufficient.

Step 4: Set the root ball upright in the center of the new hole and completely backfill with topsoil. Do not plant too deeply or too shallow.

Step 5: Gently saturate the backfilled hole with water. Ideally, apply 2 to 3 inches of mulch atop the newly backfilled hole.

Step 6: Irrigate the transplanted root zone frequently and deeply after planting if needed, especially if transplanted during the growing season.

Step 7: Temporary staking of trees may be needed after they are transplanted. When staking, do not constrict the tree's bark with the guy-lines.

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State Headquarters ("Central Office"): 919-857-4801

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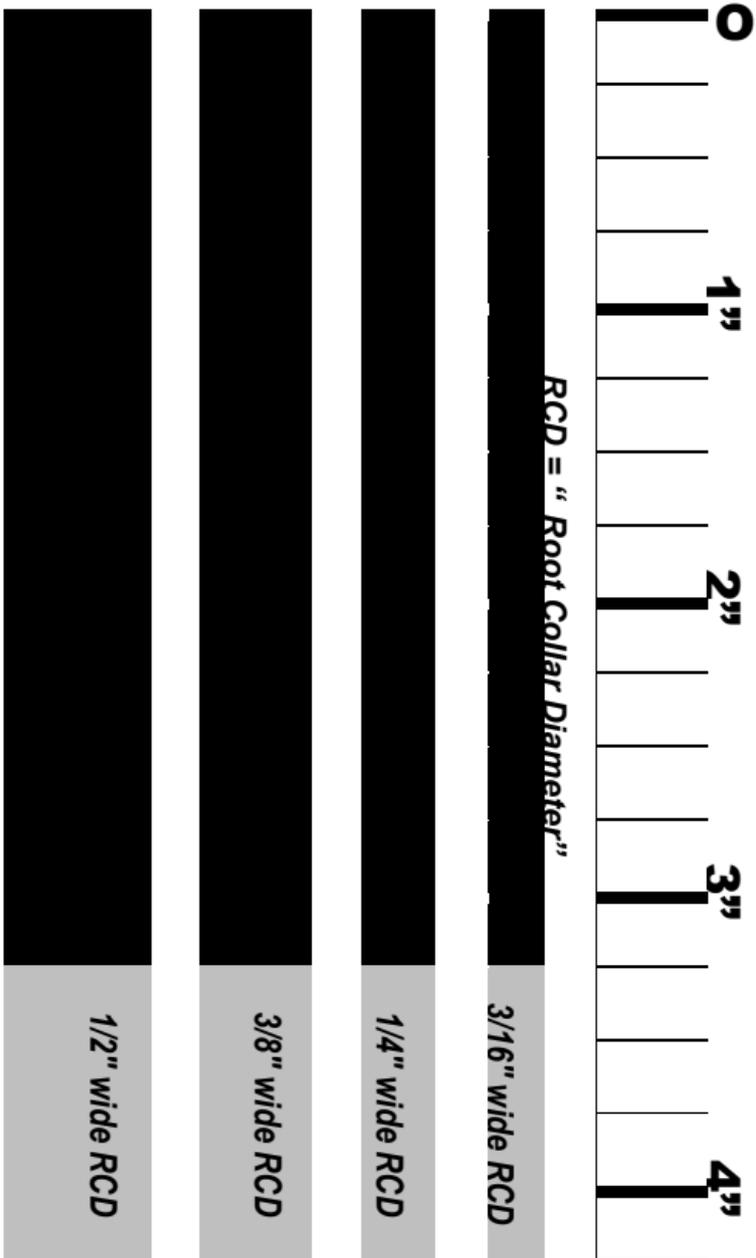
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