

Guidelines for Riparian Buffer Restoration

Department of Environment and Natural Resources
Division of Water Quality
Wetlands Restoration Program
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Purpose of these Guidelines

Riparian buffers have been identified as a valuable tool for protection of water quality when properly designed and established in the appropriate landscape setting. For this reason, the goal of the North Carolina Wetlands Restoration Program (NCWRP) is to implement projects to restore riparian buffers that have the greatest value for reducing pollutants in our surface waters as well as provide important aquatic and wildlife habitat. The purpose of these guidelines is to provide the technical information necessary for the successful planning and establishment of riparian buffers. The guidelines are intended for use by private consultants in developing restoration plans for the NCWRP but should also have utility for private landowners as well as local governments involved in the restoration of riparian buffers.



Criteria for Priority Riparian Buffer Restoration Projects

A number of factors determine the success of particular riparian buffer restoration projects. In addition to the physical characteristics of the site, issues such as land costs, land ownership, and logistical constraints must be taken into consideration. The following physical characteristics are intended to provide general guidance when identifying sites and are not intended to exclude sites that may have merit based on other criteria.

- Woody vegetation absent or sparse (less than 100 stems per acre that are ≥ 5 inches diameter at breast height) measured within 50 feet of intermittent and perennial streams, lakes, ponds, and shorelines.
- Adjacent to headwater streams or those streams defined as first, second, or third order.
- Project length greater than 1,000 feet (for projects implemented by the NCWRP).
- Ditches, gullies, or evidence of concentrated flow within 50 feet of intermittent and perennial streams, lakes, ponds, and estuaries.
- Adjacent source of nitrogen including cropland, pasture, golf course, residential development, ball fields, etc.
- Water table depth within three to four feet of surface as determined by characteristics of soil cores.



Components of a Riparian Buffer Restoration/Enhancement Plan

Site Assessment

The riparian area to be restored should be evaluated with respect to these factors that control the viability of riparian plants:

- Soil moisture
- Soil pH
- Soil texture
- Seasonal high water table depth
- Flooding potential
- Aspect, topography, and microtopographic relief

Site Preparation

The restoration/enhancement plan should address these items regarding preparation of the site for planting:

- Plow or rip site to improve compacted soil and/or eliminate areas where channelized flow has developed.
- Control of sod-forming grasses such as fescue and Kentucky bluegrass that will compete with plantings for nutrients.
- Control of invasive, exotic plants that would hinder the re-establishment of woody vegetation. Proposals for pesticide use should always be reviewed by the North Carolina Division of Water Quality staff to insure compliance with the Neuse and Tar-Pamlico Riparian Buffer Rules.

Common Invasive Exotic Plants
in North Carolina

Ailanthus altissima (Tree-of-Heaven)
Albizia julibrissin (Mimosa)
Elaeagnus umbellata (Autumn
Olive)
Hedera helix (English Ivy)
Lespedeza cuneata (Korean or
Sericea Lespedeza)
Ligustrum sinense (Chinese Privet)
Lonisera japonica (Japanese
Honeysuckle)
Microstegium vimineum (Japanese
Grass)
Paulownia tomentosa (Princess
Tree)
Pueraria lobata (Kudzu)
Rosa multiflora (Multiflora Rose)
Wisteria sinensis (Chinese Wisteria)

- Stabilize areas of bare soil. Refer to the following list for species of grasses/sedge appropriate for soil stabilization. The majority of these species are by necessity not native to North Carolina. At present, there are only a few species of native grasses useful for erosion control that are commercially available. Please note that fescue grasses should not be used for soil stabilization. Fescue grasses, particularly tall fescue, are competitive and will inhibit the eventual re-establishment of native species.

Agrostis alba (Redtop)

Found in fields, pastures, roadsides, and other disturbed places throughout North Carolina, this native warm season grass should be

used sparingly for erosion control and soil stabilization.

Carex stricta (Sedge)

This sedge occurs naturally in marshes and low meadows throughout the mountains and northern piedmont and coastal plain of North Carolina. This species has utility in a mix for soil stabilization in moist areas.

Dactylis glomerata (Orchardgrass)

This perennial, cool season bunchgrass is a good alternative to fescue because it is less competitive and allows native herbs to colonize the site.

Hordeum spp. (Barley)

A number of species of barley can be used for soil stabilization. Barley is a cool season, annual grass that when moisture is available will germinate in the fall, stay green during the winter, and then die in the spring as competition for warm season plants increases.

Panicum clandestinum (Deer
Tongue)

This native, perennial, warm season bunchgrass can be used in moist low woods primarily in the piedmont and mountains.

Panicum spp. (Panic Grasses)

A number of species of panic grasses can be used for soil stabilization

depending on the moisture regime and soils of the site.

Panicum virgatum (Switchgrass)

This native, perennial, warm season bunchgrass can tolerate a wide range of moisture regimes. It can be used along streams, in wet or dry woods, brackish and freshwater marshes, sloughs, swales, and low pinelands primarily in the eastern piedmont and coastal plain.

Pennisetum glaucum (Brown Top or Pearl Millet)

This fast-growing, robust, annual grass exhibits good drought tolerance which makes this species an important warm season option for soil stabilization.

Phalaris arundinacea (Reed Canarygrass)

A native to North Carolina, this perennial cool season grass is used for the stabilization of pond shorelines, drainage ditches, and streambanks in the mountains and western piedmont. It is established by planting freshly cut stem slips or rhizome fragments. Please note that this species is aggressive and forms large monotypic stands that displace other species. It should only be used if no other species are available.

Secale cereale (Winter Rye or Rye Grain)

Winter rye is a cold-hardy annual grass that will germinate and grow at low temperatures. By maturing early, it offers less competition

during the late spring, a critical time in the establishment of perennial species. Winter rye germinates quickly and is tolerant of poor soils.

Sorghum bicolor (Sudangrass)

Only the small-stemmed varieties of this annual warm season grass should be used. Sudangrass is useful for temporary seeding, and it is adapted to soils relatively high in clay content. Seed for common Sudangrass is not always available, but other small-stemmed types may be used, such as the hybrid Trudan. The coarse-stemmed Sorghum-Sudangrass hybrids are not appropriate for erosion control.

Suppliers of Grass Seed*

Ernst Conservation Seeds
9006 Mercer Pike
Meadville, PA 16335
814-336-2404
800-873-3321

Lofts Seed Company, Inc.
P.O. Box 26223
Winston-Salem, NC 27114-6223
800-543-7333

Mellow Marsh Farm
205 Anolis Road
Pittsboro, NC 27312
919-542-3532

Southern Tier Consulting, Inc.
2701-A Route 305
P.O. Box 30
West Clarksville, NY 14786
800-848-7614

*North Carolina suppliers are preferred.

Species Diversity and Composition

The most effective riparian buffers have trees and shrubs to provide perennial root systems and long-term nutrient storage. The design of a riparian buffer can be modified to fit the landscape and the landowner's needs, for example, by replacing shrubs with more trees, substituting some of the trees with shrubs, or incorporating a grass zone. In any scenario, the width of the woody vegetation should be at least 30 feet directly adjacent to the streambank/shoreline.

Choose 10-12 species of native trees and/or shrubs appropriate for site based on site assessment and reference conditions. In addition, please note that this list is alphabetical and does not take into account the assemblages of plants

found in nature. The inventory of plants found on the reference site can help determine an appropriate assemblage for the restoration site. In addition, the North Carolina Natural Heritage Program's *Classification of the Natural Communities of North Carolina: Third Approximation* is a valuable reference on natural assemblages of plants (Shafele, Michael P. and Alan S. Weakley, 1990).

Typically, there should be at least three or four understory trees for every canopy tree to provide structural diversity similar to mature forests. Where shrub species are incorporated into the planting plan, they should be distributed more densely at outer edge of riparian buffer to reduce light penetration and recolonization by invasive exotic species. Refer to Table 1 for a list of native tree and shrub species appropriate for use in riparian buffers.

Table 1. Master List of Native Plants

Native Regions	Light Requirements	Moisture Requirements
M= Mountains	S= Shade	L= Low Moisture
P= Piedmont	P= Partial Sun	M= Moderate Moisture
C= Coastal Plain	F= Full Sun	H= High Moisture
		A= Aquatic

Scientific Name	Common Name	Region			Light			Moisture				
		M	P	C	S	P	F	L	M	H	A	
Medium to Large Trees												
<i>Acer barbatum</i>	Southern sugar maple		X	X	X	X				X		
<i>Acer saccharinum</i>	silver maple		X		X	X	X		X			
<i>Acer saccharum</i>	sugar maple	X					X	X	X			
<i>Betula alleghaniensis</i>	yellow birch	X			X	X			X			
<i>Betula lenta</i>	cherry birch, sweet birch	X			X	X			X			
<i>Betula nigra</i>	river birch	X	X	X		X	X		X	X		
<i>Carya aquatica</i>	water hickory			X		X	X			X		
<i>Carya cordiformis</i>	bitternut hickory	X	X	X	X	X	X		X	X		
<i>Carya glabra</i>	pignut hickory	X	X	X	X	X	X	X	X			

Scientific Name	Common Name	Region			Light			Moisture			
		M	P	C	S	P	F	L	M	H	A
<i>Carya ovata</i>	shagbark hickory	X	X	X	X	X	X		X		
<i>Carya tomentosa</i>	mockernut hickory	X	X	X	X	X	X	X	X		
<i>Celtis laevigata</i>	sugarberry, hackberry		X	X	X	X			X		
<i>Chamaecyparis thyoides</i>	Atlantic white cedar			X		X	X		X	X	
<i>Cladrastis kentuckea</i>	yellowwood	X			X	X			X		
<i>Diospyros virginiana</i>	persimmon	X	X	X	X	X	X	X	X		
<i>Fagus grandifolia</i>	American beech	X	X	X	X	X			X		
<i>Fraxinus americana</i>	white ash	X	X	X	X	X			X		
<i>Fraxinus pennsylvanica</i>	green ash	X	X	X	X	X			X	X	
<i>Fraxinus profunda</i>	pumpkin ash, red ash		X	X		X				X	
<i>Juglans nigra</i>	black walnut	X	X	X	X	X			X		
<i>Liriodendron tulipifera</i>	tulip poplar, yellow poplar	X	X	X	X	X	X		X		
<i>Magnolia acuminata</i>	cucumber magnolia	X	X		X	X			X		
<i>Magnolia fraseri</i>	Fraser magnolia	X				X			X		
<i>Nyssa aquatica</i>	water tupelo			X	X	X	X			X	X
<i>Nyssa sylvatica</i>	black gum	X	X	X	X	X	X	X	X		
<i>Nyssa sylvatica var. biflora</i>	swamp black gum			X	X	X	X			X	
<i>Oxydendrum arboreum</i>	sourwood	X	X	X		X	X	X	X		
<i>Picea rubens</i>	red spruce	X			X	X	X		X		
<i>Pinus echinata</i>	shortleaf pine	X	X	X		X	X	X			
<i>Pinus palustris</i>	longleaf pine		X	X			X	X	X		
<i>Pinus rigida</i>	pitch pine	X					X	X			
<i>Pinus serotina</i>	pond pine			X			X		X	X	
<i>Pinus strobus</i>	white pine	X	X			X	X		X		
<i>Platanus occidentalis</i>	sycamore	X	X	X		X	X		X	X	
<i>Populus deltoides</i>	eastern cottonwood		X	X			X			X	
<i>Populus heterophylla</i>	swamp cottonwood			X		X	X			X	
<i>Prunus serotina</i>	black cherry	X	X	X	X	X	X	X	X		
<i>Quercus alba</i>	white oak	X	X	X		X	X	X	X		
<i>Quercus bicolor</i>	swamp white oak		X		X	X				X	
<i>Quercus coccinea</i>	scarlet oak	X	X		X	X		X			
<i>Quercus falcata</i>	Southern red oak	X	X	X	X	X		X	X		
<i>Quercus pagoda</i>	cherrybark oak		X	X	X	X			X	X	
<i>Quercus laurifolia</i>	laurel oak			X	X	X	X		X	X	
<i>Quercus lyrata</i>	overcup oak		X	X	X	X				X	
<i>Quercus margaretta</i>	sand post oak			X		X	X	X			
<i>Quercus marilandica</i>	black jack oak	X	X	X	X	X		X			
<i>Quercus michauxii</i>	swamp chestnut oak		X	X	X	X	X		X	X	
<i>Quercus nigra</i>	water oak		X	X	X	X	X	X	X		
<i>Quercus phellos</i>	willow oak		X	X	X	X	X		X	X	
<i>Quercus prinus</i>	chestnut oak	X	X		X	X		X			
<i>Quercus rubra</i>	Northern red oak	X	X		X	X		X	X		
<i>Quercus shumardii</i>	shumard oak		X	X	X	X			X	X	
<i>Quercus stellata</i>	post oak	X	X	X	X	X		X			
<i>Quercus velutina</i>	black oak	X	X	X	X	X		X			
<i>Quercus virginiana</i>	live oak			X		X	X	X			
<i>Robinia pseudoacacia</i>	black locust	X	X	X		X	X		X		
<i>Taxodium ascendens</i>	pond-cypress			X		X	X				X
<i>Taxodium distichum</i>	bald-cypress			X		X	X				X

Scientific Name	Common Name	Region			Light			Moisture			
		M	P	C	S	P	F	L	M	H	A
<i>Tilia americana</i> var. <i>heterophylla</i>	basswood	X	X		X	X			X		
<i>Tsuga canadensis</i>	Eastern hemlock	X	X		X	X	X		X		
<i>Tsuga caroliniana</i>	Carolina hemlock	X	X			X	X	X			
<i>Ulmus alata</i>	winged elm		X	X	X	X	X	X	X		
<i>Ulmus americana</i>	American elm	X	X	X	X	X			X		
Small Trees											
<i>Amelanchier arborea</i>	downy serviceberry, shadbush	X	X	X	X	X			X		
<i>Amelanchier canadensis</i>	Canada serviceberry			X			X		X	X	
<i>Amelanchier laevis</i>	smooth serviceberry	X				X	X	X	X		
<i>Asimina triloba</i>	pawpaw	X	X	X	X	X			X		
<i>Carpinus caroliniana</i>	ironwood, American hornbeam	X	X	X	X	X			X	X	
<i>Cercis canadensis</i>	eastern redbud	X	X	X	X	X			X		
<i>Chionanthus virginicus</i>	white fringetree, old man's beard	X	X	X		X	X		X		
<i>Cornus alternifolia</i>	alternate-leaf dogwood	X			X	X			X		
<i>Cornus florida</i>	flowering dogwood	X	X	X	X	X		X	X		
<i>Crateagus crus-galli</i>	cockspur hawthorn	X	X	X		X	X	X	X		
<i>Crateagus flabellata</i>	fanleaf hawthorn	X	X			X			X		
<i>Crateagus flava</i>	October haw	X	X	X		X	X		X		
<i>Cyrilla racemiflora</i>	titi			X		X	X		X	X	
<i>Fraxinus caroliniana</i>	water ash			X	X	X				X	
<i>Gordonia lasianthus</i>	loblolly bay			X	X	X	X		X	X	
<i>Halesia tetraptera</i> (<i>H. carolina</i>)	common silverbell	X	X		X	X			X		
<i>Ilex opaca</i>	American holly	X	X	X	X	X		X	X	X	
<i>Juniperus virginiana</i>	Eastern red cedar	X	X	X		X	X	X	X		
<i>Magnolia tripetala</i>	umbrella tree	X	X		X				X		
<i>Magnolia virginiana</i>	sweetbay magnolia		X	X	X	X	X		X	X	
<i>Morus rubra</i>	red mulberry	X	X	X	X	X			X		
<i>Osmanthus americana</i>	wild olive, devilwood			X	X	X			X		
<i>Ostrya virginiana</i>	Eastern hop-hornbeam	X	X		X	X			X		
<i>Persea borbonia</i>	red bay			X	X	X	X	X	X		
<i>Persea palustris</i>	swamp bay			X	X	X	X		X	X	
<i>Pinus pungens</i>	table mountain pine	X					X	X			
<i>Prunus americana</i>	American wild plum	X	X			X			X		
<i>Prunus caroliniana</i>	Carolina laurel-cherry			X		X	X	X	X		
<i>Quercus incana</i>	bluejack oak			X		X	X	X			
<i>Quercus laevis</i>	turkey oak			X		X	X	X			
<i>Rhus glabra</i>	smooth sumac	X	X				X	X	X		
<i>Rhus hirta</i> (<i>Rhus typhina</i>)	staghorn sumac	X					X	X			
<i>Salix caroliniana</i>	swamp willow	X	X	X		X	X		X	X	
<i>Salix nigra</i>	black willow	X	X	X		X	X		X	X	
<i>Sassafras albidum</i>	sassafras	X	X	X		X	X	X	X		
<i>Staphylea trifolia</i>	bladdernut		X		X				X	X	
<i>Symplocos tinctoria</i>	horse-sugar, sweetleaf	X	X	X	X	X		X	X		
<i>Ulmus rubra</i>	slippery elm	X	X		X	X			X		
Shrubs											
<i>Aesculus sylvatica</i>	painted buckeye	X	X		X	X			X		
<i>Alnus serrulata</i> *	common alder	X	X	X	X	X	X			X	X

Scientific Name	Common Name	Region			Light			Moisture			
		M	P	C	S	P	F	L	M	H	A
<i>Aronia arbutifolia</i>	red chokeberry	X	X	X	X	X			X	X	
<i>Baccharis halimifolia</i>	silverling		X	X			X	X	X	X	
<i>Callicarpa americana</i>	American beautyberry		X	X	X	X	X		X		
<i>Calycanthus floridus</i>	sweet-shrub	X	X		X	X			X		
<i>Castanea pumila</i>	Allegheny chinkapin	X	X	X	X	X	X	X			
<i>Ceanothus americanus</i>	New Jersey tea	X	X	X		X	X	X			
<i>Cephalanthus occidentalis</i>	buttonbush	X	X	X		X	X				X
<i>Clethra acuminata</i>	mountain sweet pepperbush	X			X	X			X		
<i>Clethra alnifolia</i>	sweet pepperbush			X	X	X			X	X	
<i>Comptonia peregrina</i>	sweet fern	X	X			X	X				
<i>Cornus amomum</i>	silky dogwood	X	X	X	X	X				X	X
<i>Cornus stricta</i>	swamp dogwood			X	X	X				X	
<i>Corylus americana</i>	American hazel, hazelnut	X	X		X	X			X		
<i>Euonymus americanus</i>	hearts-a-bustin', strawberry bush	X	X	X	X	X		X	X		
<i>Fothergilla gardenii</i>	witch-alder			X		X			X	X	
<i>Gaylussacia frondosa</i>	dangleberry			X	X	X	X		X	X	
<i>Hamamelis virginiana</i>	witch hazel	X	X	X	X	X		X	X		
<i>Hydrangea arborescens</i>	wild hydrangea	X	X		X	X			X		
<i>Ilex coriacea</i>	gallberry			X	X	X			X	X	
<i>Ilex decidua</i>	deciduous holly, possumhaw		X	X	X	X			X		
<i>Ilex glabra</i>	inkberry			X	X	X	X		X	X	
<i>Ilex verticillata</i>	winterberry	X	X	X	X	X	X		X	X	
<i>Ilex vomitoria</i>	yaupon holly			X	X	X	X	X			
<i>Itea virginica</i>	Virginia willow		X	X	X	X				X	
<i>Kalmia angustifolia var. caroliniana</i>	lamb-kill, sheep-kill			X		X	X		X	X	
<i>Kalmia latifolia</i>	mountain laurel	X	X		X	X		X	X		
<i>Leucothoe axillaris</i>	coastal dog-hobble			X	X	X			X		
<i>Leucothoe fontanesiana</i>	dog-hobble	X	X		X				X		
<i>Leucothoe racemosa</i>	fetterbush		X	X	X	X			X	X	
<i>Lindera benzoin</i>	spicebush	X	X		X				X		
<i>Lyonia ligustrina</i>	northern maleberry	X	X	X		X			X	X	
<i>Lyonia lucida</i>	shining fetterbush			X	X	X			X		
<i>Myrica cerifera*</i>	Southern wax-myrtle		X	X	X	X	X	X	X	X	
<i>Myrica cerifera var. pumila*</i>	dwarf Southern wax-myrtle			X		X	X	X	X		
<i>Myrica heterophylla*</i>	bayberry, evergreen bayberry			X	X	X			X		
<i>Pieris floribunda</i>	evergreen mountain fetterbush	X					X	X	X		
<i>Rhododendron atlanticum</i>	dwarf azalea			X		X			X		
<i>Rhododendron calendulaceum</i>	flame azalea	X			X	X			X		
<i>Rhododendron catawbiense</i>	Catawba rhododendron	X	X		X	X	X	X	X		
<i>Rhododendron maximum</i>	rosebay rhododendron	X	X		X	X		X	X		
<i>Rhododendron periclymenoides</i>	pinxter flower, wild azalea	X	X	X	X	X			X		
<i>Rhododendron viscosum</i>	swamp azalea	X	X		X	X		X	X		
<i>Rhus copallina</i>	winged sumac	X	X	X		X	X	X	X		
<i>Rosa carolina</i>	pasture rose, Carolina rose	X	X	X		X	X	X	X		
<i>Rosa palustris</i>	swamp rose	X	X	X		X	X				X
<i>Rubus allegheniensis</i>	Alleghany blackberry	X	X				X	X			
<i>Rubus cuneifolius</i>	blackberry		X	X		X	X	X	X		
<i>Rubus odoratus</i>	purple flowering raspberry	X				X			X		
<i>Salix humilis</i>	prairie willow	X	X				X	X			

Scientific Name	Common Name	Region			Light			Moisture				
		M	P	C	S	P	F	L	M	H	A	
<i>Salix sericea</i>	silky willow	X	X	X		X	X					X
<i>Sambucus canadensis</i>	common elderberry	X	X	X			X		X	X		
<i>Spiraea alba</i>	narrow-leaved meadowsweet	X					X		X			
<i>Spiraea latifolia</i>	broad-leaved meadowsweet	X					X		X			
<i>Spiraea tomentosa</i>	meadowsweet	X	X	X		X	X				X	
<i>Stewartia malacodendron</i>	silky camellia			X	X	X			X			
<i>Stewartia ovata</i>	mountain camellia	X	X		X	X			X			
<i>Styrax grandifolia</i>	bigleaf snowbell		X	X	X	X			X			
<i>Vaccinium arboreum</i>	sparkleberry		X	X	X	X		X	X			
<i>Vaccinium corymbosum</i>	highbush blueberry	X	X	X	X	X	X	X	X	X		
<i>Vaccinium crassifolium</i>	creeping blueberry			X		X			X			
<i>Vaccinium elliotii</i>	mayberry			X	X				X			
<i>Vaccinium stamineum</i>	deerberry, gooseberry	X	X	X	X	X		X				
<i>Vaccinium pallidum</i>	lowbush blueberry	X	X		X	X		X				
<i>Viburnum acerifolium</i>	maple-leaf viburnum	X	X		X	X		X	X			
<i>Viburnum dentatum</i>	Southern arrowwood viburnum	X	X	X	X	X	X		X			
<i>Viburnum nudum</i>	possumhaw viburnum	X	X	X	X	X					X	
<i>Viburnum prunifolium</i>	blackhaw viburnum	X	X	X	X	X			X			
<i>Viburnum rafinesquianum</i>	downy arrowwood		X		X	X			X			
<i>Viburnum rufidulum</i>	rusty blackhaw		X	X	X	X		X				
<i>Xanthorhiza simplicissima</i>	yellowroot	X	X	X	X			X	X			

* These species fix nitrogen and should not be used for riparian restoration adjacent to Nutrient Sensitive Waters.

Where grasses are incorporated into the planting plan on the outside of the buffer strip, only native grasses should be used. Native grasses produce a much more extensive and deep root system than commonly used non-native grasses such as fescue.

<p>Common Native Grasses</p> <p><i>Andropogon gerardii</i> (Big Bluestem)</p> <p><i>Andropogon virginicus</i> (Broomsedge)</p> <p><i>Arundinaria gigantea</i> (Giant Cane)</p> <p><i>Eragrostis spectabilis</i> (Purple Love Grass)</p> <p><i>Panicum anceps</i> (Beaked Panicum)</p> <p><i>Panicum clandestinum</i> (Deertongue)</p> <p><i>Panicum hemitomon</i> (Maidencane)</p> <p><i>Panicum virgatum</i> (Switchgrass)</p> <p><i>Schizachyrium scoparium</i> (Little Bluestem)</p> <p><i>Sorghastrum nutans</i> (Indiangrass)</p> <p><i>Tridens flavus</i> (Purple-Top)</p> <p><i>Tripsacum dactyloides</i> (Gama Grass)</p>

Planting Density

Trees should be planted at a density sufficient to provide 320 trees per acre at maturity. To achieve this density, approximately 436 (10x10 feet spacing) to 681 (8x8 feet spacing) trees per acre should be planted initially. Shrubs should be planted at a density sufficient to provide 1,200 shrubs per acre. Refer to Table 2 for the number of trees and shrubs per acre based on various methods of spacing.

Table 2. Number of Trees/Shrubs per Acre by Various Methods of Spacing

Spacing (feet)	Trees/Shrubs (number)
2x2	10,890
3x3	4,840
4x4	2,722
5x5	1,742
6x6	1,210
7x7	889
8x8	681
9x9	538
10x10	436
11x11	360
12x12	302
13x13	258



Plant Size

In many cases, the most cost effective and successful size plant material is bare root seedlings. Some species such as the hickories do poorly as bare root seedlings and will be much more successful as containerized seedlings. In either case, tree shelters should be used to accelerate growth and increase survivability of seedlings. In addition, management of competing vegetation after planting is easier, mowing and weed wacker strikes are prevented, herbicides are isolated from trunk contact, and grazing by deer are restricted. The use of tree shelters may only be practical from an economic standpoint for more expensive seedlings of species difficult to establish, such as red oak. Reductions in maintenance costs and increased seedling vigor associated with tree shelters suggest that tree shelter plantings may be a more cost-effective approach than planting unprotected larger material. In urban or other high visibility areas, some specimen trees and shrubs should be incorporated into the planting plan for projects implemented by the NCWRP.

When live stakes or dormant cuttings are incorporated in a planting plan, choose only the previous season's growth. Live stakes should typically be approximately ¾ inch in diameter and three feet long, and dormant cuttings should be approximately ½ inch in diameter and two feet long.

Supplier of Tree Shelters:

Treessentials Company
2371 Waters Drive
Mendota Heights, MN 55120-1163
800-248-8239

Suppliers of Native Plant Material

Local nurseries are the best option in acquiring plants that will be successful. Plants grown from seeds or cuttings collected close to the restoration area will be the most likely to survive and reproduce. The following is a list of nurseries that supply native plant material. This list is not considered exhaustive or an endorsement by the NCWRP but merely a source of potential vendors of native plants.

Carolina Greenery
375 Carthage Road
West End, NC 27376-8731
910-947-3150

Cedar Point Nursery and Garden Center
100 Commercial Court
Swansboro, NC 28584
252-393-6880

Coastal Plain Conservation Nursery
3067 Conners Drive
Edenton, NC 27932
252-482-5707

Cure Nursery
880 Buteo Road
Pittsboro, NC 27312
919-542-6186

Denton's Nursery
3535 NC 42 West
Wilson, NC 27893
252-237-0022

Fern Valley Farms
1624 Fern Valley Road
Yadkinville, NC 27055
336-463-2412

Hoffman Nursery
5520 Bahama Road
Rougemont, NC 27572
919-479-6620

Laurel Springs Nursery
401 Regal Street
Hendersonville, NC 28792
828-692-4012
888-823-4622

McLamb Nursery, Inc.
640 Greenleaf Road
Angier, NC 27501-9801
919-894-3709
800-900-3709

Mellow Marsh Farm
205 Anolis Road
Pittsboro, NC 27312
919-742-1200 Office / 919-742-1280 Fax

NC Division of Forest Resources
Claridge Nursery
762 Claridge Nursery Road
Goldsboro, NC 27530
919-731-7988

NC Division of Forest Resources
Edwards Nursery
701 Sanford Drive
Morganton, NC 28655
828-438-6270

NC Division of Forest Resources
Linville Nursery
6321 Linville Falls Highway
Newland, NC 28657
828-733-5236

Niche Gardens
1111 Dawson Road
Chapel Hill, NC 27516
919-967-0078

We-Du Nurseries
Rt. 5, Box 724
Marion, NC 28752
828-738-8300

Taylor's Nursery, Inc.
3705 New Bern Avenue
Raleigh, NC 27610
919-231-6161

Woodlander's, Inc.
1128 Colleton Ave.
Aiken, SC 29801
803-648-7522

Wa Ya Nursery & Tree Farm
11199 Canada Road
Tuckasegee, NC 28783
828-293-5720

For more information about suppliers of native plants contact:

'Native Plant Sources'
North Carolina Botanical Garden
University of North Carolina at Chapel Hill
CB 3375, Totten Center
Chapel Hill, NC 27599-3375
919-962-0522

Planting Layout

The planting plan should indicate that trees and shrubs will be planted in a random pattern. For inexperienced planting crews, pre-labeled flagged wires can be used to mark the random location of plantings. These flags can also be color coded for each particular species. Various colors of spray paint can also be used to differentiate species.

Planting Practices

When planting seedlings, it is helpful to mark the plants with colored flagging to make them easier to locate during maintenance tasks. The flagging can also be color-coded to mark plants that have died for replacement at a later date.

Tree protectors are also helpful for locating plants.

Tree seedlings should be kept moist and should not be exposed for extended periods of time. A correctly planted tree should have the following general characteristics:

- Planted so that the root collar is slightly below the soil surface.
- Have the main roots nearly straight or spread out.
- Have soil firm around the roots.
- Have the tree in an upright position and have it nearly even with the general ground level, not sunk in a hole or raised on a mound.

Please note that the Neuse and Tar-Pamlico Riparian Buffer Rules allow for a one time fertilizer application to establish newly planted vegetation. Ongoing fertilizer application is prohibited by these rules.



Riparian Buffer Maintenance

Control of Grasses and Forbs

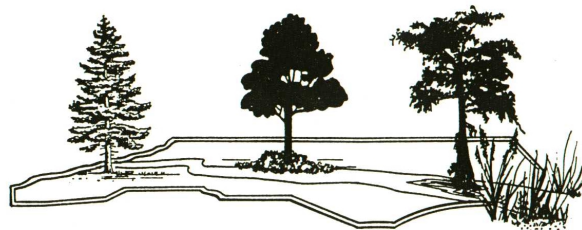
In the early stages of riparian buffer establishment, competition for nutrients by adjacent grasses and forbs will substantially inhibit seedling growth. Release from herbaceous competition has been demonstrated as the most cost-effective method to accelerate the growth of seedlings. The plan for buffer establishment must incorporate control of the herbaceous layer. Options for weed control include four to six inches of well-aged hardwood mulch, weed control fabrics, or pre-emergent herbicide. Typically, mowing to control

weeds will be impractical based on the random distribution of plantings. Weed control should be continued for three years from the time of planting.

Areas of Concentrated Flow

During the required five year monitoring period, the riparian buffer should be inspected for evidence of concentrated flow. If concentrated flow has begun to form, a level spreader or other best management practice should be installed to diffuse the flow before it enters the restored riparian buffer.

Prepared by Cherri L. Smith, North Carolina Wetlands Restoration Program. Illustrations by Karen M. Lynch and design by Marcia Nye.



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