Guidelines for Riparian Buffer Restoration

N.C. Department of Environment and Natural Resources
Ecosystem Enhancement 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 Ecosystem Enhancement Program (EEP) 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 EEP 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 $\geq$ 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 EEP).
- 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.

Riparian Buffer Design

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. The following table provides a list of native tree and shrub species appropriate for use in riparian buffers.

Master List of Native Plants

Native Regions
M= Mountains
P= Piedmont
C= Coastal Plain

Light Requirements
S= Shade
P= Partial Sun
F= Full Sun

Moisture Requirements
L= Low Moisture
M= Moderate Moisture
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											
Acer barbatum	Southern sugar maple		X	X	X	X			X		
Acer saccharinum	silver maple		X		X	X	X		X		
Acer saccharum	sugar maple	X				X	X		X		
Betula alleghaniensis	yellow birch	X			X	X			X		
Betula lenta	cherry birch, sweet birch	X			X	X			X		
Betula nigra	river birch	X	X	X		X	X		X	X	
Carya aquatica	water hickory			X		X	X			X	
Carya cordiformis	bitternut hickory	X	X	X	X	X	X		X	X	
Carya glabra	pignut hickory	X	X	X	X	X	X	X	X		
Carya ovata	shagbark hickory	X	X	X	X	X	X		X		
Carya tomentosa	mockernut hickory	X	X	X	X	X	X	X	X		
Celtis laevigata	sugarberry, hackberry		X	X	X	X			X		
Chamaecyparis thyoides	Atlantic white cedar			X		X	X		X	X	
Cladrastis kentuckea	yellowwood	X			X	X			X		
Diospyros virginiana	persimmon	X	X	X	X	X	X	X	X		
Fagus grandifolia	American beech	X	X	X	X	X			X		
Fraxinus americana	white ash	X	X	X	X	X			X		
Fraxinus pennsylvanica	green ash	X	X	X	X	X			X	X	
Fraxinus profunda	pumpkin ash, red ash		X	X		X				X	
Juglans nigra	black walnut	X	X	X	X	X			X		
Liriodendron tulipifera	tulip poplar, yellow poplar	X	X	X	X	X	X		X		
Magnolia acuminata	cucumber magnolia	X	X		X	X			X		
Magnolia fraseri	Fraser magnolia	X				X			X		
Nyssa aquatica	water tupelo			X	X	X	X			X	X
Nyssa sylvatica	black gum	X	X	X	X	X	X	X	X		
Nyssa sylvatica var. biflora	swamp black gum			X	X	X	X			X	
Oxydendrum arboreum	sourwood	X	X	X		X	X	X	X		
Picea rubens	red spruce	X			X	X	X		X		
Pinus echinata	shortleaf pine	X	X	X		X	X	X			
Pinus palustris	longleaf pine		X	X			X	X	X		
Pinus rigida	pitch pine	X					X	X			

Scientific Name	Common Name	Region			Light			Moisture			
		M	P	C	S	P	F	L	M	H	A
Pinus serotina	pond pine			X			X		X	X	
Pinus strobus	white pine	X	X			X	X		X		
Platanus occidentalis	sycamore	X	X	X		X	X		X	X	
Populus deltoides	eastern cottonwood		X	X			X			X	
Populus heterophylla	swamp cottonwood			X		X	X			X	
Prunus serotina	black cherry	X	X	X	X	X	X	X	X		
Quercus alba	white oak	X	X	X		X	X	X	X		
Quercus bicolor	swamp white oak		X		X	X				X	
Quercus coccinea	scarlet oak	X	X		X	X		X			
Quercus falcata	Southern red oak	X	X	X	X	X		X	X		
Quercus pagoda	cherrybark oak		X	X	X	X			X	X	
Quercus laurifolia	laurel oak			X	X	X	X		X	X	
Quercus lyrata	overcup oak		X	X	X	X				X	
Quercus margaretta	sand post oak			X		X	X	X			
Quercus marilandica	black jack oak	X	X	X	X	X		X			
Quercus michauxii	swamp chestnut oak		X	X	X	X	X		X	X	
Quercus nigra	water oak		X	X	X	X	X	X	X		
Quercus phellos	willow oak		X	X	X	X	X		X	X	
Quercus prinus	chestnut oak	X	X		X	X		X			
Quercus rubra	Northern red oak	X	X		X	X		X	X		
Quercus shumardii	shumard oak		X	X	X	X			X	X	
Quercus stellata	post oak	X	X	X	X	X		X			
Quercus velutina	black oak	X	X	X	X	X		X			
Quercus virginiana	live oak			X		X	X	X			
Robinia pseudoacacia	black locust	X	X	X		X	X		X		
Taxodium ascendens	pond-cypress			X		X	X				X
Taxodium distichum	bald-cypress			X		X	X				X
Tilia americana var. heterophylla	basswood	X	X		X	X			X		
Tsuga canadensis	Eastern hemlock	X	X		X	X	X		X		
Tsuga caroliniana	Carolina hemlock	X	X			X	X	X			
Ulmus alata	winged elm		X	X	X	X	X	X	X		
Ulmus americana	American elm	X	X	X	X	X			X		
Small Trees											
Amelanchier arborea	downy serviceberry, shadbush	X	X	X	X	X			X		
Amelanchier canadensis	Canada serviceberry			X			X		X	X	
Amelanchier laevis	smooth serviceberry	X				X	X	X	X		
Asimina triloba	pawpaw	X	X	X	X	X			X		
Carpinus caroliniana	ironwood, American hornbeam	X	X	X	X	X			X	X	
Cercis canadensis	eastern redbud	X	X	X	X	X			X		
Chionanthus virginicus	white fringetree, old man's beard	X	X	X		X	X		X		
Cornus alternifolia	alternate-leaf dogwood	X			X	X			X		
Cornus florida	flowering dogwood	X	X	X	X	X		X	X		
Crateagus crus-galli	cockspur hawthorn	X	X	X		X	X	X	X		
Crateagus flabellata	fanleaf hawthorn	X	X			X			X		
Crateagus flava	October haw	X	X	X		X	X		X		
Cyrilla racemiflora	titi			X		X	X		X	X	
Fraxinus caroliniana	water ash			X	X	X				X	
Gordonia lasianthus	loblolly bay			X	X	X	X		X	X	

Scientific Name	Common Name	Region			Light			Moisture			
		M	P	C	S	P	F	L	M	H	A
Halesia tetraptera (H. carolina)	common silverbell	X	X		X	X			X		
Ilex opaca	American holly	X	X	X	X	X		X	X	X	
Juniperus virginiana	Eastern red cedar	X	X	X		X	X	X	X		
Magnolia tripetala	umbrella tree	X	X		X				X		
Magnolia virginiana	sweetbay magnolia		X	X	X	X	X		X	X	
Morus rubra	red mulberry	X	X	X	X	X			X		
Osmanthus americana	wild olive, devilwood			X	X	X			X		
Ostrya virginiana	Eastern hop-hornbeam	X	X		X	X			X		
Persea borbonia	red bay			X	X	X	X	X	X		
Persea palustris	swamp bay			X	X	X	X		X	X	
Pinus pungens	table mountain pine	X					X	X			
Prunus americana	American wild plum	X	X			X			X		
Prunus caroliniana	Carolina laurel-cherry			X		X	X	X	X		
Quercus incana	bluejack oak			X		X	X	X			
Quercus laevis	turkey oak			X		X	X	X			
Rhus glabra	smooth sumac	X	X				X	X	X		
Rhus hirta (Rhus typhina)	staghorn sumac	X					X	X			
Salix caroliniana	swamp willow	X	X	X		X	X		X	X	
Salix nigra	black willow	X	X	X		X	X		X	X	
Sassafras albidum	sassafras	X	X	X		X	X	X	X		
Staphylea trifolia	bladdernut		X		X				X	X	
Symplocos tinctoria	horse-sugar, sweetleaf	X	X	X	X	X		X	X		
Ulmus rubra	slippery elm	X	X		X	X			X		
Shrubs											
Aesculus sylvatica	painted buckeye	X	X		X	X			X		
*Alnus serrulata**	common alder	X	X	X	X	X	X			X	X
Aronia arbutifolia	red chokeberry	X	X	X	X	X			X	X	
Baccharis halimifolia	silverling		X	X			X	X	X	X	
Callicarpa americana	American beautyberry		X	X	X	X	X		X		
Calycanthus floridus	sweet-shrub	X	X		X	X			X		
Castanea pumila	Allegheny chinkapin	X	X	X	X	X	X	X			
Ceanothus americanus	New Jersey tea	X	X	X		X	X	X			
Cephalanthus occidentalis	buttonbush	X	X	X		X	X				X
Clethra acuminata	mountain sweet pepperbush	X			X	X			X		
Clethra alnifolia	sweet pepperbush			X	X	X			X	X	
Comptonia peregrina	sweet fern	X	X			X	X				
Cornus amomum	silky dogwood	X	X	X	X	X				X	X
Cornus stricta	swamp dogwood			X	X	X				X	
Corylus americana	American hazel, hazelnut	X	X		X	X			X		
Euonymus americanus	hearts-a-bustin', strawberry bush	X	X	X	X	X		X	X		
Fothergilla gardenii	witch-alder			X		X			X	X	
Gaylussacia frondosa	dangleberry			X	X	X	X		X	X	
Hamamelis virginiana	witch hazel	X	X	X	X	X		X	X		
Hydrangea arborescens	wild hydrangea	X	X		X	X			X		
Ilex coriacea	gallberry			X	X	X			X	X	
Ilex decidua	deciduous holly, possumhaw		X	X	X	X			X		
Ilex glabra	inkberry			X	X	X	X		X	X	
Ilex verticillata	winterberry	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
Ilex vomitoria	yaupon holly			X	X	X	X	X			
Itea virginica	Virginia willow		X	X	X	X				X	
Kalmia angustifolia var. caroliniana	lamb-kill, sheep-kill			X		X	X		X	X	
Kalmia latifolia	mountain laurel	X	X		X	X		X	X		
Leucothoe axillaris	coastal dog-hobble			X	X	X			X		
Leucothoe fontanesiana	dog-hobble	X	X		X				X		
Leucothoe racemosa	fetterbush		X	X	X	X			X	X	
Lindera benzoin	spicebush	X	X		X				X		
Lyonia ligustrina	northern maleberry	X	X	X		X			X	X	
Lyonia lucida	shining fetterbush			X	X	X			X		
*Myrica cerifera**	Southern wax-myrtle		X	X	X	X	X	X	X	X	
*Myrica cerifera var. pumila**	dwarf Southern wax-myrtle			X		X	X	X	X		
*Myrica heterophylla**	bayberry, evergreen bayberry			X	X	X			X		
Pieris floribunda	evergreen mountain fetterbush	X					X	X	X		
Rhododendron atlanticum	dwarf azalea			X		X			X		
Rhododendron calendulaceum	flame azalea	X			X	X			X		
Rhododendron catawbiense	Catawba rhododendron	X	X		X	X	X	X	X		
Rhododendron maximum	rosebay rhododendron	X	X		X	X		X	X		
Rhododendron periclymenoides	pinxter flower, wild azalea	X	X	X	X	X			X		
Rhododendron viscosum	swamp azalea	X		X		X	X		X	X	
Rhus copallina	winged sumac	X	X	X		X	X	X	X		
Rosa carolina	pasture rose, Carolina rose	X	X	X		X	X	X	X		
Rosa palustris	swamp rose	X	X	X		X	X				X
Rubus allegheniensis	Alleghany blackberry	X	X				X	X			
Rubus cuneifolius	blackberry		X	X		X	X	X	X		
Rubus odoratus	purple flowering raspberry	X				X			X		
Salix humilis	prairie willow	X	X				X	X			
Salix sericea	silky willow	X	X	X		X	X				X
Sambucus canadensis	common elderberry	X	X	X			X		X	X	
Spiraea alba	narrow-leaved meadowsweet	X					X		X		
Spiraea latifolia	broad-leaved meadowsweet	X					X		X		
Spiraea tomentosa	meadowsweet	X	X	X		X	X			X	
Stewartia malacodendron	silky camellia			X	X	X			X		
Stewartia ovata	mountain camellia	X	X		X	X			X		
Styrax grandifolia	bigleaf snowbell		X	X	X	X			X		
Vaccinium arboreum	sparkleberry		X	X	X	X		X	X		
Vaccinium corymbosum	highbush blueberry	X	X	X	X	X	X	X	X	X	
Vaccinium crassifolium	creeping blueberry			X		X			X		
Vaccinium elliottii	mayberry			X	X				X		
Vaccinium stamineum	deerberry, gooseberry	X	X	X	X	X		X			
Vaccinium pallidum	lowbush blueberry	X	X		X	X		X			
Viburnum acerifolium	maple-leaf viburnum	X	X		X	X		X	X		
Viburnum dentatum	Southern arrowwood viburnum	X	X	X	X	X	X		X		
Viburnum nudum	possumhaw viburnum	X	X	X	X	X				X	
Viburnum prunifolium	blackhaw viburnum	X	X	X	X	X			X		
Viburnum rafinesquianum	downy arrowwood		X		X	X			X		
Viburnum rufidulum	rusty blackhaw		X	X	X	X		X			
Xanthorhiza simplicissima	yellowroot	X	X	X	X			X	X		

** These 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.

Common Native Grasses

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

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.

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 EEP.

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.

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.

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 postion 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.

Illustrations by Karen M. Lynch