# STREAMBANK AND SHORELINE STABILIZATION

- Techniques to Control Erosion and Protect Property -



Coconut logs, live stakes, toe of slope protection and riparian restoration - Photograph courtesy of Register-Nelson Environmental Consultants.

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#### Introduction

Appropriate selection and application of streambank or shoreline protection measures should vary in response to specific objectives and site conditions.

treambank and shoreline stabilization consists of vegetative, structural and bioengineering methods to stabilize AND protect streambanks and shorelines. This document presents diagrams of the methods and practices listed in the Georgia DNR – Environmental Protection Division's (EPD) July 2007 "Streambank and Shoreline Stabilization Guidance" document and provides information about preferred riparian vegetation for stabilization projects.

Stabilizing streambanks with natural vegetation has many advantages over hard armoring such as riprap, seawalls and gabions. Streams with well-established vegetation on their banks provide for better water quality and fish and wildlife habitats. Vegetation is extremely important for the biological, chemical and physical health of the stream as well as the stability of the system.

Vegetation is not a panacea for controlling erosion and must be considered in light of site-specific characteristics. When vegetation is combined with low-cost building materials or engineered structures, numerous techniques can be created for streambank erosion control. This document summarizes a number of methods that utilize vegetation and bioengineering.



Illustrated Streambank Restoration

**NOTE:** This handbook does not attempt to assume that bioengineering for streambank protection is a cure unto itself. First, streambed stability, another whole subject area, must be achieved before banks are addressed. Therefore, careful study should be made to determine the causes of erosion before bioengineering is considered. If streambeds are not stable, it does little good to attempt streambank stabilization. This document does not attempt to address the details of fluvial geomorphology involved in streambed stabilization.

#### **Causes of Erosion**

Streambank and shoreline erosion is a natural process. Human activities often contribute to or accelerate the natural streambank or shoreline erosion process, exacerbating the negative effects. However, with thought and planning, such activities can be modified to avoid or reduce those effects. Human activities contributing to or accelerating the natural streambank or shoreline erosion process include:

#### **Clearing Natural Vegetation**

Often done by landowners to expand views or increase recreational areas, it destroys the roots of plants that provide significant streambank and shoreline stabilization.

#### **Construction or Development (Urbanization)**

Construction and development uphill of a streambank or shoreline can result in increased stormwater runoff, resulting in increased pollutant and sediment loads to the waterbody. Urbanization can lead to extensive loss of natural vegetation along the streambanks and shorelines, which increases the rate of erosion.

#### **Impervious Surfaces and Structures (Stormwater Runoff)**

Pavement, buildings, roofs, drainage ditches, etc. increase the amount, velocity and energy of stormwater, resulting in more runoff being routed to streams and lakes (and less into the ground), and increasing erosion.

#### **Agricultural Practices**

These can modify the rate of erosion and increase levels of nutrients in streams and lakes. Agricultural practices, such as plowing, drainage ditches, irrigation and grazing, can increase the rate of erosion.

#### **Streambank or Shoreline Stabilization Projects**

Erecting seawalls and other such projects reduce habitat and commonly affect other properties due to the redirection of waves and energy away from the area in which the seawall was installed.

# Planning a Streambank or Shoreline Stabilization Project

Stream channel and shoreline erosion problems vary widely in type and scale, and there is no one measure that works in all cases. Stabilization structures and vegetative measures should be planned and designed by a design professional with experience in this field. Many of the practices involve the use of manufactured products and should be installed in accordance with the manufacturer's specifications. In ordered to determine what type of streambank or shoreline project needs to be implemented, you should first determine the severity of your erosion problem. Severe erosion covers a large area of bank (linear extent greater than three times average bank height) and is occurring at a rate in excess of one foot per year or a rate that is unacceptable for safety, environmental or economic reasons.

If your streambank or shoreline is severely eroded, you will need to stabilize the soil to promote plant growth. There are three general approaches to bank stabilization:

- Live Planting
- Bioengineering
- Hard Armoring

The best method for stabilizing and protecting your streambank or shoreline depends upon your specific situation. Factors to consider include the size and location of your stream or shoreline as well as the cause and severity of the erosion. In many cases, the best approach is to use a combination of methods. Before attempting any streambank or shoreline stabilization activities, you should obtain all applicable permits or approvals.

#### **Preferred Practices**

#### **Preserving the Natural Streambank or Shoreline**

Stabilization of your streambank or shoreline can be as simple as not mowing the grass or not cutting the trees and shrubs along the edge of the banks. This allows natural vegetation to grow or become re-established. A naturally vegetated shoreline has many benefits. It prevents contaminants or excess nutrients from entering the water; it prevents erosion caused by rain, wind, wave and ice action; and it provides food, shade and cover for fish and wildlife. If some vegetation must be removed, limit the amount. Try to prune trees and shrubs back instead of removing them altogether.

#### **Soil Bioengineering Systems**

Projects incorporating bioengineering practices using native riparian vegetation are preferred for streambank and shoreline stabilization. However, certain structural components of stabilization are highly effective and occasionally necessary. Natural approaches seek to restore hydrological and ecological balance by using methods that are structurally sound, economically feasible and ecologically sustainable. While there are many ways to protect an existing streambank/shoreline or restore an eroded one, choosing appropriate materials and design is important. Some methods may include planting native, deep-rooting vegetation, as well as bioengineering. Consult with a plant materials specialist for guidance on plant selection. Species that root easily, such as willows, are required for measures such as live staking and live fascines. Lists of Georgia's native vegetation for soil bioengineering and related systems are provided in the appendices.

## **Planting Densities**

EPD recommends that trees be planted at a density of 10 feet on center (ft o.c.) or 436 trees per acre. If planted alone, shrubs should be planted at an average density of 6 ft o.c. (1210 shrubs per acre) and groundcovers (4" containers) at an average density of 1.5 ft o.c. (19,360 containers per acre). When combined with planting trees, shrubs and/or groundcover may be planted at a density of 774 shrubs per acre and 18,150 containers per acre. Live stakes are typically planted at 2 ft o.c. Please reference <a href="http://www.soundnativeplants.com/calculator.htm">http://www.soundnativeplants.com/calculator.htm</a> for further planting density information.

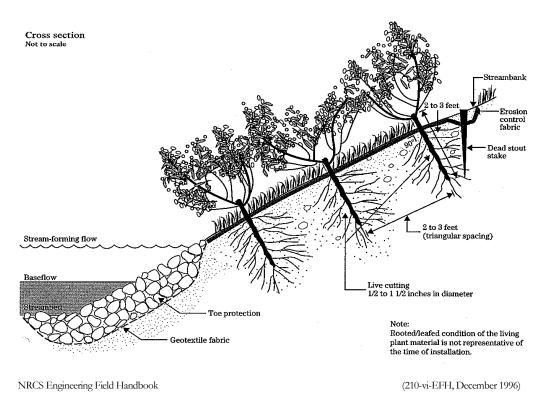
#### **Soil Bioengineering Systems**

Some of the most common and useful soil bioengineering systems for restoration and protection of streambanks and shorelines are described in the following sections.

#### **Live Staking**

Live stakes are living, woody plant cuttings capable of rooted when inserted into the banks. These stakes, commonly willow species, can root and grow into shrubs that overtime will stabilize the streambank or shoreline and provide riparian habitat.

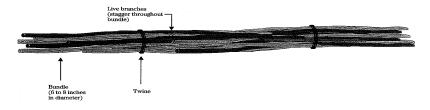
**Figure 1**. Live stake details



#### **Live Fascines (Fascine Rolls/Wattles)**

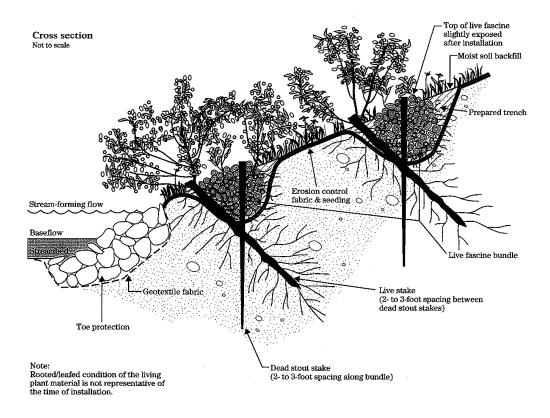
Live facines are bound bundles of live branch cuttings that are buried onto the bank and staked into place along the slope contour. Willow branches are the most commonly used for this method.

Figure 2. Live fascine details



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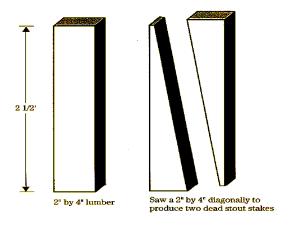
Figure 3. Live fascine details



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Figure 4. Preparation of a dead stout stake



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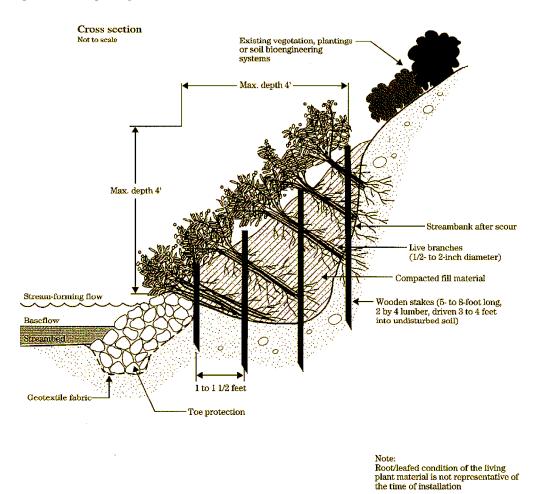
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Not to scale

#### **Branchpacking**

Branchpacking is the process of incorporating alternating layers of live branch cuttings and compacted soils into a hole, gully or slump. This method is used to fill in depressions along the streambank or shoreline.

Figure 5. Branchpacking details

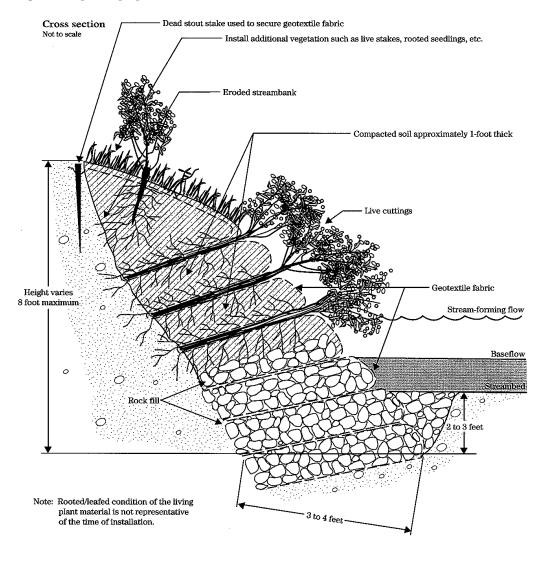


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#### **Vegetated Geogrid**

Vegetated geogrids are similar to branchpacking except that natural or synthetic geotextile materials are wrapped around each soil lift between the layers of live branch cuttings.

Figure 6. Vegetated geogrid details

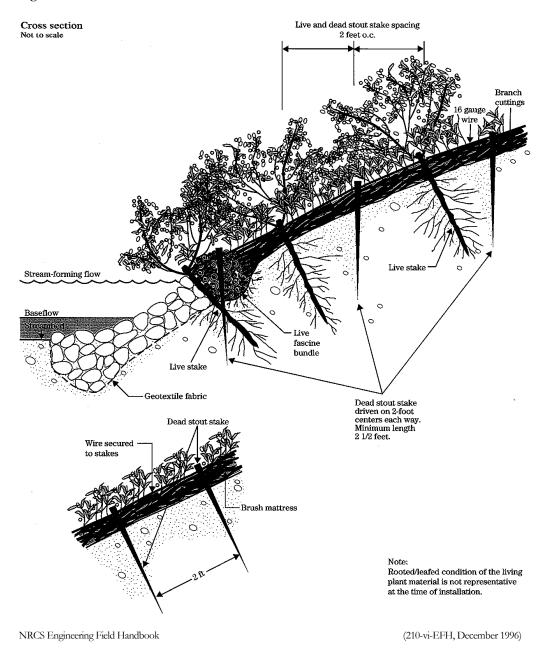


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#### **Brushmattress**

A brushmattress system consists of live branch cuttings, live stakes, and live fascines installed to cover and stabilize the entire streambank/shoreline and secured in place. This method is installed above the normal stream flow and provides immediate protective coverage of the bank.

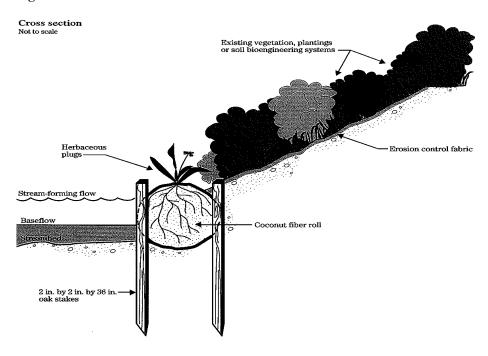
Figure 7. Brushmattress details

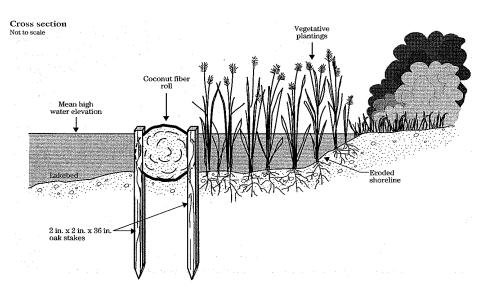


#### **Coconut Fiber Roll**

A coconut fiber roll is a flexible "log" made from coconut hull fibers, staked at the toe of the bank. The technique is often used in conjunction with native plants to trap sediment and encourage plant growth.

Figure 8. Coconut fiber rolls detail



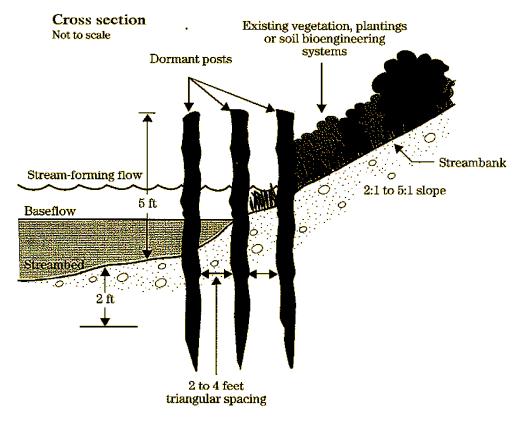


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#### **Dormant Post Plantings (Live Posts)**

Dormant post plantings form a permeable revetment that is constructed from rootable vegetative material placed along streambanks in a square or triangular pattern.

Figure 9. Dormant post details



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# **Acceptable Practices**

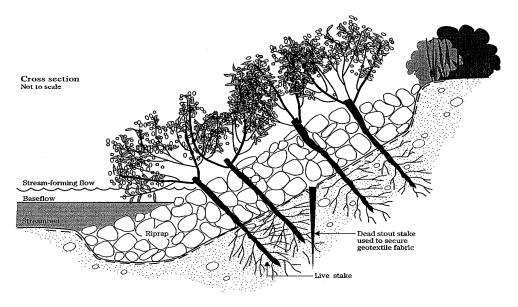
#### **Integrated Bioengineering Practices**

Acceptable stabilization methods are integrated bioengineering with one or more structural component useful in areas with higher velocity flows and/or wave action. This is most often appropriate at the "toe" of the bank or shoreline to prevent additional bank slumping. Structural components should be minimal and only used when necessary to ensure long-term success of the stabilization efforts.

#### **Joint Planting**

Joint planting or vegetated riprap involves tamping live stakes into joints or open spaces in rocks that have been placed on a slope. Vegetation, especially deep rooting species, planted above and immediately behind the rock will greatly increase the stability of the slope

Figure 10. Joint planting details



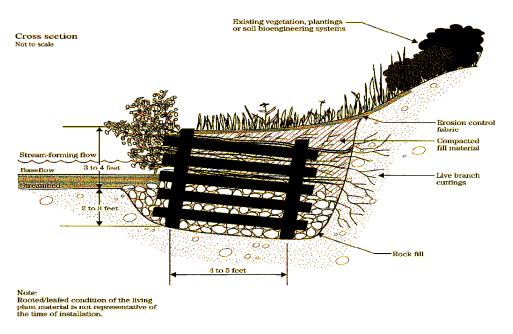
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#### **Live Cribwall**

A live cribwall is a box-like structure with a framework of logs or timbers, rock and live cuttings that can protect eroding streambanks or shorelines. Once live cuttings become established, mature vegetation gradually takes over the structural functions of the logs or timbers.

Figure 11. Live cribwall details

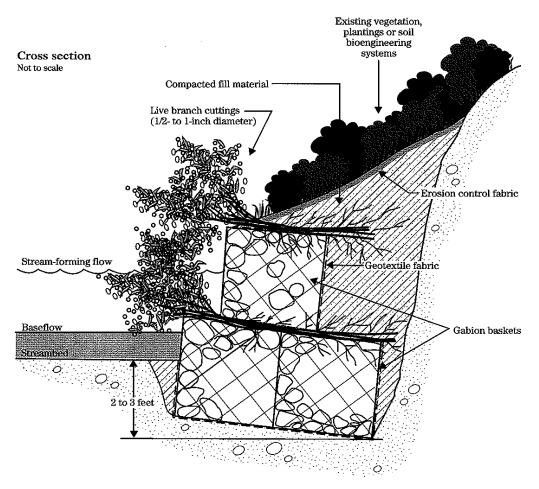


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#### **Vegetated Rock Gabions**

Gabion baskets are rectangular containers fabricated from a heavily galvanized steel wire or triple twisted hexagonal mesh. These empty gabions are placed in position, wired to adjoining gabions, filled with stones, and then wired shut. Vegetation is incorporated into rock gabions by placing live branches on each consecutive layer between the rock filled baskets.

Figure 12. Vegetated gabion details



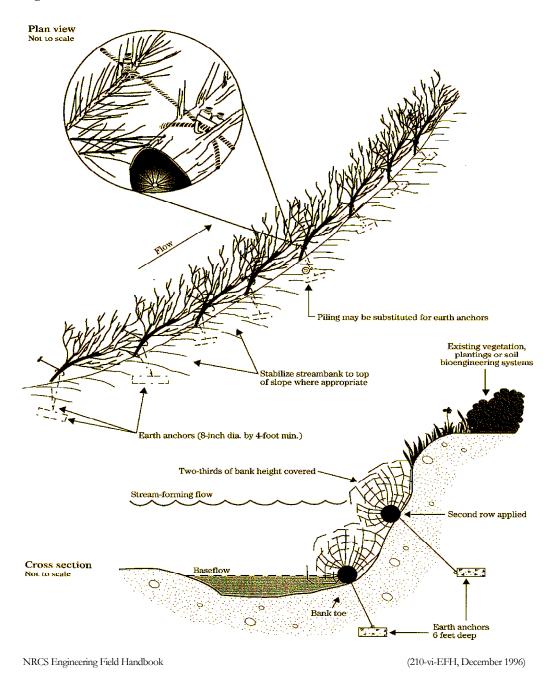
Note: Rooted/leafed condition of the living plant material is not representative of the time of installation.

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#### **Tree Revetments**

Tree revetments are rows of cut trees anchored to the toe of the bank. This is a low cost method, often used for toe protection with other bioengineering techniques.

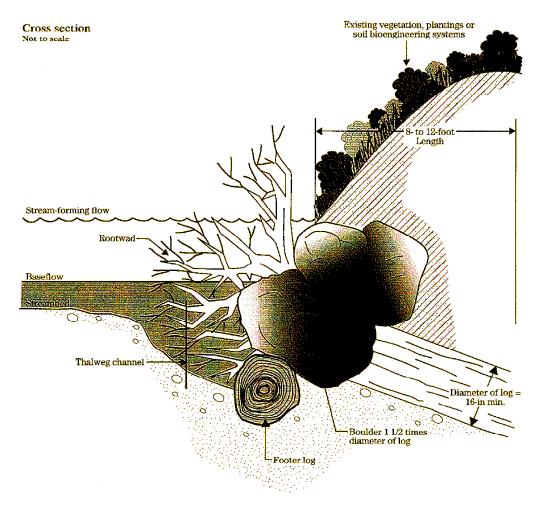
Figure 13. Tree revetment details



#### Log, Rootwad, and Boulder Revetments

These revetments are systems composed of logs, rootwads, and boulders selectively placed in and on streambanks.

Figure 14. Log, rootwad, and boulder revetment details



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# **Discouraged Practices**

Discouraged practices are structural practices with limited or minimally functional vegetation, or no re-vegetation. These are traditional and conventional methods of hard-armoring streambanks and shorelines to address erosion problems. These methods often degrade the quality of aquatic habitat and contribute to erosion in other areas, either downstream or along other shorelines. Since newer practices are available and more contractors are familiar with better stabilization practices, the use of hard armoring is discouraged, however, there are severely eroded locations where hard-armoring is necessary.

#### **Rock Riprap**

Riprap stabilization designs should include appropriate bank slope and rock size to protect the bank from wave and current action and to prolong the life of the embankment. A final slope ratio of at least 1:2 (vertical to horizontal) is recommended, and a more stable 1:3 slope should be used where possible.

A layer of gravel, small stone, or filter cloth placed under and/or behind the rock helps prevent failure. In many cases, only the toe of the slope may need rock reinforcement; the remainder can be planted with native vegetation.

Cross section
Not to scale

Existing vegetation, plantings or soil bioengineering systems

Erosion control fabric

Stream-forming flow

Top of riprap minimum thickness = maximum rock size

Gravel bedding, geotextile fabric, as needed

Bottom of riprap minimum thickness = 2 x maximum rock size

Figure 15. Rock riprap details

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#### **Rock Gabions**

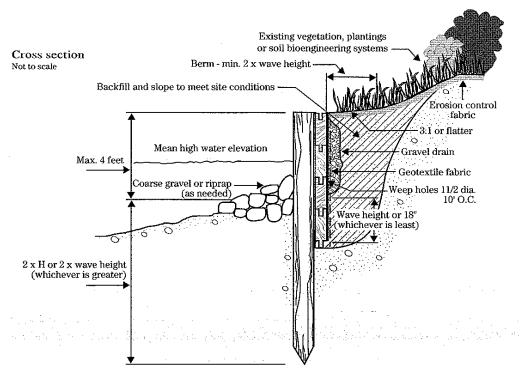
Rock gabions with vegetation are a more acceptable stabilization practice. See details for gabion baskets on page 13.

#### **Bulkheads and Seawalls**

Bulkheads and seawalls are not encouraged and generally are not approved. These structures (typically sheet steel, concrete or wood) produce a sterile, vertical, flat-faced object that is of little use to aquatic organisms and other wildlife. They also tend to reflect wave energy rather than dissipate it, usually resulting in erosion problems in front of the "fix" and elsewhere.

However, when erosive forces are severe, existing building foundations or structures are threatened, and other stabilization approaches would not be effective, a new or replacement retaining wall may be warranted. In these cases, rock should be placed at the toe to reduce the adverse impacts of reflected wave energy.

Figure 16. Timber bulkhead detail



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# **Summary**

Streambank and shoreline work should be proposed only when a problem exists and needs fixing (i.e., to stabilize identified erosion areas) - not to decorate, landscape or reclaim land. When work is necessary, natural approaches should be considered first. **Permits and buffer variances may be required from the following agencies:** 

#### U.S. Army Corps of Engineers

Savannah District 100 W. Oglethorpe Avenue Savannah, GA 31401 (912) 652-5279/5770

#### U.S. Fish and Wildlife Service

Southeast Region 1875 Century Blvd, Suite 400 Atlanta, GA 30345 (404) 679-4000

#### Georgia DNR - Environmental Protection Division

Watershed Protection Branch 4220 International Parkway, Suite 101 Atlanta, GA 30354 (404) 675-6240

#### Georgia DNR - Coastal Resources Division

One Conservation Way Brunswick, GA 31520 (912) 264-7218

#### Georgia DNR - Historic Preservation Division

254 Washington Street SW Atlanta, GA 30334 (404) 656-2840

Local Governments (Cities, Counties)

Other Entities (Utilities, Authorities)

Please contact appropriate agencies BEFORE beginning any stabilization activities.

### **Additional Resources**

#### **Plants**

Calculating Plant Quantities for Restoration Projects <a href="http://www.soundnativeplants.com/calculator.htm">http://www.soundnativeplants.com/calculator.htm</a>

Sources for Native Plants and Seed <a href="http://gnps.org/resources/Native Nurseries.php">http://gnps.org/resources/Native Nurseries.php</a>

#### **Streambank and Shoreline Stabilization**

Guidelines for Streambank and Shoreline Restoration <a href="http://www.files.georgia.gov/SWCC/Files/Guidelines">http://www.files.georgia.gov/SWCC/Files/Guidelines</a> Streambank Restoration.pdf

Natural Resources Conservation Service – Handbooks – Part 650 Engineering Field Handbook, Chapter 16 Streambank and Shoreline Protection <a href="http://directives.sc.egov.usda.gov/">http://directives.sc.egov.usda.gov/</a>

The Shoreline Stabilization Handbook <a href="http://nsgd.gso.uri.edu/lcsg/lcsgh04001.pdf">http://nsgd.gso.uri.edu/lcsg/lcsgh04001.pdf</a>

Streambank and Shoreline Stabilization Guidance <a href="http://www.gaepd.org/Files-PDF/techguide/wpb/Streambank">http://www.gaepd.org/Files-PDF/techguide/wpb/Streambank</a> and Shoreline Stabilization <a href="Guidance.pdf">Guidance.pdf</a>

Appendix A – Woody Plants for Soil Bioengineering and Associated Systems in Georgia

Scientific Name	Common Name	Plant Type	Region *	Establishment Speed	
Acer negundo	boxelder	small to medium tree		fast	
Acer rubrum	red maple	medium tree	M, P, C	fast	
Alnus serrulata	smooth alder	large shrub	M, P, C	medium	
Amorpha fruitcosa	false indigo	shrub	M, P, C	fast	
Aronia arbutifolia	red chokeberry	shrub	M, P, C	fast	
Asimina triloba	pawpaw	small tree	M, P, C		
Betula nigra	river birch	medium to large tree	M, P, C	fast	
Carpinis caroliniana	american hornbeam	small tree	M, P, C	slow	
Carya cordiformis	bitternut hickory	tree	P, C		
Catalpa bignonioides	southern catalpa	tree	P, C	fair	
Celtis laevigata	sugarberry	medium tree	P, C	slow	
Celtis occidentalis	hackberry	medium tree	P, C	slow	
Cephalanthus occidentalis	buttonbush	large shrub	M, P, C	medium	
Chionanthus virginicus	fringe tree	small tree	P, C		
Clethera ainifolia	sweet pepperbush	shrub	P, C		
Cornus amomum	silky dogwood	small shrub	M, P	medium	
Cornus florida	flowering dogwood	small tree	M, P, C	fair	
Cyrilla racemiflora	titi	small tree	С		
Diospyros virginiana	persimmon	medium tree	M, P, C	fair	
Fraxinus caroliniana	carolina ash	large tree	C	fast	
Fraxinus pennsylvanica	green ash	medium tree	M, P, C	fast	
Gleditsia triacanthos	honeylocust	medium tree	P. C	fast	
Hibiscus aculeatus	hibiscus	shrub	P, C C		
Ilex coriacea	sweet gallberry	small to large shrub	C		
Ilex decidua	possomhaw	large shrub to small tree			
Ilex glabra	bitter gallberry	small shrub	P, C C		
Ilex opaca	american holly	small tree	M, P, C	medium	
Ilex verticillata	winterberry	small to large shrub	M, P		
Ilex vomitoria	yaupon	large shrub	C		
Juglans nigra	black walnut	medium tree	M, P	fair	
Juniperus virginiana	eastern redcedar	large tree	M, P, C	medium	
Leucothoe axillaries	leucothoe	small to large shrub	C		
Lindera benzoin	spicebush	shrub	M		
Liquidambar	sweetgum	large tree	M, P, C		
styraciflua					
Liriodendron tulipifera	tulip poplar	large tree	M, P	fast	
Lyonia lucida	fetterbush	small to large shrub	С		

Scientific Name	Common Name	Plant Type Region *		Establishment Speed	
Magnolia virginiana	sweetbay	small tree	P, C		
Myrica cerifera	southern waxmyrtle	small shrub	С	slow	
Nyssa aquatica	swamp tupelo	large tree	С	slow	
Nyssa ogeeche	ogeeche lime	large shrub to small tree	С	medium	
Nyssa sylcatica	blackgum	tall tree	M, P, C	slow	
Ostrya virginiana	hophornbean	small tree	M, P, C	slow	
Persea borbonia	redbay	small to large tree	С	slow	
Platanus occidentalis	sycamore	large tree	M, P, C	fast	
Populus deltoides	eastern cottonwood	tall tree	M, P, C	fast	
Quercus alba	white oak	large tree	M, P, C	slow	
Quercus laurifolia	swamp laurel oak	tree	С	fast	
Quercus lyrata	overcup oak	medium tree	P, C	slow	
Quercus michauxii	swamp chestnut oak	medium tree	M, P, C	fair	
Quercus nigra	water oak	medium tree	M, P, C	slow	
Quercus palustris	pin oak	large tree	M	fast	
Quercus phellos	willow oak	medium to large tree	M, P, C	medium	
Quercus shumardii	shumard oak	large tree	P, C	slow	
Rhododendron atlanticum	coast azalea	small shrub	P, C		
Rhododendron viscosum	swamp azalea	shrub	P, C		
Salix nigra	black willow	small to large tree	M, P, C	fast	
Taxodium distichum	baldcypress	medium tree	С	fast	
Tsuga canadensis	eastern hemlock	large tree	M	slow	
Viburnum nudum	swamp haw	large shrub	M, P, C		

<sup>\*</sup>M=Mountain, P=Piedmont, C=Coastal

**NOTE:** EPD recommends that trees be planted at a density of 10 feet on center (ft o.c.) or 436 trees per acre. If planted alone, shrubs should be planted at an average density of 6 ft o.c. (1210 shrubs per acre) and groundcovers (4" containers) at an average density of 1.5 ft o.c. (19,360 containers per acre). When combined with planting trees, shrubs and/or groundcover may be planted at a density of 774 shrubs per acre and 18,150 containers per acre. Live stakes are typically planted at 2 ft o.c. Please reference <a href="http://www.soundnativeplants.com/calculator.htm">http://www.soundnativeplants.com/calculator.htm</a> for further planting density information.

Appendix B - Plants Suitable for Rooting as Cuttings (Live Stakes) in Georgia

Scientific Name	Common	Plant Type	Rooting	Region	
	Name		Ability*		
Acer negundo	boxelder			M, P, C	
Asimina triloba	pawpaw	small tree	poor to fair	M, P, C	
Baccharis halimifolia	groundsel bush	medium shrub	good	P, C	
Cephalanthus	buttonbush	large shrub	fair to good	M, P, C	
occidentalis					
Cornus amomum	silky dogwood	small shrub	fair	M, P	
Cornus sericia	red osier			M, P	
	dogwood				
Gleditsia triacanthos	honeylocust	medium tree	poor to fair	P, C	
Populus deltoides	eastern	tall tree	very good	M, P, C	
	cottonwood				
Robinia sp.	black locust			Р, М	
Salix discolor	pussy willow	large shrub	very good		
Salix nigra	black willow	small to large tree	good to excel	M, P, C	
Salix purpurea	purpleosier	medium tree	excel	M, P, C	
	willow				
Sambucus	american elder	medium shrub	good	M, P	
canadensis					
Viburnum dentatum	arrowwood	medium to tall shrub	good	M, P, C	
Viburnum lentago	nannyberry	large shrub	fair to good	M, P, C	

<sup>\*</sup>Rooting ability from cutting

Appendix C – Grasses and Forbs Useful in Conjunction with Soil Bioengineering and Associated Systems in the Southeast

Scientific Name	Common	Soil Preference	Drought	Shade	Flood
	Name		Tolerance	Tolerance	Tolerance
Ammophila	american	sands	fair	poor	
breviligulata	beachgrass				
Andropogon gerardii	big bluestem	loams	good	poor	fair
Arundo donax	giant reed	sandy	good	poor	poor
Herarthria altissima	limpograss	sandy	poor	poor	good
Panicum amarulum	coastal	sands to loams	good	poor	good
	panicgrass				
Panicum virgatum	switchgrass	loams to sands	good	poor	good
Paspalum	seashore	sandy		poor	good
vaginatum	paspalum				
Pennisetum	elephant grass			poor	
purpureum					
Spartina pectinata	prarie cordgrass	sands to loams	good	fair	fair
Zizaniopsis miliacea	giant cutgrass	loam	poor	poor	good



Georgia Environmental Protection Division Watershed Protection Branch 4220 International Parkway, Suite 101 Atlanta, GA 30354 (404) 675-6240

www.gaepd.org



Georgia Soil and Water Conservation Commission State Headquarters 4310 Lexington Road P. O. Box 8024 Athens, GA 30603 (706) 552-4470

www.gaswcc.georgia.gov



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