Jamie L. Whitten Plant Materials Center

Coffeeville, MS

Vol. 12 No. 2 Technical Note September 1996

BIOTECHNICAL EROSION CONTROL

Joseph A. Snider

ABSTRACT

The need exists for effective, low cost conservation measures to stabilize steep slopes, streamchannels, shorelines and other critical areas in the southeastern United States. This study was conducted to evaluate the potential of selected plant species and Biotechnical Erosion Control (BEC) techniques for streambank stabilization in the Mid-South. Plantings were first conducted in a constructed aquatic cell at the Jamie L. Whitten Plant Materials Center (PMC). Subsequent plantings were established on Goodwin Creek, located in Panola County, Mississippi, to evaluate local riparian species and selected PMC plant accessions under natural streamchannel conditions. At the site, plantings were subjected to swift floodwaters, sediment deposition, erosion, harsh environments and predation by beavers. The shrub willows, *Salix spp.*, and giant reed, *Arundo donax*, consistently demonstrated superior establishment ability. Once established, these species provided streambank protection, encouraged colonization of other plant species, and improved aquatic and wildlife habitat. The application of BEC technology is very labor intensive, but a high benefit to cost ratio is obtainable.

INTRODUCTION

Inexpensive, practical, effective, and adaptable means of protecting steep, unstable slopes, and eroding streambanks and shorelines are needed to supplement current conservation measures recommended for the PMC service area. Biotechnical Erosion Control methods, also called soil bioengineering, combines the use of specialized plant materials with engineering and plant science principles, and provide a cost effective alternative to the use of rock, steel and concrete for critical area stabilization. Biotechnical erosion control measures were widely used prior to the last half century before being made obsolete by large earthmoving equipment and an array of constructed structures. Use of BEC technology is now being revived and viewed as a viable option for use with or as an alternative to many standard engineering practices. Where successfully applied, BEC practices and materials also provide environmental benefits, and improve fishery and wildlife habitat. Biotechnical Erosion Control technology encompasses a broad array of available plant materials, techniques, and applications. Detailed information may be found in the USDA Engineering Field Handbook (1992).

In the service area of the PMC, there are many miles of stream channels needing bank stabilization. Relatively high rainfall and highly erodible streambank materials, coupled with the absence of channel bed geological controls produce rapid bank erosion and streambed degradation. Tons of soil are lost each year to this process. Channel erosion varies, but incised channel widening of 100-300% can occur in a relatively short (20-30 year) period (Whitten and Patrick, 1981). On Goodwin Creek, sediment yield from the widening channel is large, with mean yield over a five year period measuring 2.9 tons/yard/year (Grissinger et al., 1991). As the streambed degrades, the bank becomes steeper and the chance of failure increases proportionally, especially when the soil becomes saturated. Massive bank caving occurs when gravitational forces exceed soil strength. Streambank vegetation helps prevent caving by removing excess soil moisture through transpiration. Root systems provide additional mechanical reinforcement to the bank (Dickerson, 1992).

Objective of this study was to evaluate the performance of selected riparian herbaceous and woody species and BEC techniques. Criteria evaluated were ease of establishment, planting procedure, root and stem development, survival, and effectiveness after storm events.

In 1992, a BEC technique utilizing bundles of live stems or fascines was evaluated at the PMC. Fascine bundles of one herbaceous and six woody species were placed at three moisture regimes and evaluated for rooting, stem growth and survival. In 1993, the PMC conducted further trials on Goodwin Creek using live woody fascine bundles, live woody stake plantings, and herbaceous rhizome and plug planting techniques. A number of locally available riparian species and selected PMC accessions were screened to determine establishment methods and BEC suitability under natural streambank conditions.

The Goodwin Creek site is well documented in USDA, Agricultural Research Service (ARS), National Sedimentation Laboratory reports. The ARS has extensively monitored the site and recorded storm events, floodwater velocities, sediment yield, and cross sectional changes in the stream channel (Murphy et al., 1985, Grissinger et al., 1991).

MATERIALS AND METHODS

A. PMC Evaluations:

Live fascine trials utilizing both PMC accessions and locally available woody riparian species were tested under three moisture regimes to determine installation recommendations and plant response. These include:

Type	**Common name**	**Species**	**Accession**
shrub	prairie willow	*Salix humilis*	9004886
shrub	Bankers willow	*Salix x cotteti*	434285
shrub	erect willow	*Salix rigida*	900488
shrub	gilg willow	*Salix gilgiana*	9004882
shrub	autumn olive	*Elaeagnus umbellata*	local
tree	black willow	*Salix nigra*	local
tree	river birch	*Betula nigra*	local
herbaceous	giant reed	*Arundo donax*	432432

Fascine bundles were constructed of live dormant stems harvested in early March. Bundle size averaged four inches in diameter and were four to six feet in length. Stem size of the individual whips ranged from 5/16 inch to 1 1/2 inch caliper with stem size varying according to species. Ties were placed around the grouped stems at 18 inch intervals to secure the stems into compact bullet shaped bundles. Bundles were placed horizontally into shallow trenches in each of three moisture regimes and covered, leaving only a few stems on the upper edge of the bundle exposed. The three moisture regimes included: (a) saturated or partially inundated soils at waterline (b) moist, non-saturated soil four inches above waterline (c) well-drained soil 12 inches above waterline. The site utilized for these trials was a constructed aquatic cell in which the water level could be regulated. The bundles were removed from the cell after one growing season and shoot and root development were evaluated.

B. Goodwin Creek Evaluations:

In 1993, stream plantings were begun on Goodwin Creek. Initially, seven herbaceous species and fourteen woody species were planted at the site. These included:

Type	**Common name**	**Species**
herbaceous	'Alamo' switchgrass	Panicum virgatum
herbaceous	'Flageo' marshhay cordgrass	*Spartina paten*
herbaceous	eastern gamagrass	*Tripsacum dactyloides*
herbaceous	'Halifax' maidencane	*Panicum hemitomon*

herbaceous	switchcane	*Arundinacea gigantea*
herbaceous	giant reed	*Arundo donax*
herbaceous	soft rush	*Juncus effusus*
woody	boxelder	*Acer negundo*
woody	eastern cottonwood	*Populus deltoide*s
woody	italian hybrid popular	*Populus x canadensis*
woody	sycamore	*Platanus occidentalis*
woody	river birch	*Betula nigra*
woody	button willow	*Cephlalanthus occidentalis*
woody	american hazelnut	*Corylus americana*
woody	smooth alder	*Alnus serrulata*
woody	european black alder	*Alnus glutinosa*
woody	stream alder	*Alnus rugos*a
woody	'Bankers' dwarf willow	*Salix x cotteti*
woody	gilg willow	*Salix gilgiana*
woody	erect willow	*Salix rigida*

Three additional shrub species planted adjacent to the channel in 1994 included:

woody	sandbar willow	*Salix exigua*
woody	'Ruby' redosier dogwood	*Cornus sericea*
woody	'Streamco' purpleosier willow	*Salix purpurea*

Site conditions varied and presented an opportunity to try the plant materials on different soils, slopes, and exposures along the channel. These were established using live stake and live fascine bundle planting techniques.

Live stakes were made from sections of woody materials three feet in length ranging in diameter (caliper) from 3/4 to 1 1/2 inch. An iron bar was driven into the ground and worked to form holes of sufficient size for placement of the live stakes. The stakes were inserted 2/3 their length, leaving 1 foot of stake exposed. Soil was then refilled around each stake and compacted.

Live fascine bundles were similar in construction as used in trials at the PMC. These bundles were installed on a gently sloping gravel bar where deposition was occurring and on a low, exposed, vertical cut bank that was being subjected to erosion. On the sand and gravel bar, the bundles were placed in a slightly inclined position in shallow trenches near the stream. The bottom of the trench was at water table level. The lower 2/3 of each bundle was completely covered with sand or gravel and the tip end or upper 1/3 of the bundle was left exposed. Bundles were oriented so that they lay at a 45 degree angle to the flow of the stream, with the base end of the bundles angled downstream. On the low, vertical cut bank, trenches were carved into the bank and the lower section of the bundles were embedded in a steeply inclined position. The base of the bundles was immersed below waterline and the upper portion usually extended above the top of the bank. Each bundle was secured to stakes to prevent movement or loss from high velocity flows.

Herbaceous species were planted along the waters edge and on a steep vertical bank using seedling plugs and rhizome material. At planting, a 21 gram slow release fertilizer tablet (20-10-5 of N-P-K) was inserted by each plant, stake or rhizome. An additional 200 pounds per acre of 13-13-13 fertilizer was surface broadcast over the test area after planting.

SIGNIFICANT FINDINGS

A. PMC Evaluations

In fascine bundle trials conducted in constructed aquatic cells at the PMC, the willow species, with exception of the prairie willow, formed abundant roots and stem sprouts along the entire length of the fascine bundles. River birch produced few roots and stem sprouts, while autumn olive formed no roots or stems. Giant reed canes also did not form any roots or sprouts. However, canes were of the previous growing season which very rarely survive overwinter.

Moisture regime was strongly relational to establishment. Plant development was poorest in the inundated or saturated soil zone. Anaerobic conditions reduced both rooting and stem sprout development. Although plant response in the upper zone was good, the optimum moisture regime for plant growth was the area immediately above the water line. (Table 1). Soils in this regime remained moist, with favorable aerobic conditions existing for good root development.

B. Goodwin Creek evaluations

Techniques used in soil bioengineering are subject to both failure and success. Natural processes continue and plants may be damaged or destroyed before they become firmly established and functional. Many of the materials planted at the Goodwin creek site failed to root or were washed out by major storm events. Fascine and live stake plantings of gilg, erect and Bankers willow species rooted and sprouted quickly, although many fascines washed away before becoming fully established. Redosier dogwood, sandbar willow, and Streamco willow live stake plantings rooted and made new top growth, but were not as vigorous as gilg, erect and Bankers willow live stakes. Most other woody species failed to root or had poor survival. Use of the fascine bundle technique has potential for rapid bank cover and protection, but being shallow planted, the fascines are subject to being uncovered by swift water before becoming fully established. Live stake plantings have not been adversely affected by deep sediment deposits or swift floodwaters, but have not made as rapid spread or cover as fascines bundles. Further investigation is needed to determine the density and design requirements of live stake and fascine plantings to insure acceptable survival rates and maximum bank protection.

During winter, the willows were utilized as a food source by beaver. This predation appears to benefit willow growth, forcing the plants to produce new stem sprouts. Introducing plant materials to the previously barren sand and gravel bars has created niches favorable for colonization by other plants. A diversity of plants is desirable in order to form a stable ecosystem for aquatic organisms and wildlife habitat improvement, and long term streambank protection.

Plantings of giant reed had good survival at Goodwin Creek It has withstood extreme competition, high velocity floodwater, and has made good growth even on deep, droughty sandbars. Giant reed rhizomes have large reserves of stored energy and can be successfully planted any month of the year, at depths from two to twelve inches (USDA, 1987). Within a growing season, rhizome increase from a single planting piece will provide a formidable barrier against bank erosion.

CONCLUSIONS

The shrub willow species and giant reed show strong potential for use in streambank stabilization. Their long, slender, flexible stems help slow swift floodwaters and enable the current to drop some of its sediment load. These flexible stems can bend against the weight of large debris, and reduces the chance of creating stream blockages. Lower decumbent stems of the shrub willows root as sediments accumulate around them. These interlocking root systems provide additional mechanical reinforcement to the streambank. Live fascines bundles and live stake plantings are practical and inexpensive to install and shrub willows using these techniques have demonstrated their ability to root and sprout quickly. Survival and growth is good if not washed away before becoming established. To provide effective bank protection, large quantities of fascines and live posts are needed. A planting plan should be developed describing the plant spacing and layout of the materials. A limiting factor may be obtaining sufficient amounts of the desired plant materials to carry out the plan.

REFERENCES

Dickerson, John. Unpublished notes, "Introduction to Biotechnical Erosion Control". USDA-SCS. Syracuse, New York, 1992.

Grissinger, E.H., A.J. Bowie, and J.B. Murphey. 1991. Goodwin Creek Bank Instability and Sediment Yield. Proceedings of the Fifth Federal Interagency Sedimentation Conference (FIASC), PS32-PS39, Las Vegas, Nevada, 1991, Federal Energy Regulatory Commission.

Murphy, J.B., and E.H. Grissinger, 1985. Channel Cross-Sectional Changes in Mississippi's Goodwin Creek. Journal of Soil and Water Conservation 40 (1): 148-153.

USDA. 1992. Soil bioengineering for upland slope protection and erosion reduction. *In* National Engineering Field Handbook.210. U.S. Gov. Print. Office, Washington, DC.

USDA. 1987. Advanced evaluations of giant reed: I. Results of the monthly planting study. USDA-SCS. Coffeeville Plant Materials Center Tech. Note No. 3.

Whitten, C. B., and D.M. Patrick, 1981. Engineering Geology and Geomorphology of Streambank erosion (Report 2; Yazoo River Basin Uplands, Mississippi). Technical Report GL-79-7, Report 2 of a Series.

The United States Department of Agriculture (USDA) prohibits discrimination in its programs on the basis of race, color, national origin, sex, religion, age, disability, political beliefs and marital or familial status. (Not all prohibited bases apply to all programs). Persons with disabilities who require alternative means for communication of program information (braille, large print, audiotape, etc.) should contact the USDA Office of Communications at (202) 720-5881 (voice) or (202) 720-7808 (TDD).

To file a complaint, write the Secretary of Agriculture, U.S. Department of Agriculture, Washington, D.C., 20250, or call (202) 720-7327 (voice) or (202) 720-1127 (TDD). USDA is an equal employment opportunity employer.

Table 1: FASCINE RESPONSE AT THREE MOISTURE REGIMES

Species/ Accession	Number Sprouts	Sprout Stem Diameter	Sprout Stem Height	Root & Sprout Distribution
Arundo donax 432432				
Zone 1	0			- / - / W
Zone 2	0			- / - / W
Zone 3	0			- / - / W
Betula nigra				
Zone 1	10	1/8" - 1/4"	18" - 36"	C / 1 / Z
Elaeagnus umbellata				
Zone 1	0			- / - / W
Salix x cotteti 434285				
Rep 1 , Zone 1	87	1/8" - 1/4"	18" - 28"	A / 2 / X
Rep 1 , Zone 2	69	1/8" - 1/4"	18" - 24"	B,D / 2 / X
Rep 1 , Zone 3	82	1/8"	18" - 24"	B,D / 2 / Y
Rep 2 , Zone 1	73	1/8" - 1/4"	12" - 18"	B,C / 2 / X
Rep 2 , Zone 2	189	1/8" - 1/4"	18" - 24"	B / 3 / Y
Rep 2 , Zone 3	52	1/16" - 3/16"	12" - 16"	B,C / 1 / Z
Salix gilgiana 9004886				
Rep 1 , Zone 1	34	1/16" - 1/8"	12" - 18"	B,C / 2 / X
Rep 1 , Zone 2	104	1/8" - 3/8"	24" - 60"	A / 3 / X
Rep 1 , Zone 3	2	1/16"	6" - 8"	B / 1 / Z
Rep 2 , Zone 1	88	1/16"	6" - 24"	C / 2 / X
Rep 2 , Zone 2	132	1/4"	12" - 72"	A / 3 / Y
Rep 2 , Zone 3	30	1/8" - 1/4"	12" - 36"	A / 2 / Y
Salix humilis 9004886				
Zone 1	0			- / - / W
Zone 2	0			- / - / W
Zone 3	0			- / - / W
Salix rigida 9004885				
Rep 1 , Zone 1	77	1/8" - 5/16"	24" - 30"	A / 3 / X
Rep 1 , Zone 2	55	1/8" - 5/16"	24" - 36"	A / 3 / Y
Rep 1 , Zone 3	30	1/8" - 1/4"	18"- 36"	C / 2 / Y
Rep 2 , Zone 1	84	1/4"	6" - 14"	C / 2 / X
Rep 2 , Zone 2	127	1/4"	14" - 20"	A / 3 / Y
Rep 2 , Zone 3	175	1/4"	14" - 20"	A / 3 / Y

LEGEND:

Moisture Regime Zones
Zone 1: 12" above waterline
Zone 2: 1-3" above waterline
Zone 3: Inundated to 1" above waterline

Root and Sprout Distribution along fascine

A. Entire length of fascine
B. Butt 1/3 length of fascine
C. Middle 1/3 length of fascine
D. Tip 1/3 length of fascine

Fascine rooting ability

1. Sparse roots along fascine
2. Good root development along fascine
3. Massive root development along fascine

Fascine survival (original stems in bundle)

W. All fascine material dead
X. All fascine material living
Y. Only upper fascine stems in bundle living
Z. Only few scattered fascine stems in bundle living