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Biotechnical Streambank Protection: The use of plants to stabilize streambanks

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What Is It?

Biotechnical streambank protection utilizes living plant materials to reinforce soil and stabilize slopes. Plants can be used as the primary structural component or in combination with inert materials like rock, concrete, and steel to help stabilize streambanks. Many terms have been used to describe the engineering use of plant materials for slope stabilization (Figure 1). The Natural Resources Conservation Service (NRCS) uses the term Soil Bioengineering to describe the use of living plant material for soil reinforcement, hydraulic drains, barriers to earth movement, and hydraulic pumps or wicks. The underlying concept for all terms is the use of plants to reduce the erosive forces of water and increase soil's resistance to those erosive forces.

Biotechnical stabilization is not a new concept. Documented examples of its use date back to the Romans. There are numerous references from the 1930s that advocated biotechnical designs. The NRCS (previously the Soil Conservation Service) utilized extensive biotechnical techniques on the Winooski River Watershed project in Vermont that has been well documented since its installation in 1938. After World War II these techniques seemed to have lost favor to the hard engineering approaches that rely heavily on rock, concrete, and steel. However, the growing concern for more ecologically beneficial solutions has renewed interest in biotechnical approaches.

Benefits of biotechnical techniques

The primary benefits of using biotechnical techniques are stabilized streambanks and reduced bank erosion. Other benefits include:

- Improve water quality by reducing sediment
- Improve terrestrial and aquatic habitat
- Improve soil quality
- Increase moisture uptake
- Reduce cost
- Reduce water temperature by shading
- Increase riparian corridor continuity
- Improve aesthetics
- Reduce near bank stress
- Anchor or shield inert materials

Figure 1-Terms used to describe the use of plant materials in structural design.

- Biotechnical Stabilization
- Soil Bioengineering
- Bioengineering
- Water Bioengineering
- Green Construction
- Living Construction
- Green Engineering
- Natural Construction
- Biogeotechnology
- Ground Bioengineering
- Biotechnical Soil Stabilization
- Biotechnical Erosion Control

Installing a brushmattress, one of many biotechnical techniques.

Is it appropriate for your site?

The biotechnical approach provides numerous environmental benefits, but may not be appropriate in high-risk settings where immediate stabilization is needed. Other site conditions may also limit the use of biotechnical designs (Figure 2). However, biotechnical approaches can almost always be combined with hard engineering to add environmental benefits.

Figure 2- Some factors that may preclude a biotechnical solution

- Excessive channel shear
- Streambed instability may undermine bank treatment
- Soil pH<4 or Iron Sulfide present
- Soil depth <12 inches to bedrock
- Dense shade that limits plant growth
- Soil too droughty during growing season to support vegetation
- High streambank (>6 foot)
- Time of year (plants not dormant)
- Soil stability and seepage problems
- Depth of the failure

Understanding stream dynamics

Determining an appropriate design requires an understanding of stream dynamics. In some alluvial systems streams migrate across the valley floor. As they move across the landscape they erode the outside of meander curves and deposit sediment on the inside of curves. When the stream system is in balance this movement usually occurs at a slow, acceptable rate while maintaining its pattern, cross section, and profile. However, due to disturbances many stream systems are out of balance and exhibit accelerated bank erosion and down cutting streambeds. Biotechnical bank treatments can be effective in reducing the accelerated bank erosion, but are ineffective for streambed stabilization. If the streambed is actively down cutting, the imbalance between water and sediment loads entering upstream must be addressed or grade control measures will be needed prior to bank stabilization efforts.

Streambank protection can be very expensive and the decision to implement this or any other alternative needs to be carefully thought out. Understanding the cause of the erosion will help identify the appropriate remedy. Determine if the streambank instability is a result of local conditions (i.e. soil conditions, livestock, vegetation removal, etc.) or a watershed wide disturbance (i.e. land conversion, channel straightening, etc.). Efforts should be made to eliminate the cause of the disturbance. If this is impractical, establish a riparian buffer area where the stream can meander and establish its new equilibrium. Where adjacent land use does not allow for the natural movement of the stream, armoring the bank may be required to slow lateral channel migration. Traditionally, bank armoring has been done with inert materials such as rock; however, some biotechnical designs are also effective.

There are no hard and fast rules as to where to implement biotechnical protection. The occurrence of woody vegetation in stable adjacent reaches can be used as a guide. The bankfull elevation is a geomorphically significant point in many stream systems and can be used to help determine where to implement biotechnical techniques. Woody vegetation typically does not occur below the level of bankfull elevation.

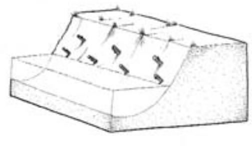
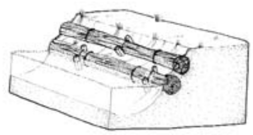
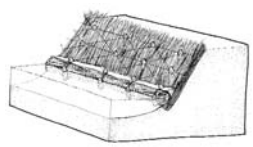
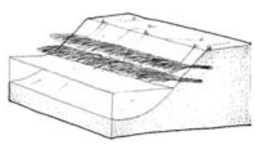
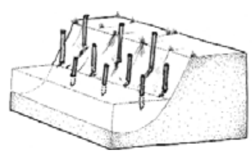
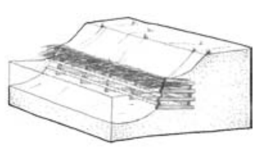
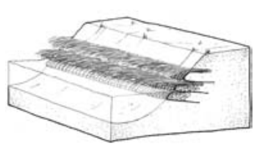
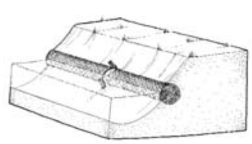
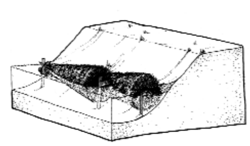
Overview of biotechnical techniques

The type of vegetation needed to stabilize streambanks will depend on specific site conditions. Grasses can be effective at increasing the soil's resistance to sheet and rill erosion, but may not be effective in protecting the streambank. In most situations, woody vegetation will be needed to withstand the stream's energy. Woody pioneer species that can root from stem or branch cuttings are commonly used for slope stabilization. The cuttings provide immediate mechanical protection when planted, and then add soil reinforcement and stability as they root and grow. Other plants can then invade the site and provide long-term protection.

There are numerous biotechnical designs (see Table 1). They vary from using only live cuttings, cuttings with erosion control matting, cuttings with inert structures, and dead tree revetments.

Selecting an appropriate biotechnical technique will depend on the type of erosion, the objectives of the project, local site conditions, budget, availability of plant materials and time of year. Table 1 provides guidance as to the type of erosion each technique is best suited to treat. Biotechnical approaches are well suited for local scour erosion and small slumps. On more extensive problems a decision needs to be made as to whether the objective is to attempt to halt the stream migration or to merely try and slow it to an acceptable rate. Most streambank erosion starts with the stream eroding away the base (also called the toe) of the channel bank, which creates an unstable bank slope that eventually collapses. The key to any bank treatment is securing the toe of the channel bank. If the toe of the slope is lost, the treatment used on the remaining slope will be undermined. Since most

Table 1: Examples of Common Biotechnical Streambank Protection Techniques

Schematic	Description	Type of erosion control	Comments
	**Live Stakes** (Pole planting) The insertion of live, rootable vegetative cuttings into the ground.	Bank scour	Suitable for simple erosion problem.
	**Fascines** Bundles of live cuttings tied together and placed in a shallow tranch parallel or diagonal to the slope.	Bank scour Overbank runoff	Useful on moderate to severe situations. Can be placed either perpen-dicular or diagonal to the slope.
	**Brushmattress** A combination live stakes, fascine and branches that cover a slope.	Bank scour Debris gouging	Generally limited to a slope less than 2:1. Height of protection limited by length of branches used.
	**Brushlayer** Layers of live branch cuttings placed in a trench perpendic-ular to the slope and back-filled.	Bank scour Gullies from overbank runoff	Can be used to fill small local slumps. Erosion matting is need to mini-mize erosion of backfill from stream water.
	**Post Planting** Dormant rootable posts placed in a square or triangular pattern to form a permeable revetment.	Bank scour	Can be used without bank shaping.
	**Vegetated Log Crib** Box-like interlocking arrange-ments of logs or timber that have layers of live branch cuttings.	Toe erosion Local slump or blowout Bank scour Shallow mass movement	Useful on vertical slopes that have limited room for bank shaping. Limit heights to 6' or less.
	**Vegetated Geogrid** Alternate layers of live branches and lifts formed by wrapping geotextile material around soil material.	Toe erosion Local slump or blowout Bank scour Shallow mass movement	Useful on vertical slopes that have limited room for bank shaping. Limit heights to 8' or less.
	**Vegetated Fiber Rolls** Cylindrical structures com-posed of coconut husk fiber bound together with coir twine.	Toe erosion	Usually vegetated with herbaceous material. Intended for temporary stabilization to let other materials colonize area.
	**Tree Revetments** A revetment composed of whole trees that are cabled together and anchored.	Toe erosion Bank scour	Provides temporary toe protection allowing local plants to colonize area. Live stakes or other treatment recommended upslope of the revetment.

woody plants do not grow in standing water, some inert material (rock, woody debris, etc.) is usually incorporated into the design to help armor the toe of the slope below the water line. Designs that do not incorporate an inert toe treatment (i.e. post plantings, tree revetments) only tend to slow rather than stop the channel migration process. For more information on planning see *AFN-24, SA-7: Planning Biotechnical Streambank Protection.*

Streambank stabilization design is complex and requires special expertise. An interdisciplinary approach is needed to develop an appropriate design. There are also many local, state and federal requirements that have to be met when installing a streambank stabilization project. Check with your local NRCS office or state department of natural resources office before beginning any streambank activities to determine what requirements you need to follow. Don't be afraid to ask for advice, there are many agencies that can assist you.

Additional Information

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