Stream Bank Erosion: Soil Bioengineering Solutions

The principal causes of streambank erosion can be classed as geologic, climatic, vegetative, and hydraulic. These causes may act independently, but normally work in an interrelated manner. Erosion is a normal occurrence that happens as a river or stream moves through its floodplain. Direct human activities, such as channel confinement, simplification, realignment and damage to or removal of streambank vegetation, are major factors in increasing abnormal stream channel and bank erosion.

The two basic categories of erosion protection measures are those that work by reducing the force of water against a streambank or shoreline and those that increase a streambanks resistance to erosive forces. Stormwater reduction or retention methods, stream bed grade reduction, and designs that reduce flow velocity within the stream itself fall into the former category (force reduction). These are typically very expensive, highly designed projects that affect the way water flows within a stream. The latter category includes measures that focus on the streambank itself including anything from riprap (large quarry rock) armoring to live vegetation soil bioengineering and a combination of manufactured and live material systems.

As a first priority consider those measures that

- begin by removing the source of disturbance if it is within the control of the landowner
- are self-sustaining or reduce requirements for future human support;
- use native, living materials for restoration and are therefore biodynamic;
- restore the physical, biological, and chemical functions and values of streams or shorelines;
- improve water quality through reduction of temperature and chronic sedimentation problems;
- provide opportunities to connect fragmented riparian areas; and retain or enhance the stream corridor or shoreline system

Soil bioengineering is a solution that can address moderate to localized streambank erosion depending upon the scale of erosion present. The general concept relies upon restoring strongly rooted, woody vegetation

Woody vegetation protects streambanks in several ways:

- Root systems help hold the soil particles together increasing bank stability.
- Vegetation may increase the hydraulic resistance to flow and reduce local velocities in small channels.
- Vegetation acts as a buffer against the hydraulic forces and abrasive effect of transported materials.
- Dense vegetation on streambanks can induce sediment deposition and build banks.
- Vegetation can redirect flow away from the bank.

Soil Bioengineering Techniques

IMPORTANT: digging or displacing (removal) or backfilling (fill) nonorganic material like soil, river cobble, gravel, concrete, etc., in the area below the ordinary high water line of a stream (typically below the perennial/woody vegetation line) may require a permit. Please consult a professional before planning on working in this area. You can be fined by the State of Oregon for unpermitted activity below the ordinary high water line.

Live Stakes

A system of stakes creates a living root mat that stabilizes the soil by reinforcing and binding soil particles together and by extracting excess soil moisture. Most willow species root rapidly and begin to dry out a bank soon after installation.

Applications and effectiveness

- Effective streambank protection technique where site conditions are uncomplicated, construction time is limited, and an inexpensive method is needed.
- Appropriate technique for repair of small earth slips and slumps that frequently are wet.
- Can be used to peg down and enhance the performance of surface erosion control materials.
- Enhance conditions for natural colonization of vegetation from the surrounding plant community.
- Stabilize intervening areas between other soil bioengineering techniques, such as live fascines.
- Produce streamside habitat.

Construction guidelines

Live material sizes—The stakes generally are 0.5 to 1.5 inches in diameter and 2 to 3 feet long. The specific site requirements and available cutting source determine sizes.

Live material preparation

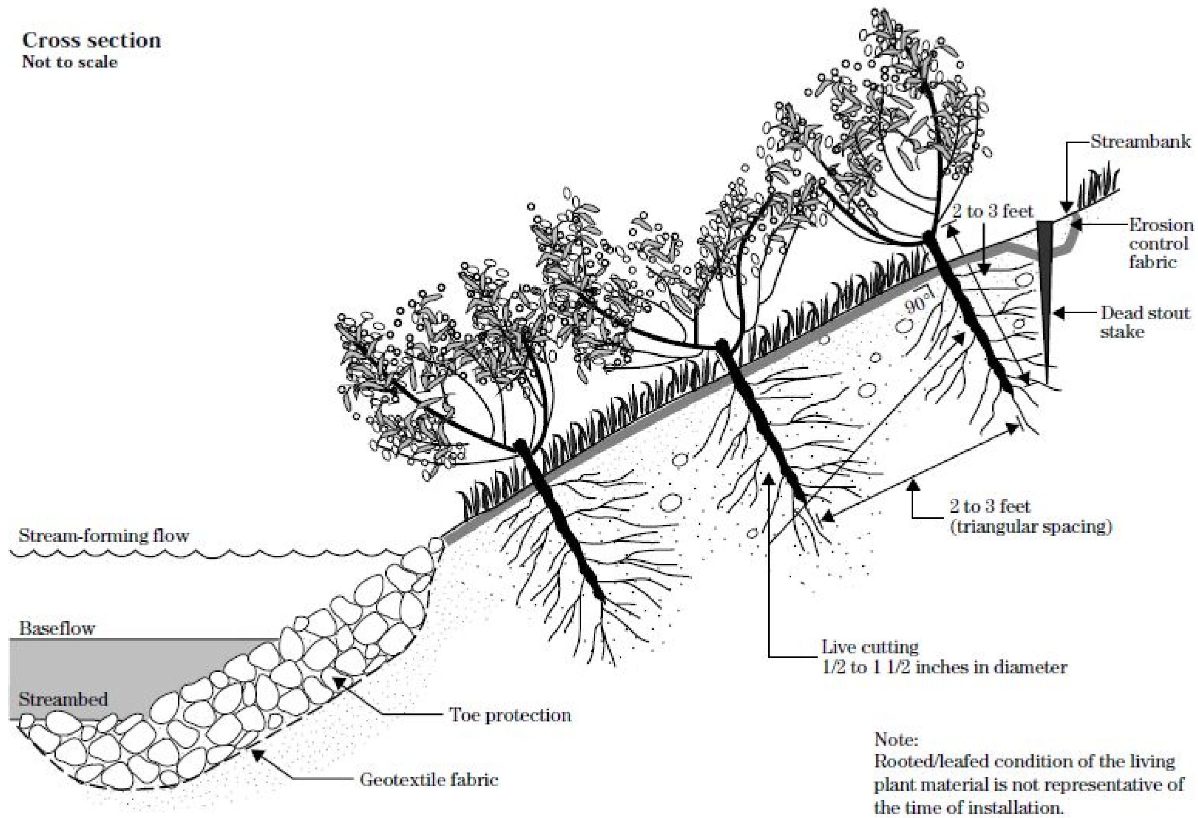
- The materials must have side branches cleanly removed with the bark intact.
- The basal ends should be cut at an angle or point for easy insertion into the soil. The top should be cut square.
- Materials should be installed immediately (same day) after harvest however research has shown that survival increases dramatically if material is allowed to soak for 12- 24hrs following harvest and then installed.

Installation

- Erosion control fabric should be placed on slopes subject to erosive inundation.
- Tamp the live stake into the ground at right angles to the slope and diverted downstream. The installation may be started at any point on the slope face.
- The live stakes should be installed 2 to 3 feet apart using triangular spacing. The density of the installation will range from 2 to 4 stakes per square yard. Site variations may require slightly
- Placement may vary by species. For example, along many western streams, tree-type willow species are placed on the inside curves of point bars where more inundation occurs, while shrub willow species are planted on outside curves where the inundation period is minimal.
- The buds should be oriented up.
- Four-fifths of the length of the live stake should be installed into the ground, and soil should be firmly packed around it after installation.
- Do not split the stakes during installation. Stakes that split should be removed and replaced.
- An iron bar can be used to make a pilot hole in firm soil.

• Tamp the stake into the ground with a dead blow hammer (hammer head filled with shot or sand).

Figure 16–4 Live stake details



Live fascines

Live fascines are long bundles of branch cuttings bound together in cylindrical structures (fig. 16–7). They should be placed in shallow contour trenches on dry slopes and at an angle on wet slopes to reduce erosion and shallow sliding.

Applications and effectiveness

• Apply typically above bankfull discharge (stream-forming flow) except on very small drainage area sites (generally less than 2,000 acres).
• Effective stabilization technique for streambanks. When properly installed, this system does not cause much site disturbance.
• Protect slopes from shallow slides (1 to 2 foot depth).
• Offer immediate protection from surface erosion.
• Capable of trapping and holding soil on a streambank by creating small dam-like structures, thus reducing the slope length into a series of shorter slopes.
• Serve to facilitate drainage where installed at an angle on the slope.

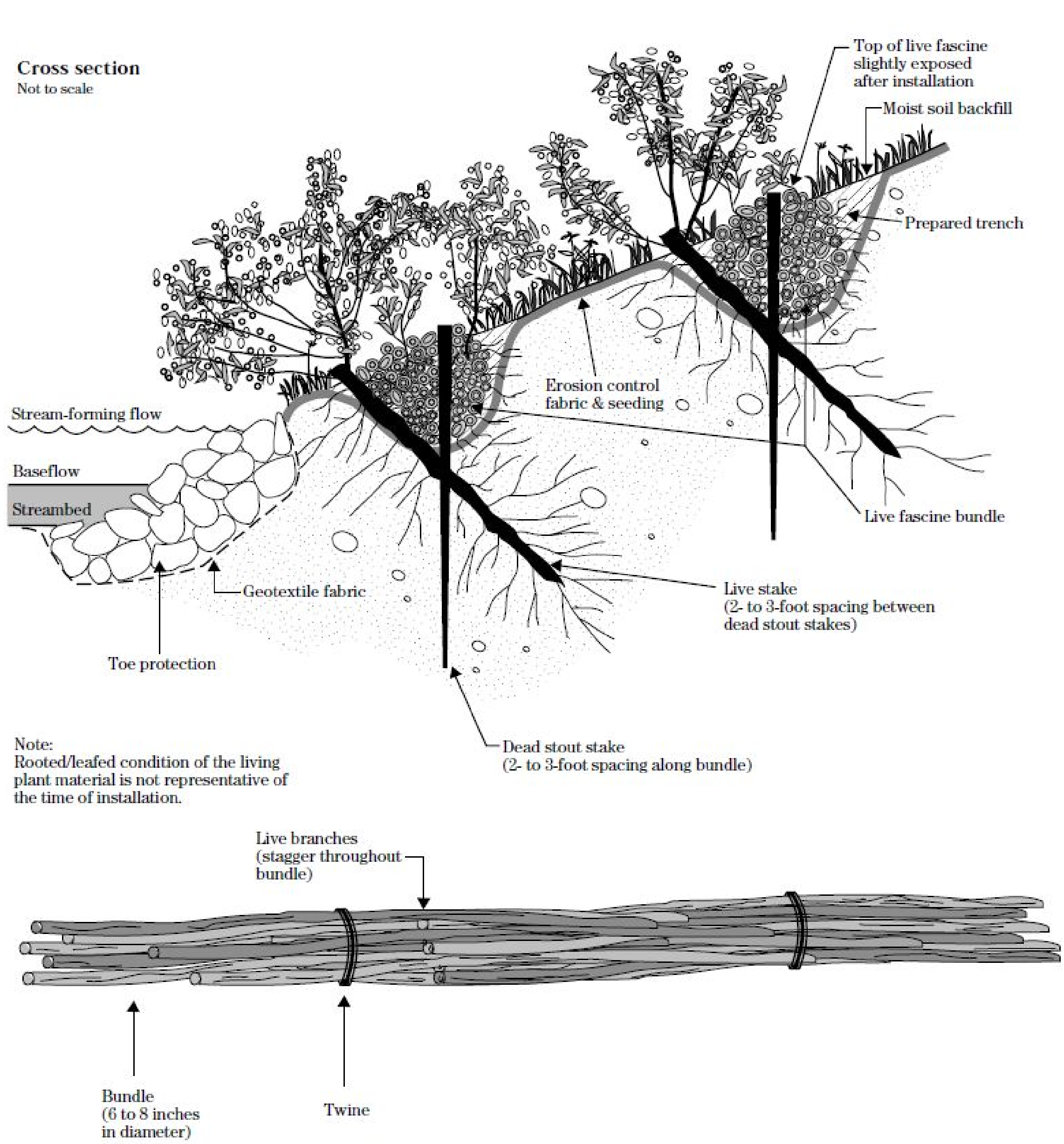
• Enhance conditions for colonization of native vegetation by creating surface stabilization and a microclimate conducive to plant growth.

Construction guidelines
Live materials—Cuttings must be from species, such as young willows or shrub dogwoods that root easily and have long, straight branches.

Live material sizes and preparation
• Cuttings tied together to form live fascine bundles normally vary in length from 5 to 10 feet or longer, depending on site conditions and limitations in handling.
• The completed bundles should be 6 to 8 inches in diameter, with all of the growing tips oriented in the same direction. Stagger the cuttings in the bundles so that tops are evenly distributed throughout the length of the uniformly sized live fascine.
• Live stakes should be 2.5 feet long. Inert materials—String used for bundling should be untreated twine. Dead stout stakes used to secure the live fascines should be 2.5-foot long, untreated, 2 by 4 lumber. Each length should be cut again diagonally across the 4-inch face to make two stakes from each length (fig 16–8). Only new, sound lumber should be used, and any stakes that shatter upon installation should be discarded.

Installation
• Prepare the live fascine bundle and live stakes immediately before installation.
• Beginning at the base of the slope, dig a trench on the contour approximately 10 inches wide and deep.
• Excavate trenches up the slope at intervals specified in table 16–1. Where possible, place one or two rows over the top of the slope.
• Place long straw and annual grasses between rows.
• Install jute mesh, coconut netting, or other acceptable erosion control fabric. Secure the fabric.
• Place the live fascine into the trench (fig. 16–9a).
• Drive the dead stout stakes directly through the live fascine. Extra stakes should be used at connections or bundle overlaps. Leave the top of the dead stout stakes flush with the installed bundle.
• Live stakes are generally installed on the downslope side of the bundle. Tamp the live stakes below and against the bundle between the previously installed dead stout stakes, leaving 3 inches to protrude above the top of the ground (fig. 16–9b). Place moist soil along the sides of the bundles. The top of the live fascine should be slightly visible when the installation is completed. Figure 16–9c shows an established live fascine system 2 years after installation is completed.

Figure 16–7 Live fascine details



Branch Packing

Branch packing consists of alternating layers of live branches and compacted backfill to repair small localized slumps and holes in streambanks (figs. 16–10, 16–11a, 16–11b, and 16–11c).

Applications and effectiveness

- Effective and inexpensive method to repair holes in streambanks that range from 2 to 4 feet in height and depth.
- Produces a filter barrier that prevents erosion and scouring from streambank or overbank flow.
- Rapidly establishes a vegetated streambank.
- Enhances conditions for colonization of native vegetation.
- Provides immediate soil reinforcement.

• Live branches serve as tensile inclusions for reinforcement once installed. As plant tops begin to grow, the branch packing system becomes increasingly effective in retarding runoff and reducing surface erosion. Trapped sediment refills the localized slumps or hole, while roots spread throughout the backfill and surrounding earth to form a unified mass.
• Typically branch packing is not effective in slump areas greater than 4 feet deep or 4 feet wide.

Construction guidelines

Live materials—Live branches may range from 0.5 to 2 inches in diameter. They should be long enough to touch the undisturbed soil of the back of the trench and extend slightly from the rebuilt streambank. Inert materials—Wooden stakes should be 5 to 8 feet long and made from 3- to 4-inch diameter poles or 2 by 4 lumber, depending upon the depth of the particular slump or hole being repaired.

Installation

• Starting at the lowest point, drive the wooden stakes vertically 3 to 4 feet into the ground. Set them 1 to 1.5 feet apart.
• Place an initial layer of living branches 4 to 6 inches thick in the bottom of the hole between the vertical stakes, and perpendicular to the slope face (fig. 16–10). They should be placed in a criss-cross configuration with the growing tips generally oriented toward the slope face. Some of the basal ends of the branches should touch the undisturbed soil at the back of the hole.
• Subsequent layers of branches are installed with the basal ends lower than the growing tips of the branches.
• Each layer of branches must be followed by a layer of compacted soil to ensure soil contact with the branches.
• The final installation should conform to the existing slope. Branches should protrude only slightly from the filled installation.
• Water must be controlled or diverted if the original streambank damage was caused by water flowing over the bank. If this is not done, erosion will most likely occur on either or both sides of the new branch packing installation.

Figure 16–10 Branchpacking details

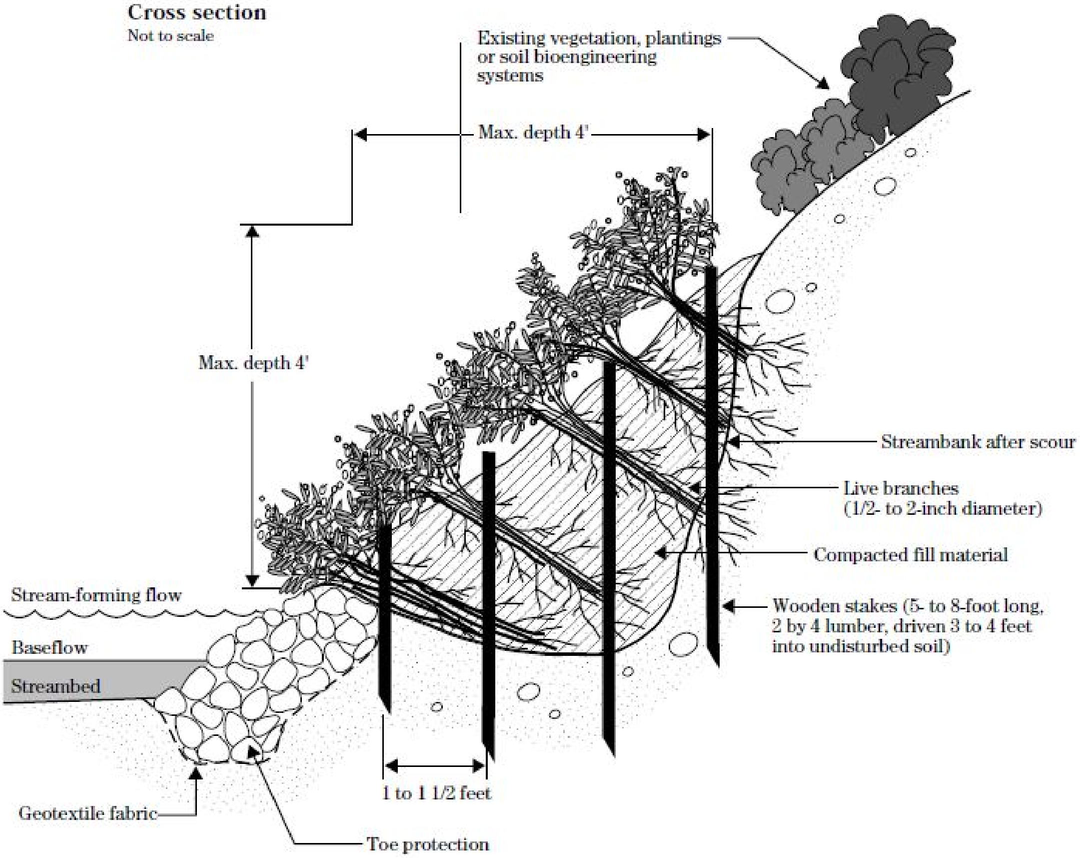


Figure 16–11a Live branches installed in criss-cross configuration (Robbin B. Sotir & Associates photo)

Figure 16–11b Each layer of branches is followed by a layer of compacted soil (Robbin B. Sotir & Associates photo)

Brush mattress

A brush mattress is a combination of live stakes, live fascines, and branch cuttings installed to cover and stabilize streambanks (figs. 16–18, 16–19a through 16–19d). Application typically starts above stream-forming flow conditions and moves up the slope.

Applications and effectiveness

• Forms an immediate, protective cover over the streambank.
• Useful on steep, fast-flowing streams.
• Captures sediment during flood conditions.
• Rapidly restores riparian vegetation and streamside habitat.
• Enhances conditions for colonization of native vegetation.

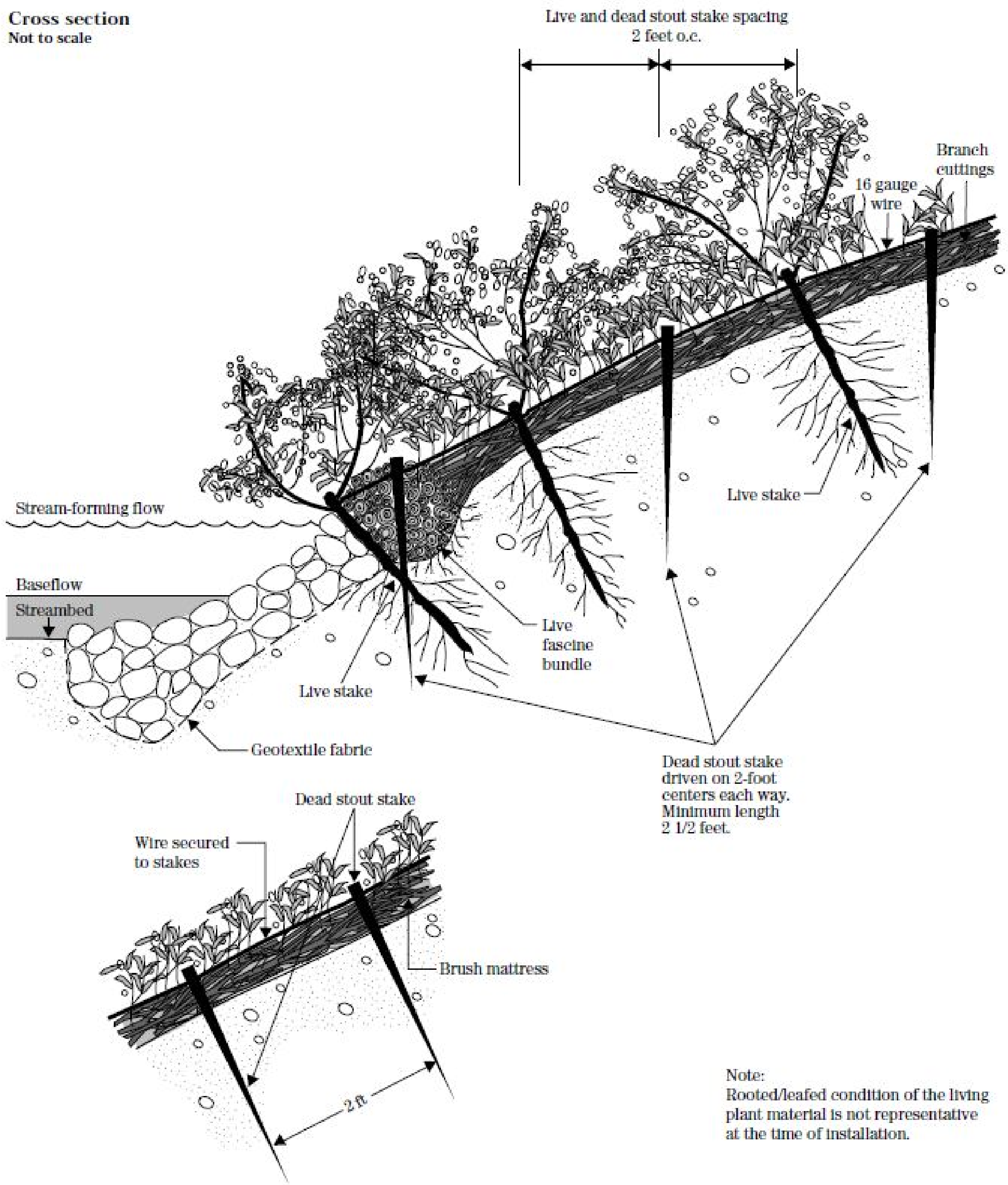
Construction guidelines

Live materials—Branches 6 to 9 feet long and approximately 1 inch in diameter are required. They must be flexible to enable installations that conform to variations in the slope face. Live stakes and live fascines are previously described in this chapter. Inert materials—Untreated twine for bundling the live fascines and number 16 smooth wire are needed to tie down the branch mattress. Dead stout stakes to secure the live fascines and brush mattress in place.

Installation

• Grade the unstable area of the streambank uniformly to a maximum steepness of 3:1.
• Prepare live stakes and live fascine bundles immediately before installation, as previously described in this chapter.
• Beginning at the base of slope, near the stream forming flow stage, excavate a trench on the contour large enough to accommodate a live fascine and the basal ends of the branches.
• Install an even mix of live and dead stout stakes at 1-foot depth over the face of the graded area using 2-foot square spacing.
• Place branches in a layer 1 to 2 branches thick vertically on the prepared slope with basal ends located in the previously excavated trench.
• Stretch No. 16 smooth wire diagonally from one dead stout stake to another by tightly wrapping wire around each stake no closer than 6 inches from its top.
• Tamp and drive the live and dead stout stakes into the ground until branches are tightly secured to the slope.
• Place live fascines in the prepared trench over the basal ends of the branches.
• Drive dead stout stakes directly through into soil below the live fascine every 2 feet along its length.
• Fill voids between brush mattress and live fascine cuttings with thin layers of soil to promote rooting, but leave the top surface of the brush mattress and live fascine installation slightly exposed.

Figure 16–18 Brushmattress details



Dormant post plantings

Dormant post plantings form a permeable revetment that is constructed from rootable vegetative material placed along streambanks in a square or triangular pattern (figs. 16–24).

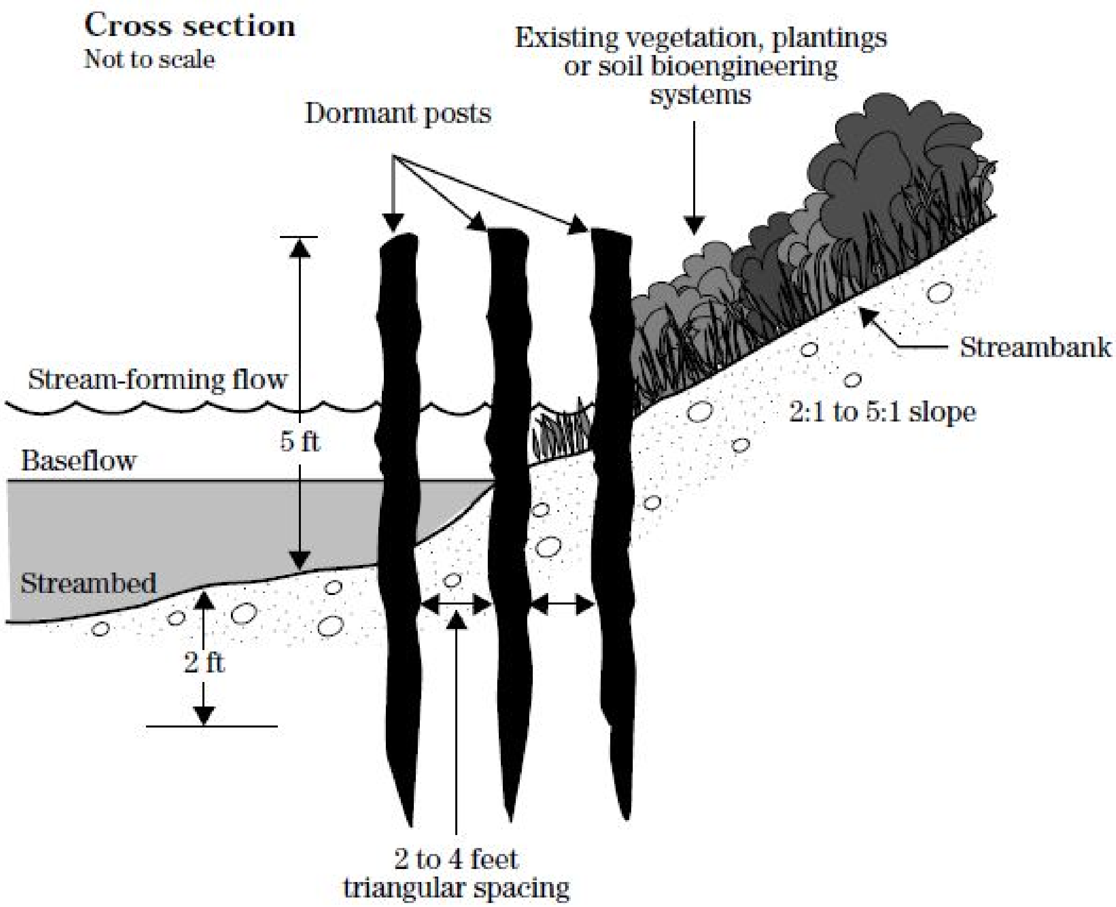
Applications and effectiveness

- Well suited to smaller, non-gravely streams where ice damage is not a problem.
- Quickly re-establishe riparian vegetation.
- Reduce stream velocities and causes sediment deposition in the treated area.
- Enhance conditions for colonization of native species.
- Are self-repairing. For example, posts damaged by beaver often develop multiple stems.
- Can be used in combination with soil bioengineering systems.
- Can be installed by a variety of methods including water jetting or mechanized stingers to form planting holes or driving the posts directly with machine mounted rams.
- Unsuccessfully rooted posts at spacings of about 4 feet can provide some benefits by deflecting higher streamflows and trapping sediment.

Construction guidelines

- Select a plant species appropriate to the site conditions. Willows and poplars have demonstrated high success rates.
- Cut live posts approximately 7 to 9 feet long and 3 to 5 inches in diameter. Taper the basal end of the post for easier insertion into the ground.
- Install posts into the eroding bank at or just above the normal waterline. Make sure posts are installed pointing up.
- Insert one-half to two-thirds of the length of post below the ground line. At least the bottom 12 inches of the post should be set into a saturated soil layer.
- Avoid excessive damage to the bark of the posts.
- Place two or more rows of posts spaced 2 to 4 feet apart using square or triangular spacing.
- Supplement the installation with appropriate soil bioengineering systems or, where appropriate, rooted plants.

Figure 16-24 Dormant post details



Coconut fiber rolls

Coconut fiber rolls are cylindrical structures composed of coconut husk fibers bound together with twine woven from coconut (figs. 16–36, 16–37a, and 16–37b). This material is most commonly manufactured in 12-inch diameters and lengths of 20 feet. It is staked in place at the toe of the slope, generally at the stream-forming flow stage.

Applications and effectiveness

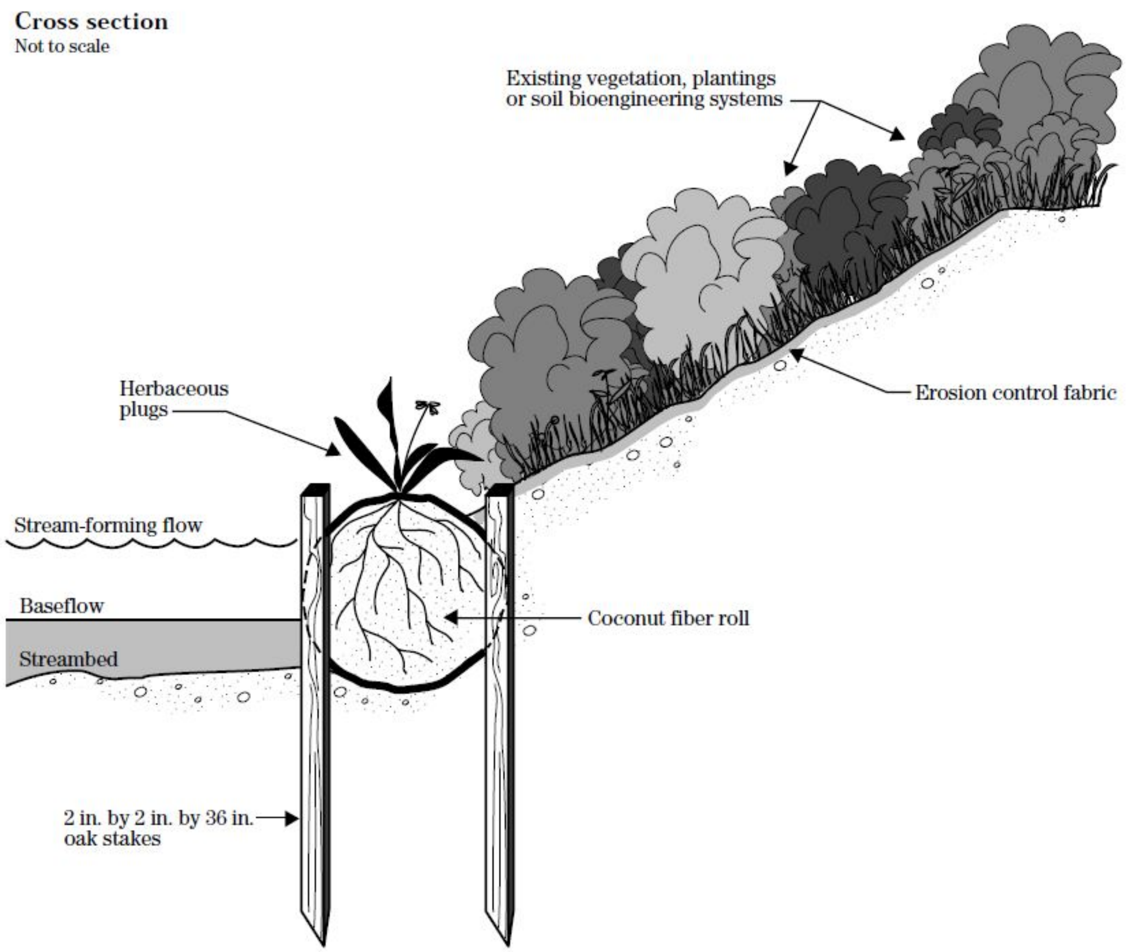
- Protect slopes from shallow slides or undermining while trapping sediment that encourages plant growth within the fiber roll.
- Flexible, product can mold to existing curvature of streambank.
- Produce a well-reinforced streambank without much site disturbance.
- Prefabricated materials can be expensive.
- Manufacturers estimate the product has an effective life of 6 to 10 years.

Construction guidelines

- Excavate a shallow trench at the toe of the slope to a depth slightly below channel grade.
- Place the coconut fiber roll in the trench.

• Drive 2 inch x 2 inch x 36 inch stakes between the binding twine and coconut fiber. Stakes should be placed on both sides of the roll on 2 to 4 feet centers depending upon anticipated velocities. Tops of stakes should not extend above the top of the fiber roll.
• In areas that experience ice or wave action, notch outside of stakes on either side of fiber roll and secure with 16-gauge wire.
• Backfill soil behind the fiber roll.
• If conditions permit, rooted herbaceous plants may be installed in the coconut fiber.
• Install appropriate vegetation or soil bioengineering systems upslope from fiber roll.

Figure 16–36 Coconut fiber roll details



Log, rootwad and boulder revetments

These revetments are systems composed of logs, rootwads, and boulders selectively placed in and on streambanks (figs. 16–22). These revetments can provide excellent overhead over, resting areas, shelters for insects and other fish food organisms, substrate for aquatic organisms, and increased stream velocity that results in sediment flushing and deeper scour pools.

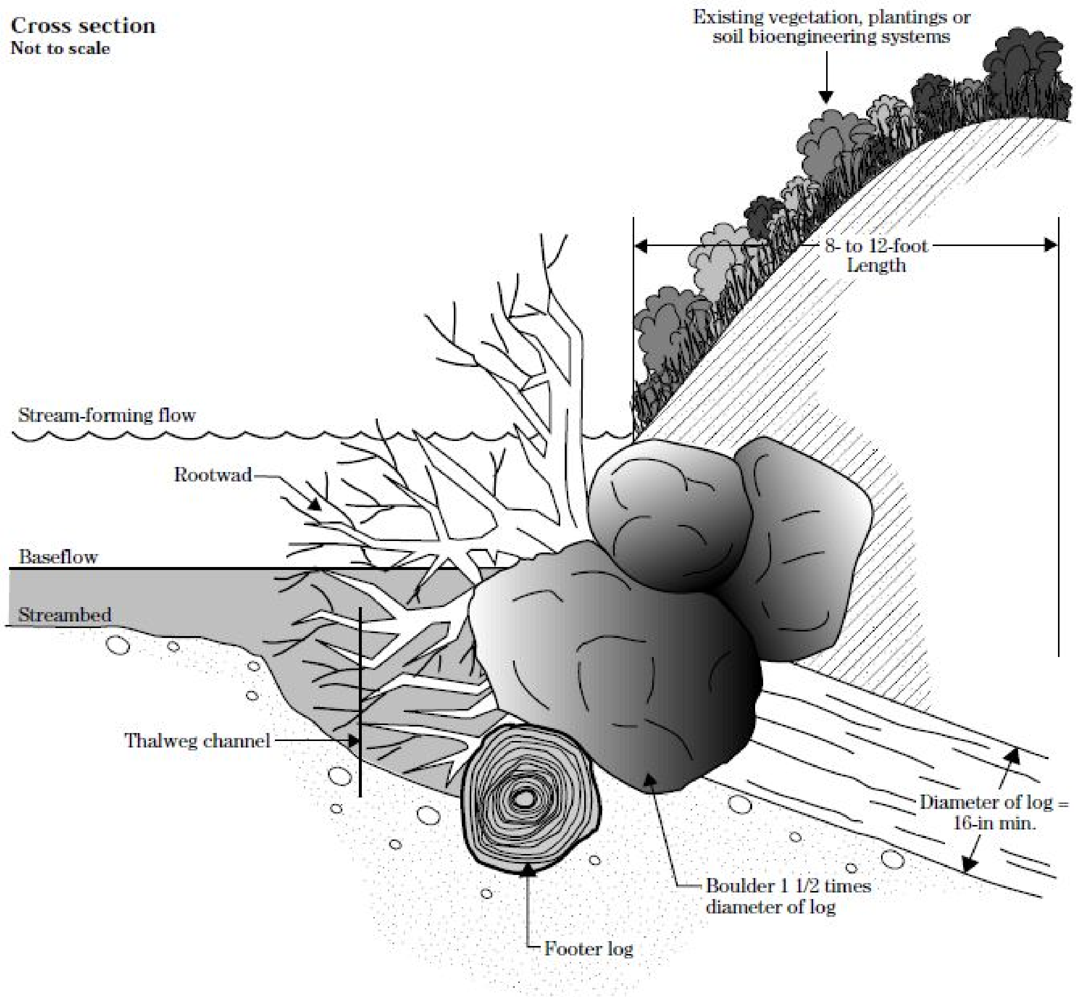
Applications and effectiveness

- Used for stabilization and to create instream structures for improved fish rearing and spawning habitat
- Effective on meandering streams with out-of bank flow conditions.
- Will tolerate high boundary shear stress if logs and root wads are well anchored.
- Suited to streams where fish habitat deficiencies exist.
- Should be used in combination with soil bioengineering systems or vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.
- Enhance diversity of riparian corridor when used in combination with soil bioengineering systems.
- Have limited life depending on climate and tree species used. Some species, such as cottonwood or willow, often sprout and accelerate natural colonization. Revetments may need eventual replacement if natural colonization does not take place or soil bioengineering methods are not used in combination.

Construction guidelines

- Use logs over 16 inches in diameter that are crooked and have an irregular surface.
- Use root wads with numerous root protrusions and 8- to 12-foot long boles.
- Boulders should be as large as possible, but at a minimum one and one-half the log diameter. They should have an irregular surface.
- Install a footer log at the toe of the eroding bank by excavating trenches or driving them into the bank to stabilize the slope and provide a stable foundation for the root wad.
- Place the footer log to the expected scour depth at a slight angle away from the direction of the stream flow.
- Use boulders to anchor the footer log against flotation.
- Drive or trench and place root wads into the streambank so that the tree's primary brace roots are flush with the streambank. Place the root wads at a slight angle toward the direction of the streamflow.
- Backfill and combine vegetative plantings or soil bioengineering systems behind and above root wad. They can include live stakes and dormant post plantings in the openings of the revetment below stream-forming flow stage, live stakes, bare root, or other upland methods at the top of the bank.

Figure 16–22 Log, rootwad, and boulder revetment details (adapted from Rosgen 1993—Applied fluvial geomorphology short course)



Recommended plant materials for Lincoln County, Oregon

Live stakes, fascines, brush mattress, branch packing, and dormant post

Sitka Willow - Salix sitchensis

Hookers Willow - Salix hookeriana

Black Cottonwood - Populus trichocarpa

Red Twig Dogwood – Cornus sericea ssp sericea

Additional Rooted plantings for stabilizing soils in the riparian area

Red Alder – Alnus rubra

Pacific ninebark – Physocarpus capitatus

Salmonberry- Rubus spectabilis

Douglas spiraea - Spiraea douglasia

Snowberry – Symphiocarpus alba

Red Elderberry – Sambucus racemosa

Nootka Rose – Rosa nookatensis

Vine maple – Acer circinatum

Western Red Cedar – Thuja plicata

Sitka Spruce – Picea sitchensis