CHAPTER 4

Planning a Successful Project


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Critical to the success of a soil bioengineering project is the importance of recognizing the static and dynamic relationships in natural systems. For example, look at the relationships between soil and plants, streams and riparian forest, and access to floodplains. Failure to notice these relationships can interrupt the ecological integrity and undermine successful stabilization attempts.

Determine the Desired Future Condition To Set Project Goals

Each bank stabilization project is a unique undertaking. There are no hard and fast rules governing the mix of techniques used to stabilize a site. There are, however, ways to avoid potential problems during planning and executing phases, by using good planning. Critical to the success of any stabilization project is the need to identify the project goal or goals. What is the desired future condition (DFC) of the project site? What are the ecological and social goals for the project? What are the desired esthetics and what are the desired behaviors of the people who will use the area after it is restored? How will management of an area need to be changed to ensure that the project is a success?

You will need an interdisciplinary team to address issues affecting the site. Issues are most likely to include esthetics, botany, ecology, fisheries, fluvial morphology, forest management, hydrology, politics, recreation and other use patterns, soils, and wildlife.

As you begin collecting data and forming the team, goals and constraints will begin to take shape. Constraints such as money, land ownership, and water diversion affect the goals. More analysis frequently leads to a need for additional team members to address new issues and for refining goals and constraints. Reviewing and understanding the historic ecology of the site and of the undisturbed areas in similar ecological settings often serve as benchmarks for determining the DFC. Aerial photographs are a valuable tool for comparing differences over time, including land- and social-use patterns. Ideally, the DFC should outline what an area should look like, based on what it is capable of sustaining. The DFC should also spell out how the project area is to be managed. It should, at a minimum, support the proper functioning conditions of the riparian and watershed ecosystems. (USDI 1998)

Critical to the success of a soil bioengineering project is the importance of recognizing the static and dynamic relationships in natural systems. For example, look at the relationships between soil and plants, streams and riparian ecosystem, and access to floodplains. Failure to notice these relationships can interrupt the ecological integrity and undermine successful stabilization attempts. It is also important to understand the linkages between these areas and the people that use them. In addition, a review of the following will assist with identifying the proper relationships: historical photographs and written records; topographical maps; soil type; fishing productivity records; and stream and watershed analysis.

Planners for soil bioengineering projects should seek long-term solutions to the problem rather than using new “quick-fix” technological advances (such as interconnecting concrete blocks) that only treat symptoms. Determine the nature of the problem by using a holistic analytical approach, assessing upstream and downstream conditions, lateral and vertical conditions, and their connections to the problem area. Such assessments will help determine whether the problem is unique or symptomatic of other problems in the watershed. It is of critical importance for planners to gain a thorough understanding of the underlying problem and how it interacts with other natural processes of the watershed.

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When planners have a firm grasp of the problem and its causes, they can work to restore and safeguard the functional and structural integrity of the target area by using sound engineering and scientific principles. A properly functioning watershed ecology ensures a healthy watershed.

Partners—Collaborative Stewardship

Successful stabilization projects generally share one common critical distinction. They bring together a diverse group of people who share a common goal.

Anyone who has a stake in clean water is a potential partner. Partners can shore up your weak areas and reinforce your strong ones. Strong partnerships are a great advantage when confronting or winning over opposition. Look for partners in local and national land and wildlife conservation organizations and clubs, civic groups, faith-based groups, schools and colleges, and businesses.


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USDA Forest Service, U.S. Fish and Wildlife, and the Vermont Department of Environmental Conservation representatives confer at a site.

Other agencies can be gold mines. They can contribute funding and expertise. The National Resources Conservation Service (NRCS), formerly the Soil Conservation Service, is the keeper of soils data and has potential funding for partners on private land. The U.S. Fish and Wildlife Service may also be a willing partner and a source of funding for partnerships with private landowners. The U.S. Environmental Protection Agency (EPA) awards 319 Grants to the private sector for watershed improvements. State fish and game departments and State departments of natural resources are also potential partners, as are local water districts.

Tips for Using Soil Bioengineering Techniques

This section discusses approaches for successful use of soil bioengineering and specific techniques for proper seeding and harvesting, storage, and installation of live plant material.

Tree Revetments

Generally, bank protection, often referred to as armoring, will be needed if a problem is on an outside bend. Tree revetments, root wads, or a combination of log revetments and boulders (if the boulders occur naturally in the area) work well. These structures protect the banks during high flows, keeping the water off the banks while riparian plants have a chance to revegetate them. Some type of armor might also be necessary on straight stretches of a stream to mitigate impacts from land use, boat wakes, or fetches.

Tree revetments are temporary protection designed to armor a bank while native riparian plants are reestablished. The new roots will hold the bank together while and after the revetments decay. Revetments also provide habitat and nutrients from installation through decomposition.


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This 90-degree bend was stabilized using log revetments, root wads, live fascines, and live posts. It has withstood a 100-year flood event and ice flows. The visible flat area, formerly a cornfield, has been planted with riparian tree species. Two-foot squares of plastic were placed around the bases of the plants to control weed growth. Mad River, VT.

There are several sources for tree revetments. Slash piles, with branches intact, are a good source. Branches provide excellent shade and habitat for aquatic life and trap sediment. This trapped sediment helps to build a new bank. Also, adjacent private property owners might be willing to provide trees.

Recycled Christmas trees are another possible source that may give the community a sense of involvement or may be seen as unacceptable. It is best to investigate ahead of time. Collecting and sorting is labor intensive. Smaller (short) trees, and tinsel, will need to be eliminated.

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Small tree revetment in Vermont. The bank will be allowed to slough.

There is often a gap between a revetment and the bank. This gap can be filled with soil or with rock and soil and readied for any number of vegetative treatments. This type of fill also makes an excellent bed for natural seed germination, as does bank slough.

Toe Protection

There are several methods to protect a toe from being undermined. They include tree revetments, live cribwalls, root wads, live siltation, trench pack, brush mattress, dead fascine, vegetated geogrid, coconut logs, jute-mat logs, and native rock. When using these techniques, trench down to a depth below the anticipated scour, building from there to protect the toe from washing out.

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This outside bend was stabilized using root wads, fascines, and live posts. A county road was saved. Ashland, WI.

For example, anchor a heavy, flexible brush mattress to the bottom of a tree revetment (streamside) at the time of installation, which will extend some distance out into the channel. This mattress will settle progressively if scour takes place, protecting the revetment foundation.

Keying into the Bank

"Keying in" refers to tying a structure into the bank. Fascines, revetments, jute-mat logs, and other longitudinal treatments/techniques must be keyed into the bank at both ends of the installation. This prevents water from coming around either end and eroding soil behind the soil bioengineering technique. Also, be sure the treatment extends upstream and downstream beyond the limits of the treatment area.

Ideally, the treatment on a bend would start and finish where the upstream and downstream curves begin, at their tangent points. Treatments could also be keyed in at the beginning and end of a stable section of bank at a bridge abutment; a rock outcrop; or a stable, well-vegetated section of bank.


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This once heavily grazed bank has been fenced off from cattle and seeded.

Transition segments, at the beginning and end, between a technique and a native bank are weak points. If the technique is not keyed into the bank correctly, water can get behind it and unravel the treatment. The technique may have a different roughness than the native bank, causing the water to slow down or speed up, which causes extra stress on the transition. The technique should not encroach or extend into the channel, nor should it widen the channel as compared to the existing adjacent stable channel upstream and downstream.

Seeding

Seed bare ground between stabilization methods, over erosion control fabric, and on floodplains to create an instant ground cover. Make grass seed selection based on native grasses growing in the drainage. If there are not enough native seed sources available, add annual seeds to the mix. The annual seed will provide cover while the native seed becomes established.

Chris Hoag, a wetland plant ecologist with the NRCS, suggests using a mix that includes two overstory grass species, one understory grass species, and one forb species. The seeding rate is 12 to 15 lb per acre (because seed size varies, affecting weight, you may need greater or lesser quantities of specific seed types). If the seed is broadcast, this amount should be doubled. Seed after high water so it is not washed away.


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A seeded floodplain in Lewiston, ID.

Erosion Control Fabric

Erosion control fabric is a loosely woven fabric made of coconut fiber, jute, or some other biodegradable substance used to hold soil in place. It can be used with most of the techniques, however, it will add to the cost of a project. It is not always needed. Coconut fiber is more expensive than jute. Fabric can be seeded, planted, or used alone to trap sediment.

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Erosion control fabric on a vegetated geogrid.

Fabric is laid on bare ground and staked in place, then trenched at the top and bottom edges. If several pieces are used they should be overlapped with the downstream piece laid first. When applying fabric to a bank, unroll it from the bottom up so that the fabric conforms to contours. If fabric is unrolled from the top it will bridge uneven ground, leaving air pockets, which are more prone to erosion and seed growth failures due to a lack of soil contact.

Examples of other uses are:

1. On vegetated geogrids, each “lift,” between the branch layers, is wrapped in erosion control fabric to keep the soil in place. Jute-mat logs are also made of erosion control fabric.
2. Round hay bales are wrapped in erosion control fabric to prevent them from breaking apart.

Anchors

Duckbills

Duckbills are used to anchor small tree revetments or coconut logs. They are used when the item (small tree) is too large to be anchored by a dead stout stake or when the current is too strong. They come in various sizes rated by the number of foot-pounds each duckbill will support.

Generally, a short cable is attached to the center of the anchor with a loop on the end of the cable. The cable length can be specified or the duckbill can be purchased without the cable. The duckbill has a solid end with a star pattern. Use a customized bar that fits the star or a piece of reinforced steel bar (rebar) to drive the duckbill into the ground.

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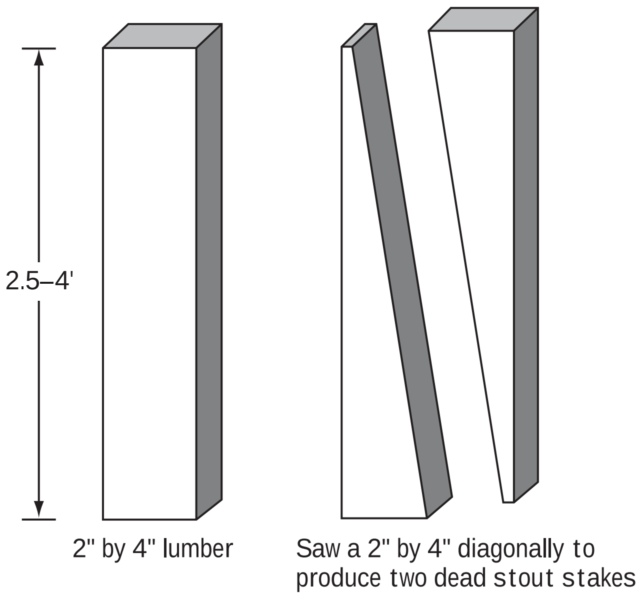
Duckbills with cables attached.

Insert a bar into the duckbill, and insert the duckbill into the soil. Begin driving by using a post driver, if available, and finish with a sledgehammer. The duckbill should be driven into the soil as far as possible. Remove the rod. Insert a short metal bar through the loop at the end of the cable, and pull up. This rotates the duckbill, making it somewhat parallel to the surface, and sets the anchor.

Dead Stout Stakes

Dead stout stakes are used in many soil bioengineering techniques to anchor branches, erosion control fabric, and jute-mat logs to the bank. Purchased or cut stakes should be an average of 2.5- to 4-ft. long, untreated, 2- by 4-in. sound lumber. Each length should be cut diagonally across the 4-in. face to make two stakes from each length. Discard stakes that shatter upon installation.



DEAD STOUT STAKE
(Not to scale)

RECOMMENDED
Dead Stout Stake Lengths

Soil Type	Stake Length
Clay	2.5 ft.
Silt	3 ft.
Sand	4 ft.
Loam	2.5 ft.

Plants and Climate

Soil type and microclimate are very important and may dictate whether or not the installation of live plant material survives. Local weather conditions dictate when to plant. Consult a botanist, soil scientist, or landscape architect for the best times to plant.

Live fascines, for example, are installed in shallow trenches and will not survive if planted on a hot dry bank. They might survive if planted at the water's edge or if they are irrigated. The same would apply to a brush mattress in an arid climate; the basal ends of the mattress must always be in moist soil.

Live posts should do well in most climates when planted deep enough to reach the dry season water table. They average 3- to 4-ft. in length and can be up to 12- to 15-ft. long (some of this length is above ground). If the depth of the dry season water table is elusive, install posts at least 2 ft deeper than the streambed. The same instructions apply for using live stakes.

Plant Materials

Collecting

- Collect plant materials and seeds within the local watershed or drainage basin, roughly at the same elevation as the project site. It is important not to introduce nonnative- or native-plant materials and seeds from different gene pools.
- Know the genus and species of deciduous plants that grow well from cuttings before you cut. (See appendix D for information.)
- Cut plants when they are dormant.
- Plant dormant cuttings the same day or within 2 days after being harvested. Store them in water or moist soil in a shaded area to prevent dehydration.
- Track where plant material was collected, the vigor of the material, and its survival rate. Manage good collection sites. Let team members from other disciplines know that this is a harvest area and that the plants have special uses.
- Transplant herbaceous plants from nearby banks immediately. Be careful not to take too many from any one spot.

Harvesting and Storing

The technique sheet for a specific treatment indicates the diameter and length of the cuttings. Cutting lengths will also vary with species and source. They can be used within a day or two or stored through the winter.

- Harvest cuttings from branches that are at least 1 year old, but not older than 12 to 15 years. Shield cut branches from the sun at all times and keep them as cool as possible.
- DO NOT cut branches with old, heavily furrowed bark, diseased or insect-infested growth, dead or broken branches, basal shoots, or suckers. (Hoag 1994)
- Consider the esthetics of the plant when selecting cuttings, DO NOT cut off more than one-third of a single plant's branches. Avoid public use sites such as campgrounds, picnic areas, fishing sites, roadways, and so on. (Hoag 1993)
- Remove (by cutting) the apical bud at the top.
- Dip the top 1 to 2 in. of each post in a mixture of equal parts latex paint and water or paraffin to seal it. This decreases desiccation and tells you which end is the top. (Hoag 1992)
- Store cuttings in a cool place, such as a walk-in refrigerator, at between 34 to 45° F. Using this technique for storage, cuttings can be stored for several months (usually 3 to 6) before planting. Wrap cuttings in burlap or peat to keep them damp.
- Before planting move cuttings outside and soak the basal ends for at least 24 hours, but no longer than 3 days. This brings the cuttings out of dormancy, leaves them well hydrated, and causes the root buds to swell. Always do this in a cool shaded area.

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Willow cuttings soaking before use.

Planting Live Materials

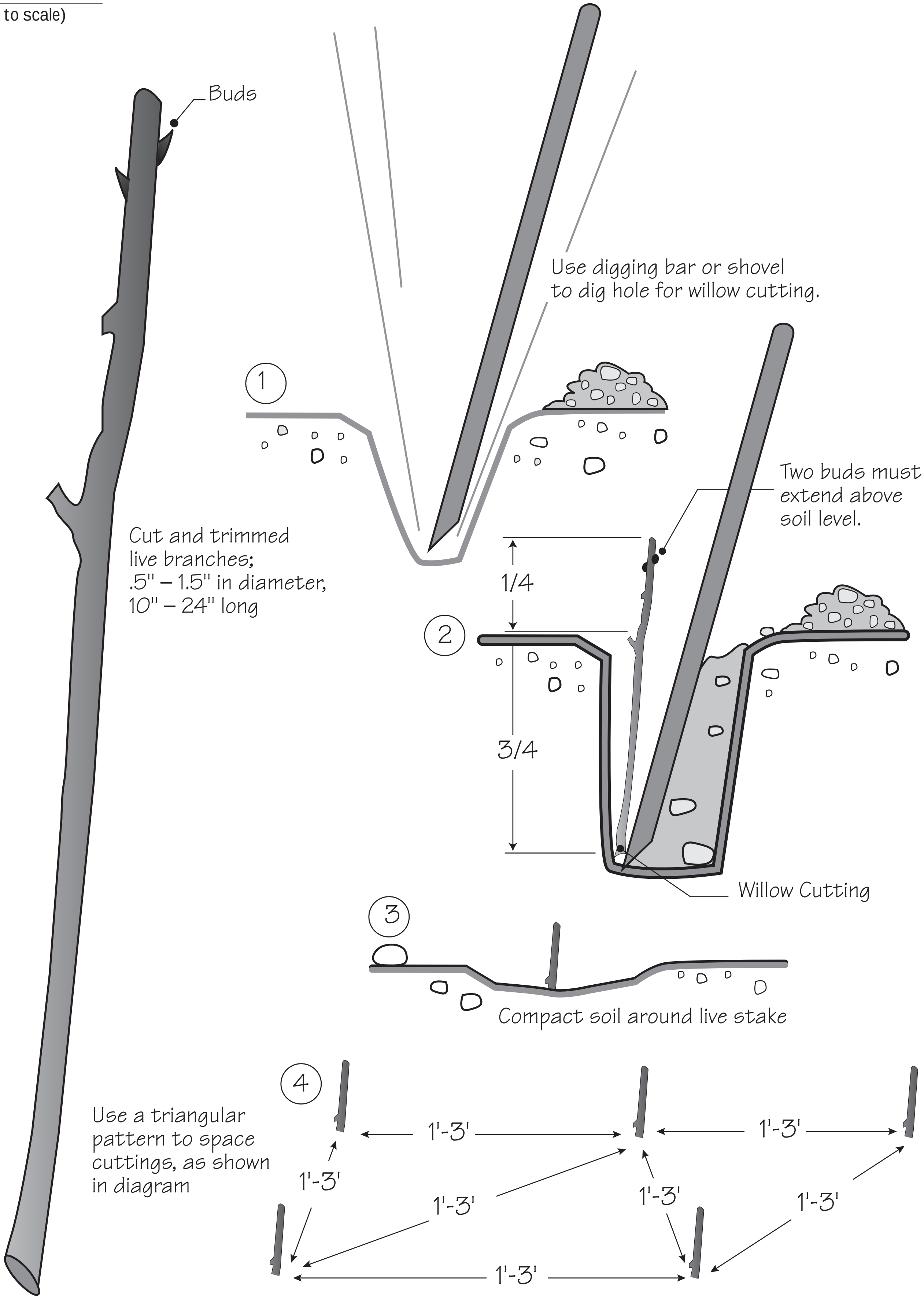
- Install the basal end, not the top; the buds always angle upward.
- Insert the cutting into the ground without tearing the bark. The bark shields the cambium layer, the vascular system for the plant. The cutting will not survive if it is damaged when the bark is torn.
- Avoid splintering or mashing the top of a cutting by using the wrong hammer. Use a dead blow hammer or a waterjet stinger (Hoag, et al. 2001) for installation.
- Ensure good soil-to-stem contact or the cutting will dry out and fail to sprout.
- Work with a soil specialist to better understand limits and opportunities within the project area. Soil types and textures determine what vegetation will do well in a particular area.

Protecting the Project Area

Work with as light a touch on the land as possible to protect soils and riparian habitat. Damage to the environment can be limited by:

- Using small equipment and hand labor.
- Limiting access.
- Locating staging areas outside work area boundaries.
- Avoiding or altering construction activities during critical times, such as fish-spawning or bird-nesting periods.
- Coordinating construction on a stream that involves more than one job or owner.
- Adopting maintenance and monitoring plans that maximize riparian vegetation and allow wide, woody, vegetative buffers.
- Scheduling construction activities to avoid expected peak flood season(s).
- Decompacting the soil in areas disturbed during construction, followed by seeding or planting rooted stock.

LIVE CUTTING
(not to scale)



Use existing natural features and native plant materials. Use natural features—such as larger trees, rock outcroppings, or turns in the bank—as places to key in a technique. If clearing and grubbing are necessary, remove only the plant materials that prohibit the installation of the technique. Do not remove plants that are already stabilizing the bank.

Remove any roots, stems, or plant materials from the soil to be reused on site. If native plant materials must be moved, move the materials so that they can be replanted on the site. Replant the plants right away or place them in wooden boxes, plastic containers, or burlap. Be sure to store the plants in a protected area for replanting later. The time of year plants are dug-up will affect their survival rates. For example, in the dry West, do not move plants during the hot dry summers when they are particularly stressed; wait until late fall.

When fill material is needed, specify a high-grade topsoil that is weed free and free of all debris, including roots, rocks, and vines. Soil should have the same or similar pH as the site soil. If necessary, add greenwaste, compost, or other usable organic matter to encourage plant growth.

Do not lose site of the goal—to grow plants and stabilize the bank.

Tools and Supplies

This is a starting list of tools. Each project is different. As situations vary, so will the tools required.

- Auger and/or Stinger.
- Ax.
- Bucket.
- Dead-blow hammer.
- The Gripper (although expensive, it works well to help tighten cables).
- Hose (to wet or water plantings).
- Lopper.
- McCloud.
- Pick ax.
- Polaski.
- Post driver.
- Reinforcement steel bar (rebar) or metal pole for making holes in the ground and in coconut matting.
- Saw horses or similar supports.
- Shovel.
- Silt screen.
- Sledge hammer.
- Shears.
- Untreated twine.
- Waterjet Stinger (see appendix C).
- Bug repellent.
- Drinking water.
- First aid kit.
- Gloves.
- Hard hat and sun hat.
- Plenty of food for volunteers.
- Sun screen.
- Waders.

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A tall, long sawhorse makes tying live fascines go smoothly and reduces back strain.

Tips from the Experienced

General Installation Tips

Check to see whether local permits are needed if you are working off forest land in partnership with a private landowner or State and local agencies. Working in a stream requires a 404 permit from the Army Corps of Engineers. Do a Job Hazard Analysis to protect workers and to help clarify what tasks are needed. It will help you plan when to do the job and who should perform which tasks—employees, contractors, or volunteers.

Training

If soil bioengineering is new in your area, conduct a training session for contractors, forest personnel, and volunteers. Call SDTDC for support and assistance in finding a qualified person in your region to use as a resource. Also, look for a soil bioengineering training class to attend.

Planning

Review the plan, equipment lists, and timeframes with an expert. Planning is complex, you do not want to be in the field without an understanding of what to do or without the correct equipment. Have a set of plans in the field. The plans should include each reach on a separate sheet, where possible. The print should be large enough for you to easily read all the words and details.

Contracts

If you are awarding a standard contract, specify that all bidders must attend a prebidder's workshop in order to bid on the contract. Soil bioengineering techniques are so new to the construction industry that a workshop is often needed to explain what soil bioengineering is and provide hands-on experience.

A service contract may be the most effective contract to use. This type of contract covers equipment rental (for example, an excavator), with operator and materials. The equipment rental is usually hourly. The person who is experienced with the installation of soil bioengineering techniques should direct the equipment operator and materials suppliers.

The Green Mountain and Finger Lakes National Forest has been doing soil bioengineering for the past 10 years. They have found service contracts to be both successful and cost effective. The materials that they have used include trees, root wads, and boulders. The bidder presents a cost per item, plus a delivery charge. Equipment and operators are hired hourly. (Willow harvesting could also be a service contract.)

Installation

If an area is likely to be inundated for a period of time, use live posts tall enough to remain above the water. The exposed buds will sprout. The second growing season is most critical; if plants and cuttings sprout the second year they have a very good chance for long-term survival.

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Live post growing in water.

If beavers are a problem, use plant species to which they are not attracted. Check with the local biologist.

If heavy equipment will be needed, consider working on the project in the winter when frozen ground minimizes damage to the riparian vegetation and to the soil.


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Soil compaction was avoided by doing heavy work when the ground was frozen. South Fork of the Flambeau River, Chequamegon-Nicolet NF.

Phasing Installation

Installation can take place in phases. For example, install dead materials such as tree revetments in the winter and live materials in the spring or the next year. Do not do this unless the plan has been approved and the money, time, and staff are available to finish the project.

Planning for Shoreline Protection Measures

Lakeshore applications may differ slightly from streambank methods because of tidal action and littoral transport. These differences are discussed at the end of each technique. Log breakwater, hay bale breakwater, and snow fence are specific to shorelines and are discussed separately.

Causes of loss of shoreline riparian vegetation and degradation may be:

- A single storm.
- Constant fetch or wave action caused by boats.
- Onshore uses including recreation, mining, reforestation (plantations planted adjacent to shorelines), development, and water diversion.
- Drought.
- A fluctuating water table.

The following shoreline information was taken from the NRCS "Engineering Field Handbook," Chapter 16.

Shoreline erosion results primarily from erosive forces in the form of waves hitting the shoreline. As a wave moves toward shore, it begins to drag on the bottom, dissipating energy. Drag eventually causes the wave to break or collapse. This major turbulence (wave break) stirs up material from the shore bottom or erodes it from banks and bluffs. Fluctuating tides, freezing and thawing, floating ice, and surface runoff from adjacent uplands may also cause shorelines to erode. In addition to the items listed earlier in this chapter, planning streambank protection measures along shorelines requires consideration of:

- Mean high- and low-water levels.
- Potential wave parameters.
- Beach slope and soil type.
- Littoral transport.
- Existing vegetation.

Water Surface Design

The high-tide or, in non-tidal areas, the full pool, is the design water surface. Design height depends on draw down of the particular reservoir. This information may be obtained from:

- Tidal tables.
- Records of lake levels.
- Topographic maps of the reservoir site in conjunction with observed high- and normal-water lines along the shore.
- The U.S. Army Corps of Engineers.
- Reservoir operator.

Potential Wave Parameters

Potential wave parameters are affected by offshore depth and are critical factors in designing shoreline protection measures. Structures that must be constructed in deep water, or in water that may become deep, are beyond the scope of this chapter. Other important considerations are:

- Dynamic wave height action in deep water (roughly, the total height of the wave is three times that which is visible).
- Decreased wave action caused by shallow water.
- Effective fetch length also needs to be considered in determining wave height. Methods for computing wave height using fetch length are in NRCS Technical Releases 56 and 69.

Beach Slope and Soil Type

Slopes should be determined above and below the waterline. The slope below the waterline should be measured at least 50 ft out.

Determine the bank soil type and foundation material. This aids in estimating the rate of erosion. A very dense, heavy clay can offer more resistance to wave action than noncohesive materials, such as sand. A thin sand lens can result in erosion problems as it may be washed out when subjected to high tides or wave action for extended periods of time. The resulting void will no longer support the bank above it, causing it to break away.

Knowledge of soil types will help determine which plants to use. A soil scientist is an important member of the project team.

Littoral Transport

The material being moved parallel to the shoreline in the littoral zone, under the influence of waves and currents, should be addressed in stabilization design. Some littoral transport is normal. It is important to determine the predominant direction of littoral transport and to verify that the supply of transport material is not coming from the bank needing protection.

The rate of littoral transport and the supply are as important as the direction of movement. No simple way to measure the supply is available. For the scope of this chapter, supply may be determined by observation of existing structures: sand beaches, auger samples of the sand above the parent material on the beach, and the presence of sandbars offshore. Other considerations are existing barriers, shoreline configuration, and inlets that tend to push the supply offshore and away from the area in question. The net direction of transport is an important and complex consideration.

This information is used to help determine where treatment is necessary and which techniques might be most effective and have the best survival rates. Another factor to consider is that littoral transport often reverses directions with a change in season. The type of existing foundation may govern the type of protection selected. For example, a rock bottom will not permit the use of techniques that are driven into the ground. A soft foundation, such as dredge spoil, may result in excessive flotation or movement of the technique in any direction.

Existing Vegetation

Existing riparian vegetation should be saved as an integral part of the erosion control system being installed.

General Lakeshore Information

Planting additional native vegetation on a shoreline may solve erosion control problems. Consult local technical guides and plant material specialists for appropriate plant species and planting specifications.

Patching

A shoreline problem is often isolated and may require only a simple patch repair. Site characteristics suitable for a patch solution include good overall protection from wave action, slight undercutting in spots with an occasional slide on the bank, and fairly good riparian vegetative growth on the shoreline.

Problems are often caused by boat wakes or excessive upland runoff. Solutions would be to armor undercut areas with a small tree revetment or coconut logs and to repair bare patches with a grass transplant, reed clumps, branch packing, fascines, live stakes, and/or live posts.

Drying out the bank best alleviates slides that occur because of a saturated soil condition. Installing willow fascines, for instance, will draw water out of the bank (Gray and Sotir, 1996). Other alternatives are subsurface drainage or a diversion. Leaning or slipping trees in the immediate slide area may need to be removed initially because of their weight and the forces they exert on the soil; however, once the saturated condition is remedied, disturbed areas should be revegetated with native riparian trees, shrubs, grasses, and forbs to establish cover.

Monitoring and Maintenance

Monitoring

Monitoring is critical for project success. Monitoring and maintenance are intertwined; monitoring may lead to maintenance.

When monitoring, look at the plants and note which ones are doing well and which ones did not survive. Is the site recovering? Note conditions such as soil moisture, aspect, sun-to-shade ratio, and degree of slope. Has the area been trampled, grazed, or driven over? Have any of the structures, such as tree revetments, shifted? Other aspects to monitor are:

- Keeping track of where plants were harvested: is there a correlation between growth rate of certain cuttings and the "mother" plants?
- Is the installation functioning as designed?
- Which areas are maturing more rapidly than others?
- Are seeds sprouting in the newly formed beds?
- Which plants have invaded the site through natural succession?
- What has sprouted in the second season?
- Which areas are experiencing difficulty and why?
- Is the bank stabilizing or washing away? Why?
- Is something occurring that is unexpected?
- Which techniques are succeeding?
- Are any of the structures failing?

Maintenance

Maintenance is absolutely necessary during the first few years after installation until the vegetation becomes established and the bank stabilizes. Partners may be willing to assist in maintenance. Structures may shift or you may notice something that was left undone. The treatments should be self-sustaining. Be sure the site is managed to give the treatment every chance to be effective over a long period of time.

Repair weakened or damaged structures including fences. Replant and reseed as necessary. Remove debris and weeds that may shade and compete with cuttings. If a flood occurs days after installation, not an uncommon occurrence, replant and rebuild structures as necessary.

Inspect the project every other week for the first 2 months after installation, then once a month for the next 6 months, and every other month for 2 years, at least. Inspect the project after heavy precipitation, flooding, snowmelt, drought, or any extraordinary occurrence. Assess damage from flooding, wildlife, grazing, a fetch, boat wakes, trampling, drought, and high precipitation. Ensure that structures are holding together, stakes and twine are secure, cables are tight, ends are keyed in, and so on.

The following is a sample monitoring form from the NRCS "The Practical Streambank Bioengineering Guide." Use it as is or customize it to fit your projects. Make sure that monitoring and maintenance are part of each project. A blank form is included in appendix C.

Soil Bioengineering Monitoring Sheet

Project Name: Clear Creek - Phase 1
Project Location: Clear Ck S. of Hwy 45 Bridge
Monitoring Team: Clear Creek H.S. Biology Class
Date: 6/25/96

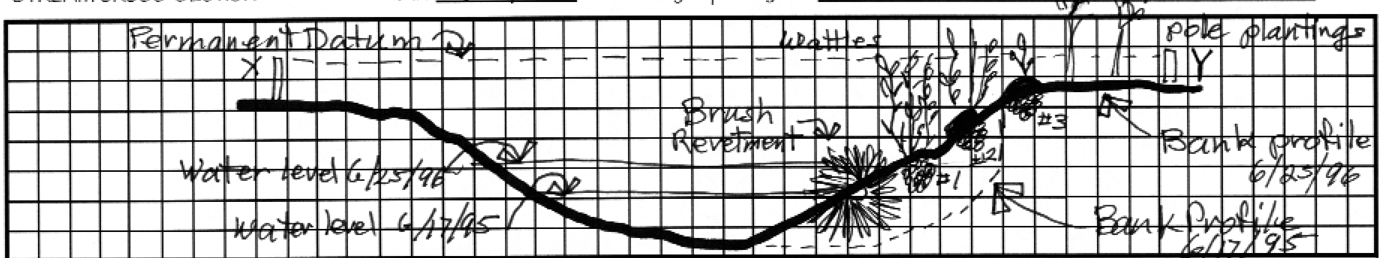
Bioengineering Technique: Brush revetment w/willow wattles + pole plantings
Riparian Species Present: Salix exigua (Sandbar willow wattles) Populus fremontii (Fremont Cottonwood pole plantings. Misc. species - Carex nebrascensis (Nebraska Sedge)

Total # of poles or post plantings: 24
# of dead: 3 # of live: 21
% of survival: 87.5
Average height: 3.4'

Average # of live stems per linear foot: Wattle #1 (12/per l.f.) Wattle #2 (8/per l.f.) Wattle #3 (2/per l.f.)
Average height of stems per linear foot: Wattle #1 (27.4") Wattle #2 (23.5") Wattle #3 (4")
Stem density per unit area: NA

Observations: Brush revetment + erosion control fabric are holding up + are catching sediment. Wattles #1 + #2 are doing great - wattle #3 is struggling. Probably should have planted pole plantings instead of wattle #3 (probably not enough moisture). Water temp. seems cooler now that channel narrower + deeper - need to do some temp. monitoring to assess this.

STREAM CROSS-SECTION ID#: 1-4 Measuring Tape Height: x 18" 4"



Recommendations for maintenance:

Scale
Horz. 1" = 5'-0"
Vert. 1" = 5'-0"

Soil Bioengineering Case Studies—Before, During, and After Construction

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Three successful soil bioengineering projects located at developed recreation sites are discussed in this section. The first is in Fairbanks, AK, on the Chena River; the second is on the Russian River, also in AK; and the third is at Woods Ferry on the Board River, Sumter National Forest, SC. Photographs of projects before, during, and after construction are included to illustrate what soil bioengineering can do and what it looks like.

The Chena River, Fairbanks, AK

This was an Army Corps of Engineering project at a park on the Chena River. A dam upstream controls the river flow. Anglers trampled the bank to get to the water, and boat wakes cut and undermined it. Cavities developed at the toe, some extending 5 ft. into the bank, and a portion of the bank had begun to collapse.

Rebuilding the Bank

In June 1996, a project incorporating several bioengineering techniques to stabilize the bank was begun. Building a large tree revetment to protect the toe and a vegetated geogrid on top were used to rebuild the bank.

BEFORE CONSTRUCTION


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Toe of the bank being washed away by boat wakes.


US Army Corps of Engineers

This section of the bank was caving in. Note the sparse vegetation.


US Army Corps of Engineers

Cavity extending 5 feet into the bank.

DURING CONSTRUCTION

Cable leading to the tree revetment in this ditch is anchored to a metal pipe used as a deadman. The pipe is in a ditch perpendicular (in the foreground) to the one leading to the river.

Excavator lowering a tree log into the river to be used as part of a tree revetment.

Excavator holding the tree log in place while it is attached by cable to the deadman in the bank.

Two trees were stacked to form this revetment. The space between the bank and the trees was filled with rock.

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Vegetated geogrid—Coconut mat is laid over the tree revetment and rock. One foot of soil will be shoveled on top of the mat to begin a vegetated geogrid.

AFTER CONSTRUCTION

US Army Corps of Engineers

Summer 1997. The willows have sprouted. Note the tree limbs of the tree revetment in the water.

Recontouring and Stabilizing the Bank

Another section of the bank, on the Chena River, was recontoured and stabilized by using live fascines, erosion control fabric, seeding, and a plant lift. Stairs were built for angler access, and a rock-toed fishing platform was added.

DURING CONSTRUCTION


US Army Corps of Engineers

A vegetated geogrid, or lift, was installed just to the left of the large angular rock at the base of the slope.


US Army Corps of Engineers

Recontoured bank.

AFTER CONSTRUCTION


US Army Corps of Engineers

Stairs were built leading to a rock fishing platform. Three lines of fascines, erosion control fabric, and seeding stabilize this recontoured bank.

DURING CONSTRUCTION


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The beginnings of a plant lift. Soil was shoveled on top of a portion of the erosion control fabric. The loose end was folded over the fabric and staked, creating a lift.

AFTER CONSTRUCTION


US Army Corps of Engineers

Plant lift with newly transplanted sedges.


US Army Corps of Engineers

The lift was plugged with transplanted sedges from the riverbank. The sedges and the mat are trapping sediment and rebuilding the bank.

The Russian River, Chugach National Forest

Kelly Wolf, a local contractor, founded the Youth Restoration Corps in 1997. In 1997 and 1998, the corps stabilized and repaired 2,219 linear ft. of riverbank in a 2-month period (the corps works 4 weeks per summer). Public donations and EPA 319 Grants have financed the projects, with the grants paying the youths' salaries.

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Youth Restoration Corps, 10 members strong.

The Forest Service helped plan the projects. The youths spend 60 percent of their time working and 40 percent learning about ecosystems, salmon, and bioengineering techniques. The cost for 2 years has been $70,000. Television advertisements have helped to fund the project. The project emphasizes three things: the value of training teens to work, environmental restoration, and education. Restored banks help ensure a healthy river; this keeps the fish and the tourists coming back.

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Fishing for salmon.

Fishing is the lifeblood of the region. The Russian River attracts approximately 44,000 anglers per year and has a combined sockeye salmon return of 200,000. At times, in one 4-mile stretch 1,000 anglers can be counted. Anglers are encouraged to fish in the water to lessen bank damage. On the east bank of the Russian River, adjacent to the Russian River Camp Ground, however, anglers have trampled riparian vegetation and compacted soil, creating alcoves or nicks in the bank.

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Trail and alcove where anglers have broken down the bank.

Dean Davidson of the Forest Service said that the best time to work is when the public is present. They offer to help, they ask lots of questions, and they even write checks to support the project.

Angler-created trails are being replaced by a single trail using light-penetrating walkways or boardwalks. These define where people should walk and thus protect habitat. A light-penetrating walkway is made of steel or fiberglass in a grid pattern. Light goes through the grid and stimulates plant growth. Walkways are used close to the river's edge and as spurs leading into the river. When the trail moves away from the water, boardwalks are used. Newly stabilized areas are fenced off for 2 years to allow soil bioengineering installations to take hold.

Obliterating Angler-Made Trails

The following photographs are of angler-made trails. The Youth Restoration Corps did the restoration. The ground was left uneven to add roughness and a natural look. Sod, cut from a nearby undisturbed area, was laid on the uneven trail, then covered with coconut matting to help retain soil moisture. As the sod grows up through the mat, the trail disappears.

As shown on page 68, rubber matting was used in certain areas to protect grassroots in heavily used areas. Plants grow up through the holes. The mat defines use areas.

BEFORE CONSTRUCTION

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Trampled vegetation lead to this compacted trail.

AFTER CONSTRUCTION

USDA Forest Service

Notice the sod growing through the matting in order to obliterate the trail.

AFTER CONSTRUCTION


USDA Forest Service

Rubber matting was used to protect soil and vegetation and control angler impacts.


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Restoring the River Bank

The first step, in this small alcove, was to replenish the rocks of the riverbed. The corps installed a coconut log on top of the rocks to tie the bank together and used duckbill anchors to hold it in place. Short root wads, anchored with cable and duckbill anchors, were used because this alcove was in a calm water area. Another coconut log was installed behind the root wads. This, and the area behind the wads, was covered with coconut mat and filled with topsoil. Sod, cuttings, and transplanted stock were installed and watered.

Another approach is to use what is at hand, in this case untreated burlap bags. Sand bags filled with topsoil can be used in lieu of vegetation. Indigenous seeds and cuttings were placed in between the bags, with sod placed on the top.

BEFORE CONSTRUCTION

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Alcove cut by anglers using the bank.

DURING CONSTRUCTION

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AFTER CONSTRUCTION

USDA Forest Service

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Woods Ferry, Sumter National Forest

The Broad River watershed is approximately 2,700 square miles at the Woods Ferry site. Woods Ferry has 39 campsites, 54 picnic areas, and a boat launch ramp. It is the largest recreation area in the forest.

Woods Ferry floods every year with the water level occasionally reaching 10 ft. or more above the bank. This site was damaged by flooding that followed heavy rains. Recreational use contributed to bank instability.

Soil bioengineering was used because of the substantially lower cost ($58,000) and because the end result would be a natural-looking and functioning bank. Soil bioengineering had not been attempted on the forest on a site that experienced the same degree of flooding.

Eight hundred and sixty ft of the bank was treated. This included two cribwalls with brush layering on top, one 180 ft. long, the other 220 ft. long. Two sections of bank, a 60-ft. section between the cribwalls and a 400-ft. section at the downstream end of the project, received a minimum treatment of live posts, live stakes, and seeding.

BEFORE CONSTRUCTION

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Notice the two leaning trees at the water level.

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Severe flood damage in January 1995.

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DURING CONSTRUCTION

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The first log of a cribwall is laid and anchored into the bank with a deadman.

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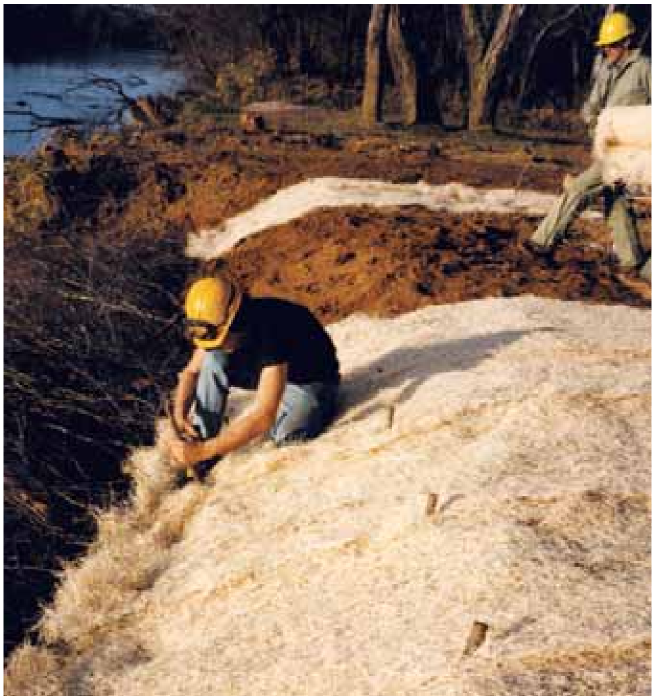
Brush layering on top of a cribwall.



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One cribwall/brush layer was finished using erosion control fabric and seeding.

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Another cribwall/brush layer was finished with a live fascine at the top of the bank. Note the brush layers extending toward the water.

AFTER CONSTRUCTION


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Growing brush layer on top of cribwall, May 1997.


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Downstream end of one cribwall keyed into a large tree.


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Revegetated stabilized bank. Notice the two trees leaning towards the water.