# The Practical Streambank Bioengineering Guide

## User's Guide for Natural Streambank Stabilization Techniques in the Arid and Semi-arid Great Basin and Intermountain West

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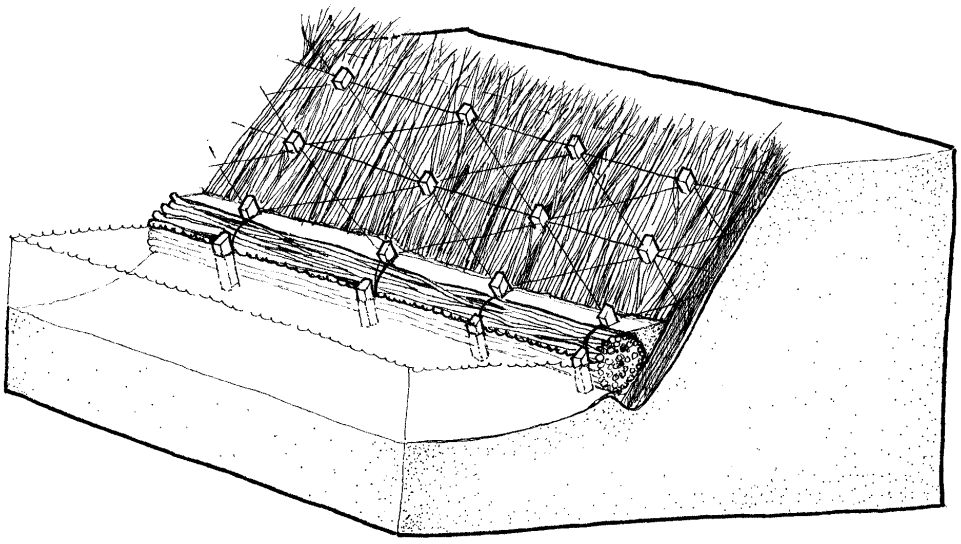
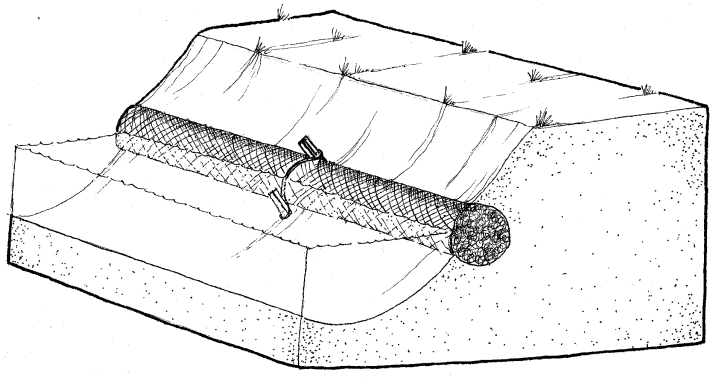
## Appendix A
## Bioengineering Techniques



Brush Mattress

# Fiberschine



## Materials:

- o fiber rolls or biologs
- o 10-12 gauge wire
- o wood stakes
- o sledgehammer
- o 2 people minimum

## Description and Use

This technique uses a coconut-fiber roll product to protect the streambank by stabilizing the toe of the slope and by trapping sediment from the sloughing streambank. Cuttings and herbaceous riparian plants are planted into the fiberschine and behind it. By the time the fiberschine decomposes, riparian vegetation will have stabilized the streambank.

## How To Install

1. Determine the length of treatment area and acquire the necessary amount of fiberschines from a supplier. Common tradenames for fiberschines include Biologs and Fiber Rolls. Be sure to order enough fiberschine to allow for 5 feet to extend past each end of the treatment area.

A list of suppliers can be obtained from the International Erosion Control Association listed in the Resource section of this guide. Fiberschines can be purchased in various diameters, with the 12 inch diameter being one of the more popular sizes.

2. Place the fiberschine along the toe of the streambank at approximately the low flow line. Submerge the fiberschine so that approximately 1/2 the fiberschine is below the water line. Place other fiberschines along the bank. Tie the ends of adjacent fiberschines together with strong twine.

3. It is critical to key the ends of the fiberschine into the bank to prevent flows from getting behind it. Both ends should then be protected with something hard such as rock to prevent the ends from being scoured.

4. Secure the fiberschine with 24 to 36 inch long wedge-shaped wooden stakes on both sides of the fiberschine at 5 foot intervals. Cut a 3/4" deep notch in each stake about 5" from the top. Tie twine or wire around each pair of stakes at the notches. Drive the stakes in so that the twine is secured against the top of the fiberschine.

Another option for securing the fiberschines is to use cable and soil anchors. This method will probably secure the fiberschine more firmly into the streambank.

5. Backfill behind the fiberschine by knocking down the top of the streambank onto the fiberschine.

6. Plant herbaceous wetland plants or willows into and behind the fiberschine. Herbaceous plants should be planted approximately 0.5-1 foot on center (see other Technique Sheets).

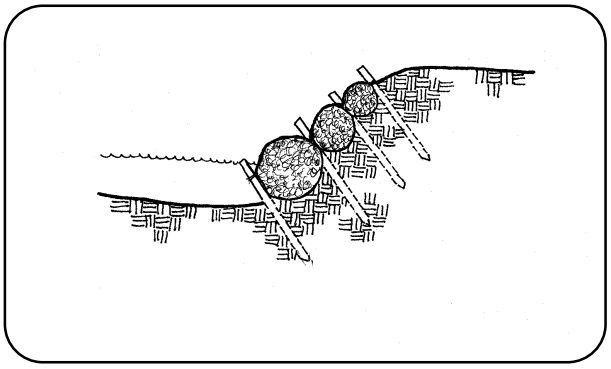
# Fiberschine

## Inventory & Planning Considerations

1. Installation of the fiberschine can usually be accomplished throughout the year. High water periods should be avoided for safety reasons.

2. The fiberschine should extend upstream and downstream past the eroded area being treated to prevent flows from getting behind the fiberschine. Analysis and calculations may reveal that additional toe protection is necessary (refer to Chapter 3 of the Streambank Bioengineering Guide). In many cases, rock may be appropriate if placed properly. Improperly placed rock can result in erosion problems on the opposite streambank as well as downstream.

3. Be sure to key the upstream and downstream end of the fiberschine into the streambank and secure it with some hard materials such as tree trunks or large rocks.



Tiered Fiberschine Construction

4. If this method is used in a highly erodible area and bank shaping is not possible, a tiered fiberschine technique may be necessary. Three fiberschines of different diameters are often used but various numbers and combinations of sizes can be used.

5. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed,

## Management

To ensure the highest success for the treated area, determine the land management practices that created the eroded streambanks and modify those land use practices necessary.

If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put the exclosure fences at the high water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time.

If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Check with your local NRCS district conservationist for cost-share programs and volunteers for fencing, planting, and other restoration activities.

Finally, a stream is an interconnected system and land use practices both upstream and downstream will affect the success of your bioengineering work. Talk with your neighbors and work together to create a healthier riparian and stream system that can benefit everyone.

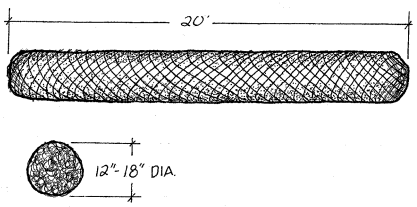
## Monitoring & Maintenance

Do not ignore the project after it has been installed. Periodic monitoring of the project will provide valuable insight into the stabilization process and may offer important information for future projects.

Periodic maintenance includes checking on the fiberschine to ensure that the posts and wire are holding the fiberschine in place. Additional native plantings may be necessary to accelerate the healing process.

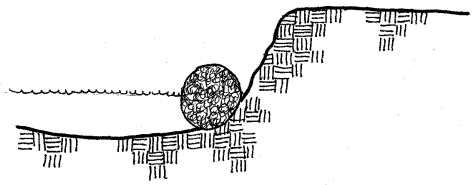
# Procedure for Fiberschines

Acquire the amount of fiberschines needed for the project.



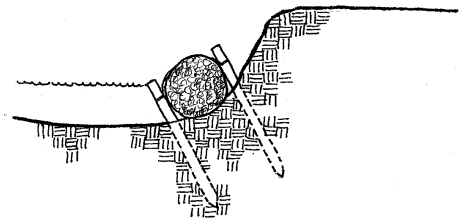

**Step One: Acquisition of fiberschines**

Place fiberschine at the toe of streambank at the low water line. Key in the ends of the fiberschine. See "How to Install".



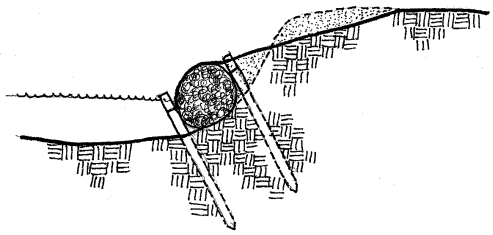
**Step Two: Excavate Trench**

Drive notched wooden stakes at 5' intervals on each side of the fiberschine. Tie twine between each pair of notched stakes. Drive stakes in until twine is tight across the top of the fiberschine.



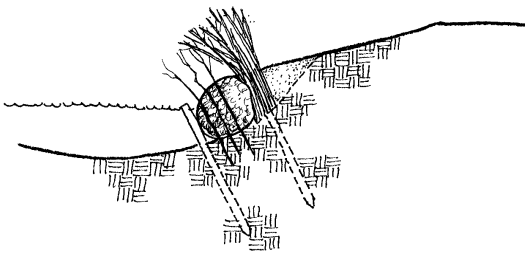
**Step Three: Secure fiberschines**

Backfill behind the fiberschine.



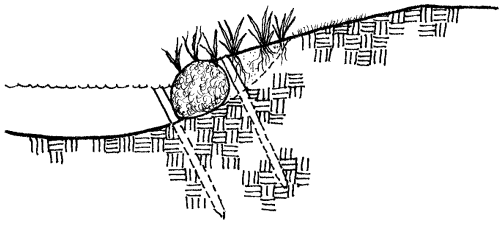
**Step Four: Backfill**

Willow cuttings should be planted into and behind the fiberschine before backfilling.



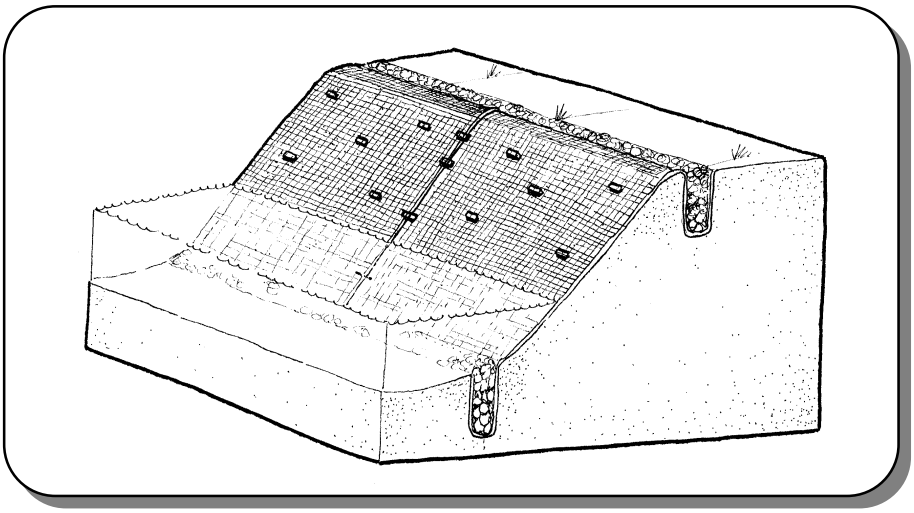
**Step 5: Willow Plantings**

Herbaceous wetland plants should be planted into the roll and the soil after backfilling. Make sure the root systems are in saturated soil.



**Step 5: Herbaceous Wetland Plantings**

# Erosion Control Fabric



## Materials:

- o erosion control fabric
- o shovel
- o sledgehammer
- o wedge-shaped wooden stakes
- o 1 person minimum

## Description and Use

Erosion control fabrics are commercially-available products that can be used to prevent erosion on slopes until vegetation establishes and has a chance to stabilize the slope. The fabrics are constructed of a variety of materials from coconut fiber or jute to straw mulch encased in plastic netting. For stream applications, a tightly woven coconut fiber blanket is the most durable option. Woody cuttings and herbaceous plants can be planted into the fabric and seed can be placed underneath the fabric. By the time the blanket decomposes (usually 2 to 5 years depending on local climate), vegetation will have significantly stabilized the streambank.

**NOTE:** Although this technique can be used by itself in a stream system, it is probably best to use this material with other techniques (see page 4).

## How To Install

Determine the square footage of the treatment area and acquire the necessary amount of fabric from a supplier. Order extra material to allow for overlap. A list of suppliers can be obtained from the International Erosion Control Association which is listed in the Resource section of this guide.

1. Seed the streambank with native herbaceous seed and rake to ensure good seed-soil contact. Fabrics are most effective on slopes that are no steeper than 2H:1V.

2. Excavate two trenches, one at the toe of the slope and the other at the top of the bank. The trench at the toe should be 12 inches deep and 6 to 8 inches wide. The trench at the top of the bank should be located at least a foot from the edge and should be 12 inches deep and 6 to 8 inches wide.

3. A key trench at the upstream end should be excavated perpendicular to the flow, connecting the ends of the other trenches (See illustrations).

4. The fabric should be placed on the streambank with the ends of the fabric in the trench so that the fabric is touching the three sides of the trench. Use a wedge-shaped wood stake to secure the fabric to the bottom of the trench.

5. Continue to cover the rest of the streambank with the fabric blanket. Install the blankets so the edge overlaps are shingled away from the direction of the current. Overlap the blanket edges approximately 12 inches and secure with wedge-shaped wooden stakes. Secure the blanket to the slope according to manufacturer specifications. Usually, a triangular spacing of 24" on center is suitable for stream applications. The upstream end of the blanket should be keyed into the final trench.

6. Backfill the trenches with excavated soil or small cobble and compact it. Pole plantings should be planted through the fabric (See page 4).

# Erosion Control Fabric

## Inventory & Planning Considerations

1. An important step with this technique is to ensure the upstream and downstream ends of the erosion control blanket are well keyed into the bank to prevent high flows from pulling the blanket out. Cobble should be placed in the key trenches to prevent the fabric from being pulled out.

2. Another important step is where the fabric overlaps, it should be shingled away from the direction of the current to prevent flows from pulling at the fabric.

3. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

## Management

To ensure the highest success for the treated area, determine the land management practices that created the eroded streambanks and modify those practices as necessary.

If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put the exclosure fences at the high water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time.

If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Check with your local NRCS district conservationist for cost-share programs and volunteers for fencing, planting, and other restoration activities.

Finally, a stream is an interconnected system and land use practices both upstream and downstream will affect the success of your bioengineering work. Talk with your neighbors and work together to create a healthier riparian and stream system that can benefit everyone.

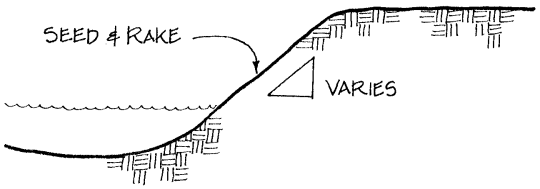
## Monitoring & Maintenance

Do not ignore the project after it has been installed. Periodic monitoring of the project will provide valuable insight into the stabilization process and may offer important information for future projects.

Periodic maintenance includes making sure the staples and key trenches are still securing the fabric blanket to the streambank. The upstream end should be carefully checked to make sure flows are not getting behind the blanket.

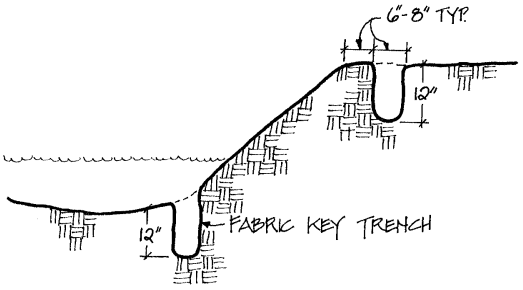
# Procedure for Erosion Control Fabric

Seed the streambank with native herbaceous seed and rake in to ensure good seed-soil contact. Slope varies-See "How to Install".



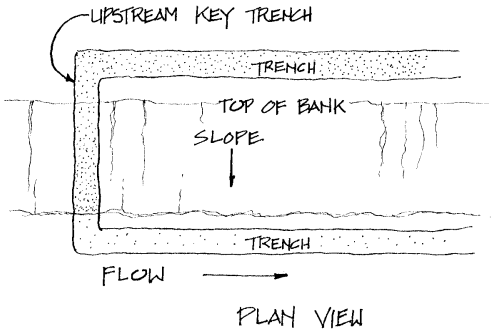

**Step One**: **Seeding**

Excavate two trenches as shown.



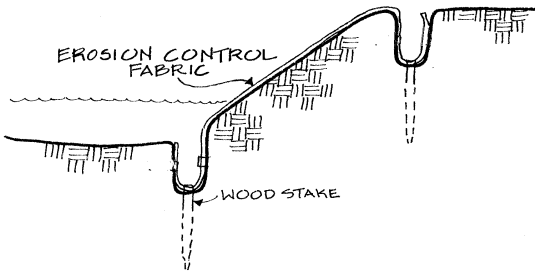

**Step Two: Excavate Trench**

Excavate an upstream key trench perpendicular to flow.



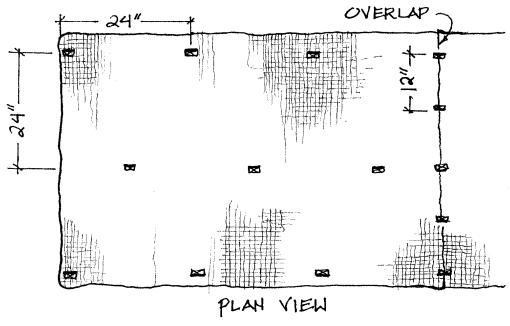

**Step Three: Upstream Key Trench**

Place fabric on streambank and in trenches and secure with a wedge-shaped wooden stake.



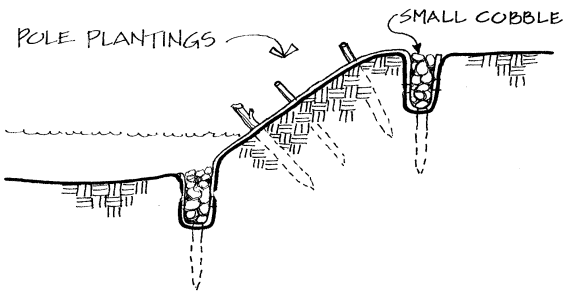

**Step Four: Fabric Placement**

After laying out the blanket, secure the fabric with wedge-shaped wooden stakes according to manufactures specs or suggested pattern.



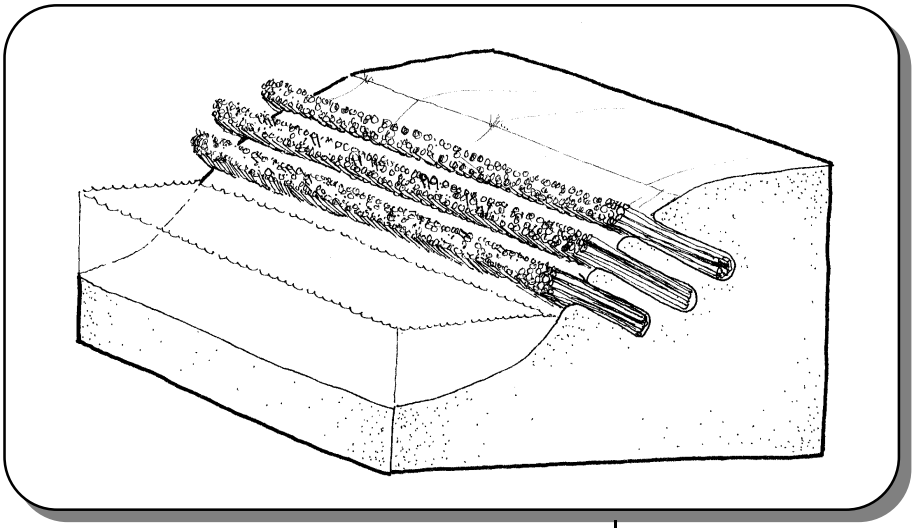

**Step Five: Suggested Stake Layout**

Backfill all trenches with excavated soil or small cobble and compact it.




**Step Six: Backfill**

# Brush Layering



## Materials:

- willow cuttings
- clothesline cord or wire
- chain saw or loppers (to harvest willows)
- shovel
- 1 person minimum

## Description and Use

This technique uses bundles of willow cuttings (*Salix* spp.) in buried trenches along the slope of an eroding streambank. This willow "terrace" is used to reduce the length of slope of the streambank. The willow cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots. Some toe protection such as a wattle, fiberschine, or rock may be necessary with this technique.

## How To Install

1. Harvest willow cuttings from a local, native stand that is in healthy condition taking no more than 2/3 of each plant. Cuttings should be at least a 1/2 inch diameter or larger to ensure an adequate supply of stored energy for rooting, but there should be a good mixture of various sizes. This is to ensure better entrapment of sediment which will promote better root growth.

Ideally, cuttings should be collected during the dormant season to ensure the highest success rate. Cuttings can be collected during the growing season if all the leaves are removed from the stem, although establishment success will be lowered. Spring plantings are more successful than fall plantings.

2. The cuttings may be tied into bundles to facilitate transportation to the project site. The terminal bud should be removed so that stem energy will be re-routed to the lateral buds for more efficient root and stem sprouting.

3. Soak the bundles for 4 to 5 days.

4. Toe protection if needed should be installed prior to excavation. Excavate a horizontal trench into the streambank along the length of the area to be treated. The trench should be located between the annual low and high water levels. The trench should be approximately 2 to 3 feet deep and the back portion must reach the permanent water table. The surface of the trench should be sloped 10 to 20 degrees such that the outside edge is higher than the inside.

5. Cut the twine on the bundles and place the cuttings in the trench. Make sure the basal cut ends reach the back of the trench. Spread the cuttings in the trench until desired thickness is achieved. In general, the thicker and denser the cuttings, the better the technique will work.

6. Slough the bank down on to the cuttings and pack the soil into the cuttings. To remove air pockets around the cuttings, water the soil when backfilling. The cuttings should extend no more than 12 to 18 inches from the bank to prevent them from being ripped out during high flows. Trim off the excess.

7. Create another terrace for cuttings behind the first layer as shown in the illustrations. Repeat the trenching and layering process until the streambank is sufficiently covered with brush layers. A brush trench can be installed at the top of the bank for overland flows (refer to Brush Trench Technique Sheet).

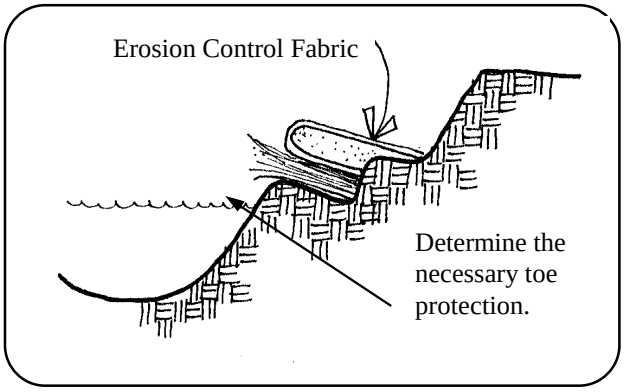
# Brush Layering

## Inventory & Planning Considerations

1. Coyote willow (*Salix exigua*) is a particularly good species for this method because of its' dense rooting system. This technique can also be used with a mixture of redoiser dogwood (*Cornus sericea*) and willow but to encourage rooting in the dogwood, the stems will need to be manually nicked or cut and treated with rooting hormone.

2. A critical inventory step is to determine the availability of moisture for the cuttings. This technique is best applied to areas with bank seepage to supply enough moisture for the cuttings. In our semi-arid to arid region, the upper portion of the streambank may not have enough permanent moisture to establish the cuttings, and thus, other techniques may be required.

3. Another critical step with this technique is to determine if toe protection is necessary. Analysis and calculations will provide some guidance (see Chapter 3 Streambank Bioengineering Guide). In many cases rock will be necessary to provide adequate protection. In addition to toe protection, erosion control fabric can be used to protect the soil




Brush Layering with Erosion Control Fabric

4. Give careful attention to the upstream and downstream ends of the treatment area to prevent flows from getting behind the layers. Tying into existing features on site such as trees and rocks or the additional placement of brush and rocks are possible solutions.

## Management

To ensure the highest success for the treated area, determine the land management practices that created the eroded streambanks and modify those practices as necessary.

If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put the exclosure fences at the high water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time.

If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Check with your local NRCS district conservationist for cost-share programs and volunteers for fencing, planting, and other restoration activities.

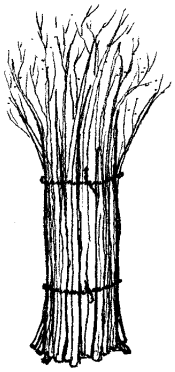
Finally, a stream is an interconnected system and land use practices both upstream and downstream will affect the success of your bioengineering work. Talk with your neighbors and work together to create a healthier riparian and stream system that can benefit everyone.

## Monitoring & Maintenance

Do not ignore the project after it has been installed. Periodic monitoring of the project will provide valuable insight into the stabilization process and may offer important information for future projects.

Periodic maintenance includes making sure the streambank is not eroding close to the side of the trench. It may be determined that some additional protection is necessary to allow more time for the cuttings to take root and stabilize the streambank.

# Procedure for Brush Layer

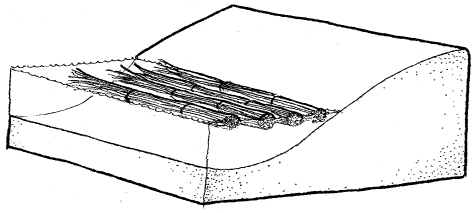


Harvest the willows and remove terminal bud.


Tie cuttings into bundles using 2 pieces of twine to facilitate transportation.

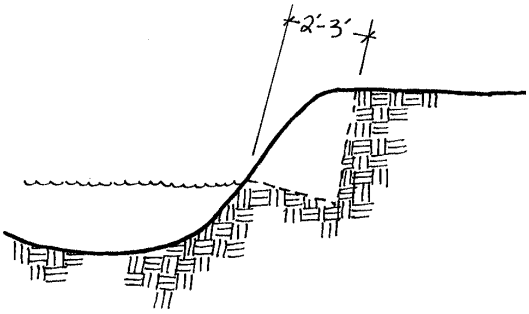
**Step One**: **Acquire Willow**

Soak the bundles for 5 to 7 days before planting. Remove from water before roots emerge.



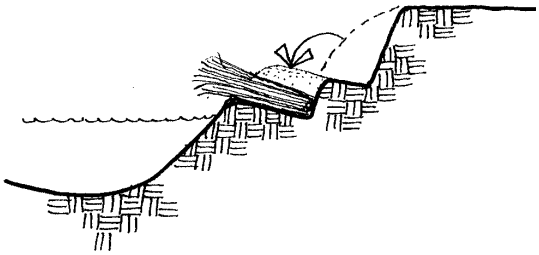
**Step Two: Soak Willow Bundles**

Install the selected toe protection. Excavate the trench and make sure the trench slopes back.



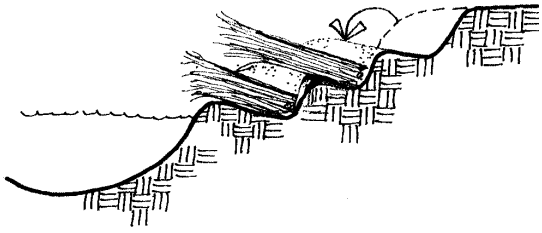

**Step Three: Excavate trench**

Lay out the cuttings along the trench and slough the bank onto the cuttings. Work the soils into the cuttings.



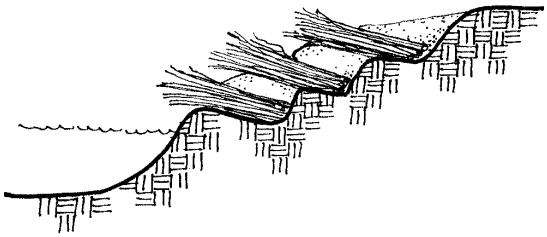
**Step Four: Layer Placement**

Create another terrace as shown and place the cuttings. Slough the bank on to the cuttings.



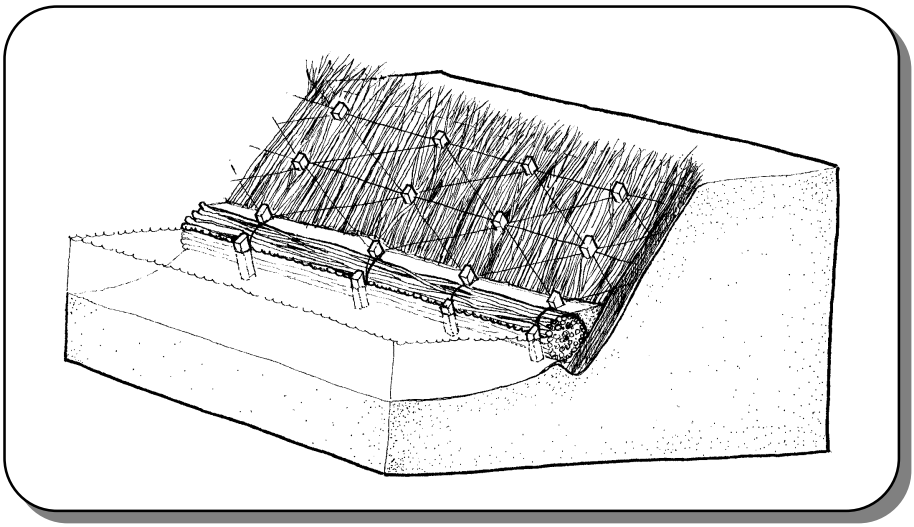
**Step Five: 2nd Layer Placement**

Repeat the process until the final layer is placed.



**Step Six: 3rd Layer Placement**

# Brush Mattress



## Materials:

- o willow cuttings
- o clothesline cord or wire
- o chain saw or loppers (to harvest willows)
- o shovel
- o 10-12 gauge wire
- o wood stakes
- o 2 person minimum

## Description and Use

This technique uses a mat of willow cuttings along the slope of an eroding streambank. The cut ends of the willows are placed in a trench at the toe of the slope and are anchored with a wattle (See other Technique Sheet). A grid of wire and wooden stakes is used to secure the mat to the slope. The willow cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots.

## How To Install

See Willow Wattle/Fascine Technique Sheet for information on collecting willow cuttings for the wattle and brush mattress.

1. Prepare the slope of the streambank by clearing away large debris, however, do not remove woody debris from the stream channel because this provides important fish habitat. The brush mattress technique is probably most effective on slopes no steeper than 2H:1V. Excavate a horizontal trench, 8 to 12 inches deep, at the toe of the streambank along the length of the area to be treated.

2. Place willow cuttings in the trench. Make sure the cut ends reach the bottom of the trench. Spread the cuttings along the face of the slope until a thickness of 4 to 6 inches is achieved.

3. Pound in a grid of 24 to 36 inch long wooden stakes into the mattress every 3 to 4 foot centers (See illustrated procedure). Use longer stakes in less cohesive soil. Secure the brush mattress by using 10-12 gauge galvanized annealed wire or clothesline cord tied in horizontal runs and then diagonally between each row of stakes. Tie the wire to the stakes in such a manner that if the wire breaks between two stakes, the integrity of the remaining wiring is maintained.

4. After wiring the mattress, drive the stakes in further to compress the mattress tightly against the streambank.

5. Construct a wattle the length of the area to be treated (refer to Willow Wattle Technique Sheet). Make sure the wattle is tightly tied together. Place the wattle in the trench over the cut ends of the brush mattress. Secure the wattle with 18 to 48 inch long wedge-shaped wooden stakes every 5 feet as shown the illustrated sequence. Use longer stakes in less cohesive soil. In some instances, a rock toe may be used instead of a willow wattle to anchor the cut ends of the mattress.

6. Backfill around the wattle and mattress by using material excavated from the trench, making sure to work soil into the branches. Use buckets of water to wash the soil down into the stems. Key the upstream end of the mattress and wattle into the streambank to prevent high flows from getting behind the mattress. It is a good idea to protect this area with some revetment, large rocks, or tree trunks.

# Brush Mattress

## Inventory & Planning Considerations

1. Make sure the upstream end of the wattle and mattress is keyed back into the bank to prevent high flows from scouring behind the mattress. Brush revetment, rock barbs, large rocks, and tree trunks can be used in front of this area to protect the mattress.

2. Be sure to pound in the stakes after wiring the mattress in order to compress the mattress tightly against the streambank.

3. Coyote willow (*Salix exigua*) is a particularly good species for this method because of its' dense rooting system.

4. Rooting hormones and fertilizers do not significantly improved success compared to the cost of the materials.

5. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

Saw a 2 x 4 diagonally to produce 2 stakes. The length will vary based on on soil conditions. Use longer stakes in less cohesive soil (i.e. sandy soils)

## Management

To ensure the highest success for the treated area, determine the land management practices that created the eroded streambanks and modify those practices as necessary.

If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put the exclosure fences at the high water line. The exclosure area should include enough of the riparian zone to allow the stream to shift naturally over time.

If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Check with your local NRCS district conservationist for cost-share programs and volunteers for fencing, planting, and other restoration activities.

Finally, a stream is an interconnected system. Land use practices both upstream and downstream will affect the success of your bioengineering work. Talk with your neighbors and work together to create a healthier riparian and stream system that can benefit everyone.

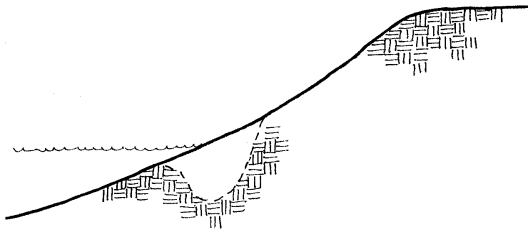
## Monitoring & Maintenance

It is important to monitor the project after it has been installed. Periodic monitoring of the project will provide valuable insight into the stabilization process and may offer important information for future projects.

Periodic maintenance includes making sure the stakes and wire are still securing the mattress to the streambank. The upstream end should be carefully checked to make sure flows are not getting behind the mattress.

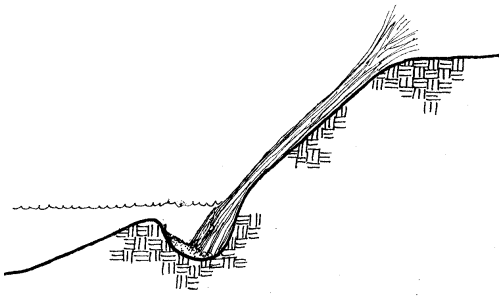
# Procedure for Brush Mattress

Willow collection, soaking and wattle construction should occur prior to excavation of the trench. See "How to Install".



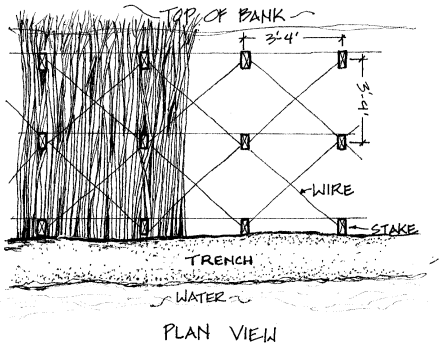
**Step One**: **Excavate Trench**

Place willows in the trench, making sure the cut ends reach the bottom.

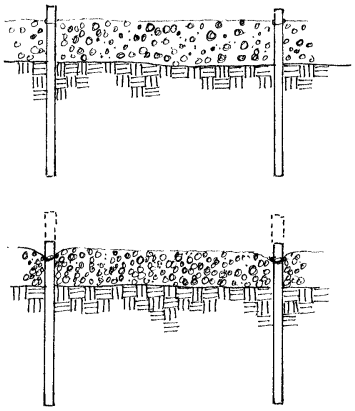


**Step Two: Mattress Placement**

Establish a gird of wedge-shaped wooden stakes and wire as shown.



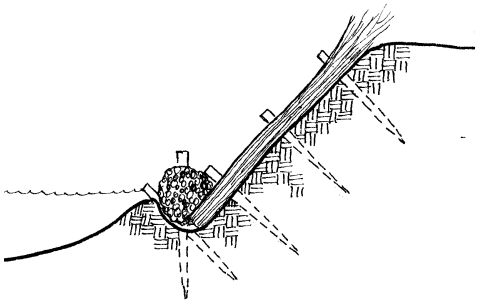

**Step Three: Stake Placement and Wiring**



After wiring the mattress, drive the stakes in further to compress the mattress against the streambank.

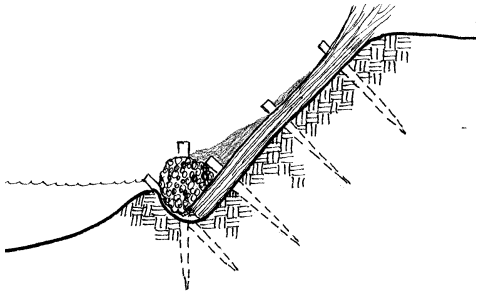
**Step Four: Mattress Compression**

Place wattle in trench. Secure wattle with 2 wedge-shaped wooden stakes as shown



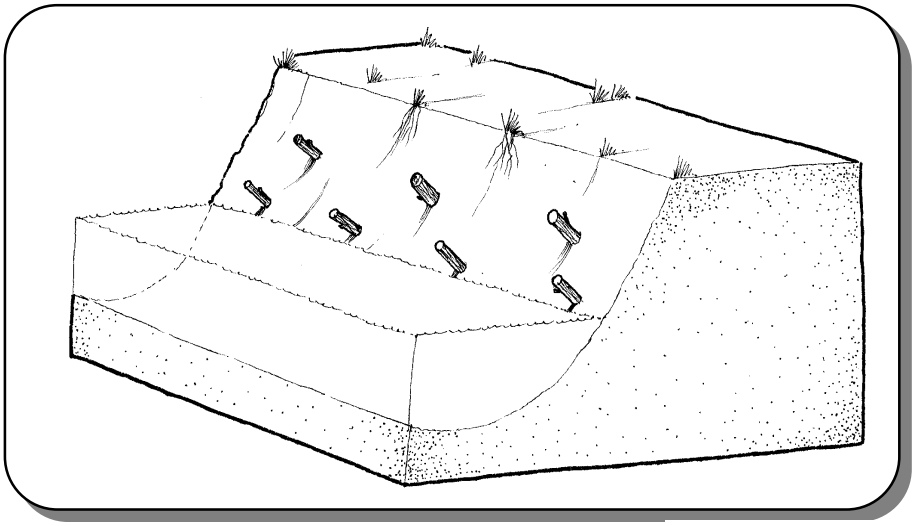
**Step Five: Secure Wattle**

The mattress and wattle should be partially covered with soil, making sure to work the soil into the voids. Leave parts of the blanket exposed for sprouting.



**Step Six: Backfill**

# Pole Plantings



## Materials:

- o willow or cottonwood cuttings
- o poly twine
- o chain saw or loppers (to harvest )
- o auger or planting bar
- o 1 person minimum

## Description and Use

Pole plantings are cuttings from willow (*Salix* spp.) or cottonwood (*Populus* spp.) used to revegetate eroding streambanks. These cuttings will sprout and take root, stabilizing the streambank with a dense matrix of roots.

## How To Install

1. Collect willow or cottonwood cuttings from a local, native stand that is in healthy condition. Thin no more than 2/3 of each total plant. Willow cuttings for pole plantings should generally be at least 1/2 inch in diameter or larger, depending upon the species.

Larger diameter cuttings have a greater supply of stored energy for rooting than smaller diameter cuttings. Bigger diameter and longer lengths are better suited for severely eroded areas and fluctuating water levels.

Ideally, cuttings should be collected during the dormant season to ensure the highest success rate. Cuttings can be collected during the growing season if all the leaves are removed from the stem, although establishment success will be lowered. Spring plantings are generally more successful than fall plantings.

2. Prepare cuttings by trimming off the top to remove the terminal bud, allowing a majority of the energy in the stem to be sent to the lateral buds for rooting and sprouting.

3. The cuttings can be tied into bundles for ease of transportation to the site.

4. Soak the bundles for 5 to 7 days. Cutting length is determined by site conditions. The cutting should extend several inches into the permanent water table to ensure adequate moisture for sprouting. At least 1/2 to 2/3's of the cutting should be below ground to prevent the cutting from being ripped out during high flows. Usually, at least 2 to 3 feet should be below ground. It should also be long enough to emerge above adjacent vegetation such that it will not be shaded out.

5. Pole plantings are usually planted with a power auger or a punch bar. It is critical to ensure the soil is packed around the cutting to prevent air pockets. "Mudding" (filling the hole with water and then adding soil to make a mud slurry) can remove air pockets .

6. It is often advisable to plant at least two rows of cuttings to cover the range in fluctuating water levels. The location of the cuttings will depend on the specific situation and hydrograph. In some cases where information is limited, one row can be planted at the low flow line and the other at the high flow line. Offset the rows to get better coverage (see illustration).

# Pole Plantings

## Inventory & Planning Considerations

1. Shrub willows such as coyote willow (*Salix exigua*) are used for planting within channel banks. Willow tree species and cottonwoods are normally planted along the upper bank and floodplain areas. Tree species usually provide more shade.

2. If this method is used in a highly erodible area, some protection will be required in front of the pole plantings. In particular, the toe of the slope is very susceptible to erosive flows and scour. Analysis and calculations of forces will provide guidance for suitable toe protection (refer to Chapter 3 of the Streambank Bioengineering Guide). In some cases, brush revetment or fiber rolls may be adequate (see other Technique Sheets), while other situations may require rock. If rock is used, careful application is required. Improperly placed rock can result in erosion problems on the opposite streambank as well as downstream.

3. As with all techniques, give careful attention to the upstream and downstream ends of the treatment area to prevent flows from getting behind the treatment. The key is to divert flows away from these endpoints. Tying into existing on site features such as trees, rocks, etc., or using brush revetment and rock barbs are some possible solutions.

4. It is important that the cuttings be placed in water immediately following harvesting if they are going to be planted during the next week. The cuttings can also be kept in cold storage (32 to 35$^{o}$ F) for up to 6 months. After removal from cold storage, soak the cuttings for 5 to 7 days prior to planting.

5. Rooting hormones and fertilizers do not significantly improved success compared to the cost of the materials.

6. Cuttings will often require initial protection from beaver. Fine wire screen or mesh can be secured around the cuttings to offer protection.

7. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

## Management

To ensure the highest success for the treated area, determine the land management practices that created the eroded streambanks and modify those practices as necessary.

If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put the exclosure fences at the high water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time.

If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Check with your local NRCS district conservationist for cost-share programs and volunteers for fencing, planting, and other restoration activities.

Finally, a stream is an interconnected system. Land use practices both upstream and downstream will affect the success of your bioengineering work. Talk with your neighbors and work together to create a healthier riparian and stream system that can benefit everyone.

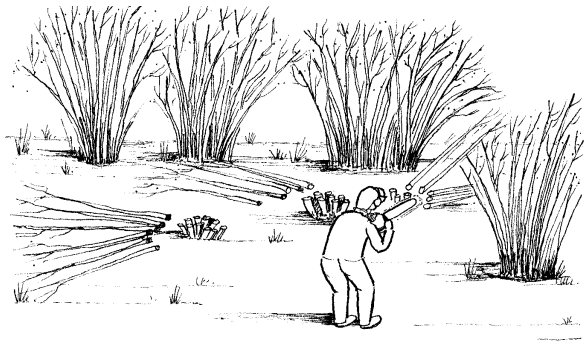
## Monitoring & Maintenance

Do not ignore the project after it has been installed. Periodic monitoring of the project will provide valuable insight into the stabilization process and may offer important information for future projects.

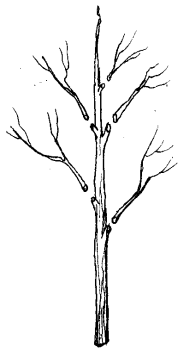
Replanting will probably be necessary to fill in areas where plantings did not grow. It is not uncommon to have some cuttings die due to highly variable water flows from year to year or from wildlife predation. Flood debris lodged around the cuttings should be removed to prevent shading and to allow growth.

# Procedure for Pole Plantings

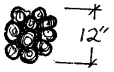
Pole cuttings can be collected from large willows and cottonwoods.



**Step One**: **Harvest Willow Cuttings**



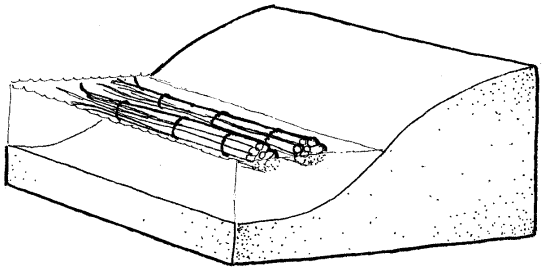
Trim off all side and terminal branches




Tie cuttings into 8-12" diameter bundles using 2 pieces of twine to facilitate transportation.

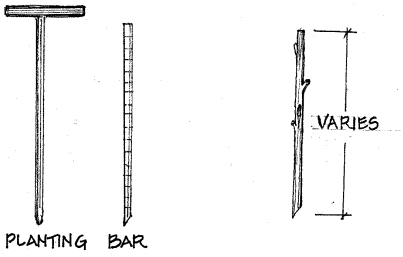
**Step Two: Create Willow Bundles**

Soak bundles for 5 to 7 days. Remove them from water before roots emerge.



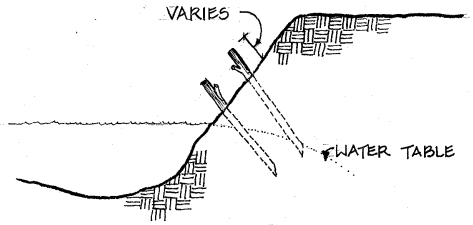
**Step Three: Soak Willow Bundles**

Final cutting length will vary (See "How to Install"). Punch bars or augers can be used for creating the holes.



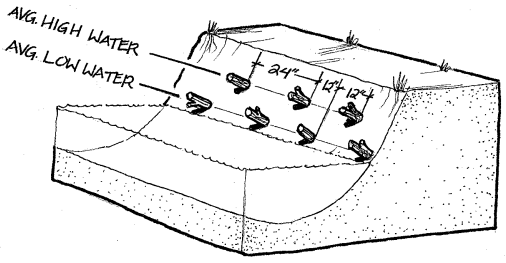

**Step Four: Planting Preparation**

Plant the pole such that the end of the cuttings extends into the water table. Above ground height varies (See "How to Install").



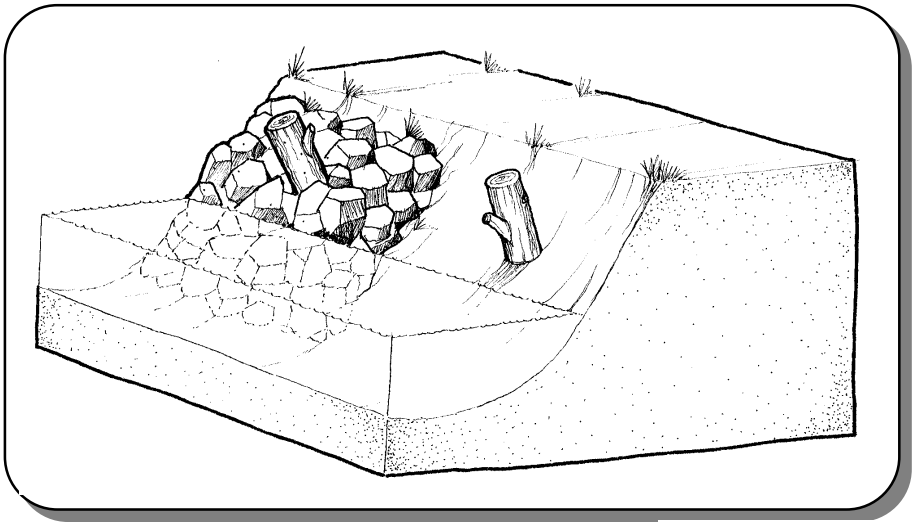

**Step Five: Pole Planting**

The following is a good spacing pattern to cover the variables of a fluctuating water level.




**Step Six: Pole Placement**

# Post Plantings



## Materials:

- o cottonwood or willow posts
- o metal cap (for pushing in posts)
- o chain saw
- o stinger & backhoe
- o 2 person minimum

## Description and Use

Post plantings use large diameter cuttings from cottonwood (*Populus spp*.) or willow (*Salix spp*.) to revegetate eroding streambanks and reservoir and lake edges. By using a stinger, posts may be planted into existing rip-rap. A stinger is a large metal punch bar mounted on a backhoe. These cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots.

Instructions for building a stinger can be obtained from:

USDA-NRCS Plant Materials Center
Box 296
Aberdeen, ID 83210
(208) 397-4133

## How To Install

1. Harvest cottonwood or willow posts from a local, native stand that is in healthy condition. Harvest only a few posts from each plant. Posts should be collected during the dormant season to ensure the highest success rate. Posts can be collected during the growing season if all leaves are removed from the stem. although establishment success will be lowered. Spring plantings are generally more successful than fall plantings.

2. The posts should range in size from 3 to 6 inches in diameter and 5 to 7 feet in length. Larger diameter cuttings have a greater supply of stored energy for rooting than smaller diameter cuttings.

Bigger diameters and longer length are better suited for severely eroded areas and fluctuating water levels. Prepare the posts by trimming off all side branches and the top. The bottom can be sharpened into a point to facilitate planting.

3. Soak the posts for 5 to 7 days prior to planting.

4. Take posts and stinger to project area. Punch holes with the stinger at 1 foot above the high waterline. This can be difficult to determine at reservoirs and streams with widely fluctuating water levels from year to year. In this case, ensure that the ends of the posts reach the low waterline at the time of planting if possible. The stinger should be removed slowly from the hole to prevent it from caving in.

5. As the stinger is removed from the hole, a person should be ready to insert a post into the hole immediately. A metal cap should then be placed over the post to protect the cutting as it is being pushed into the hole with the stinger.

6. Remove metal cap. Approximately 3 to 8 inches of the post should be left above ground. Posts can be planted every 3 to 4 feet with the realization that even with a good success rate, every post will not survive to maturity.

# Post Plantings

## Inventory & Planning Considerations

1. Successful application of this technique requires a good backhoe operator. Creating the holes and pushing in the posts without breaking them demands care and skill with the backhoe controls.

2. If this method is used in a highly erodible area that is not already rip-rapped, some protection should be placed in front of the post plantings. In particular, the toe of the slope is very susceptible to erosive flows and scour. Analysis and calculations of forces will provide guidance for suitable toe protection (refer to Chapter 3 Streambank Bioengineering Guide). In some cases, brush revetment or fiber rolls may be adequate (See other Technique Sheets), while other situations may require rock. If rock is used, careful application is required. Improperly placed rock can result in erosion problems on the opposite streambank as well as downstream.

3. As with all techniques, give careful attention to the upstream and downstream ends of the treatment area to ensure flows do not get behind the treatment. The key is to divert flows away from these endpoints. Tying into existing on site features such as trees, rocks, etc. or using brush revetment are some possible solutions.

4. It is important the posts be placed in water immediately following harvesting if they are going to be planted during the next week. The cuttings can also be kept in cold storage (32 to 35$^{o}$ F) for up to 6 months. After removal from cold storage, soak the cuttings for 5 to 7 days prior to planting.

5. Rooting hormones and fertilizers do not significantly improved success compared to the cost of the materials unless the bark is heavily furrowed.

6. Cuttings will often require initial protection from beaver. Fine wire screen or mesh can be secured around the cuttings to offer protection.

7. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

## Management

To ensure the highest success for treated area, determine the land management practices that created the eroded streambanks and modify those practices as necessary.

If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put exclosure fences at the high water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time.

If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Check with your local NRCS district conservationist for cost-share programs and volunteers for fencing, planting, and other restoration activities.

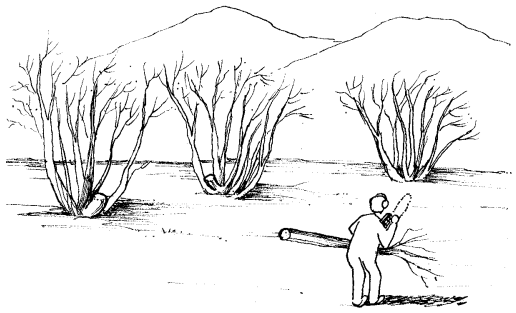
Finally, a stream is an interconnected system. Land use practices both upstream and downstream will affect the success of your bioengineering work. Talk with your neighbors and work together to create a healthier riparian and stream system that can benefit everyone.

## Monitoring & Maintenance

Do not ignore the project after it has been installed. Periodic monitoring of the project will provide valuable insight into the stabilization process and may offer important information for future projects.

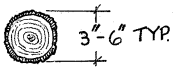
Replanting will probably be necessary to fill in areas where plantings did not grow. It is not uncommon to have some cuttings die due to highly variable water flows from year to year or from wildlife predation. Flood debris lodged around the posts should be removed to prevent shading and to allow growth.

# Procedure for Post Plantings

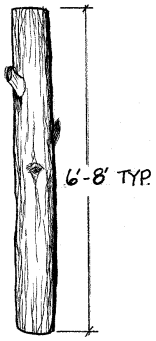


**Step One**: **Harvest Posts**

Prepare posts by trimming off side branches

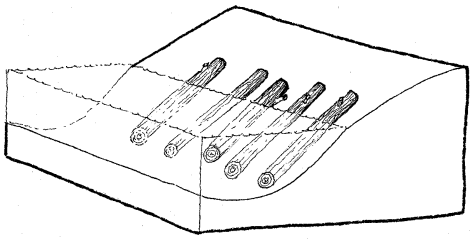



Posts may be longer based on site conditions.



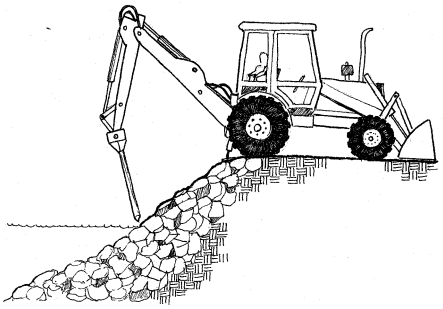

**Step Two: Post Specifications**

Soak posts for 5 to 7 days. Remove them from the water before roots emerge.



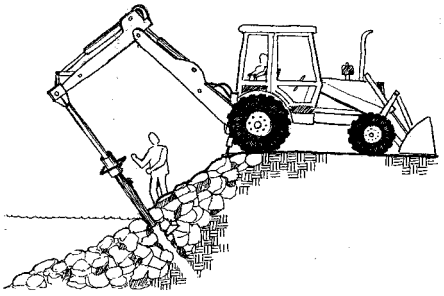
**Step Three: Soak Posts**

Punch hole with stinger at average water line.

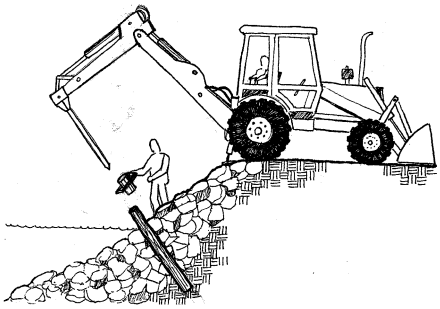


**Step Four: Punch Hole**

Place a metal cap over the post, then push the post into the hole until 12 to 18 inches extend above the rip-rap.

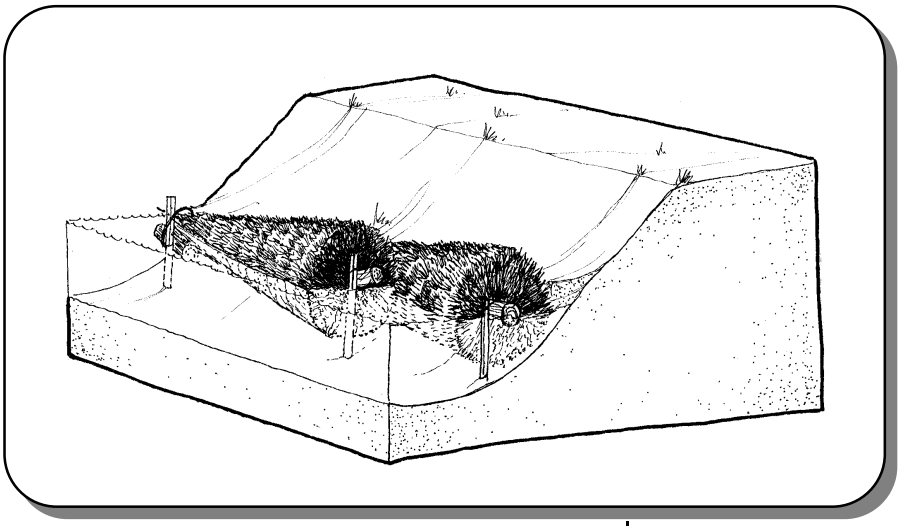


**Step Five: Post Placement**



**Step Six: Remove Metal Cap**

# Brush or Tree Revetment



## Materials:

- o dead/live brush or trees such as junipers or hawthorns
- o 10-12 gauge wire
- o poly rope
- o 7-1/2' metal t-posts
- o wire cutters
- o post pounder
- o chain saw (for cutting brush)
- o 2 people minimum

## Description and Use

Brush or trees are secured to the streambanks slow excessive erosion by diverting the current away from the bank edge's. The revetment also traps sediment from the stream and sloughing streambank and provides overhead cover for fish habitat. The revetment material does not need to sprout (most species used will not). Always plant live willows or other quickly sprouting species behind the revetment to provide permanent cover and roots.

## How To Install

1. Collect trees or brush and stage at treatment area. Use trees with dense branching such as junipers, because they will collect more sediment. Place the first tree with the stump pointing upstream at the top of the treatment area along the top of the bank. Overlap the next tree trunk into the main branches of the first one. Continue this process until a linear row of brush the length of the treatment area is created.

2. Secure the revetment together by tightly wiring at the overlap sections. Overlap by about 1/3 at each end. Wire main trunks together, leaving branches loose.

3. Pound temporary t-posts along the top of the streambank behind the revetment every 12 to 15 feet. At each post, tie an 8 to 10 foot section of rope to the revetment and wrap it around the post.

4. Pound a permanent t-post at the toe of the slope of the streambank at the upstream end of the treatment area. Lower the upper end of the revetment and secure it to the post in stream with wire.

5. Lever the revetment into the stream, while using the rope at each of the posts to control placement and to secure it temporarily. Continue the process until revetment is placed along the streambank.

6. Pound t-posts on the outside edge (stream side) of the revetment at overlap areas. Secure the revetment to posts with wire. Remove rope and temporary posts on the top of the streambank.

7. Fill in the space between the streambank and revetment with additional branches or wattles to form a dense matrix of brush.

8. (Optional) To enhance recovery of treated area, knock down the sloughing streambank on the revetment to create a more gentle streambank slope. Make sure the revetment has enough brush material to catch the soil. If not, add additional brush before shaping the bank. Willow cuttings or other quickly sprouting species should then be planted on the new slope using techniques such as willow wattles, brush mattress, vertical bundles, or willow pole plantings (see other Technique Sheets).

NOTE: Illustrated procedure is shown on page 3. Revetment can be constructed in the water by permanently installing one tree at a

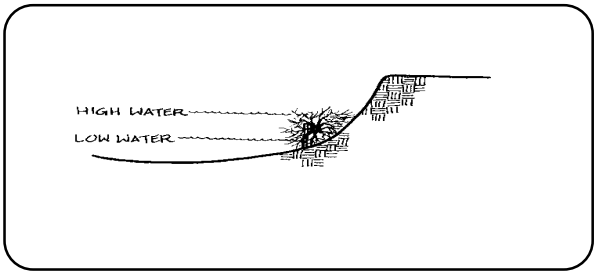
# Brush or Tree Revetment

## Inventory & Planning Considerations

1. Installation of brush or tree revetment can usually be accomplished throughout the year. For safety reasons, avoid high water periods.

2. Typically, the trunks of the revetment should be placed between the annual low and high water levels.
In areas of extreme fluctuation in water levels, it may be necessary to place a second row of revetment at the high water line in order to prevent scouring behind the revetment during flood events.

3. It is critical that the revetment extend upstream and downstream at least 1 to 3 tree lengths past the eroded area being treated to prevent flows from getting behind the revetment. Key the upstream and downstream ends of the revetment into the bank and reinforced with additional brush or rock. These endpoints are the sections most likely to fail and require substantial protection.




**REVETMENT LOCATION**

4. Never disturb the site unnecessarily. Remember that the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

## Management

To ensure the highest success for the treated areas, determine the land management practices that created the eroded streambanks and modify those land use practices as necessary.

If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put exclosure fences at the high water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time.

If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits for the streambanks and the riparian area as a whole.

Check with your local NRCS district conservationist for cost-share programs, volunteers for fencing, planting, and other restoration activities.

Finally, a stream is an interconnected system. Land use practices both upstream and downstream will affect the success of your bioengineering work. Talk with your neighbors and work together to create a healthier riparian and stream system that will benefit everyone.

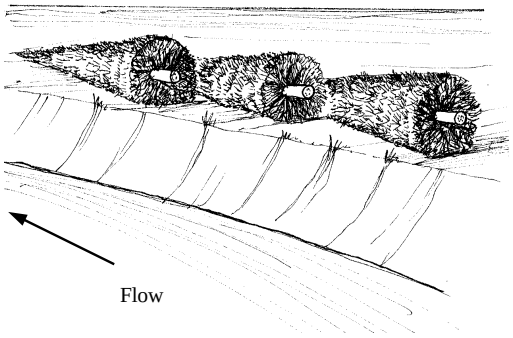
## Monitoring & Maintenance

Do not ignore the project after it has been installed. Periodic monitoring of the project will provide valuable insight into the stabilization process and may offer important information for future projects.

Periodic maintenance for brush or tree revetment includes checking the revetment to ensure that the posts and wire are holding it in place. If significant erosion is still occurring in sections of the treated area, additional brush should be added to the revetment.

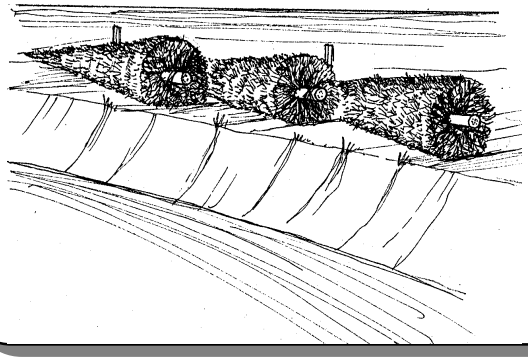
# Procedure for Brush or Tree Revetment-Option A

Overlap the trunk of one tree into the main branches of the next tree.



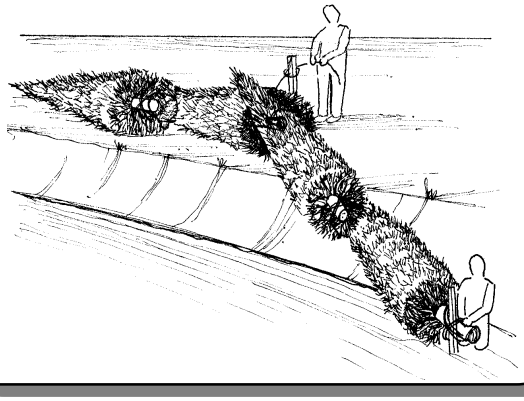

**Step One: Harvest & Stage Material**

Secure the trees together at the main trunks using wire. Place t-posts along the revetment and secure rope from the posts to the revetment



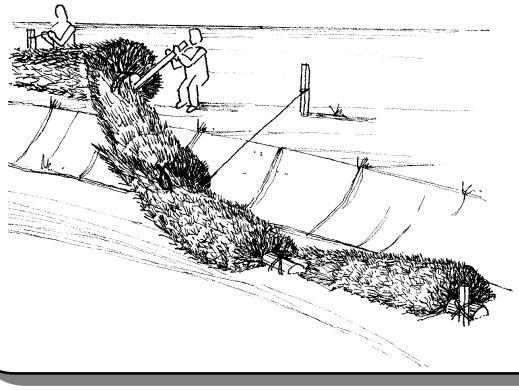
**Step Two: Fastening Revetment**

Lower revetment into stream and fasten end of revetment to a t-post placed at toe of bank.



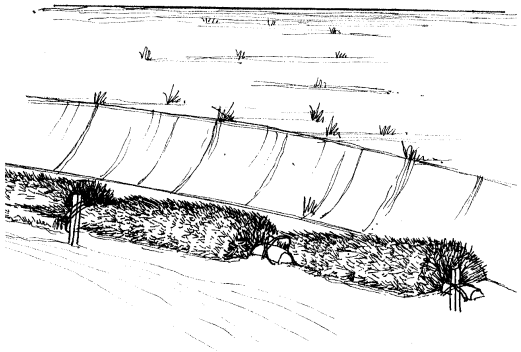
**Step Three: Begin Placement**

Lever the rest of the revetment into the stream, temporarily securing the revetment to the t-posts.



**Step Four: Final Placement**

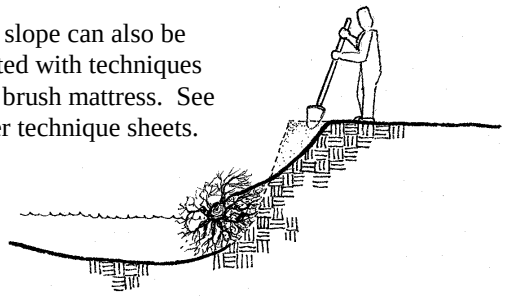
Pound t-posts next to the revetment and secure revetment to posts with wire.



**Step Five: Final T-post Placement**

Streambank can be knocked down on to the revetment. Slope should be seeded with grass and planted with willows.

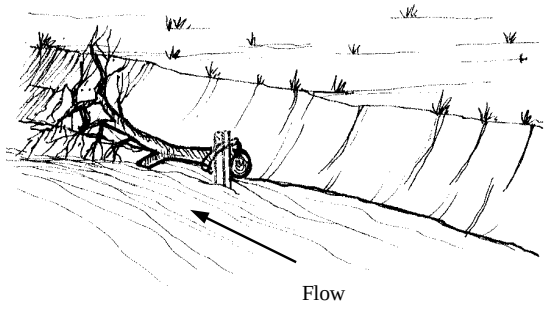
The slope can also be treated with techniques like brush mattress. See other technique sheets.



**Step Six: Optional Bank Shaping**

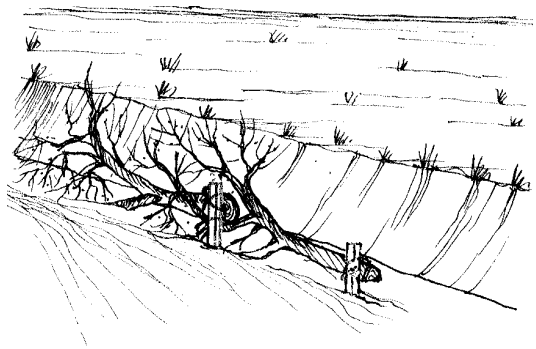
# Procedure for Brush or Tree Revetment-Option B

Pound a t-post at the downstream end and secure the trunk of the first tree to the post using wire.



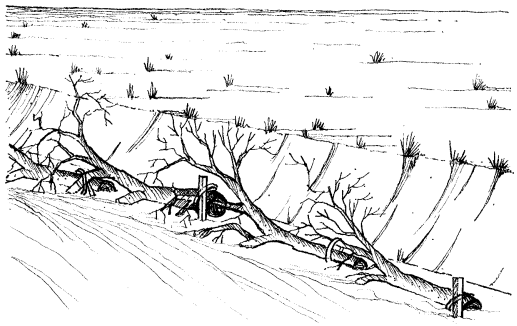

**Step One: Placement of First Tree**

Overlap the second tree onto the first tree so that no large gaps exist. Wire the trunks together.



**Step Two: Placement of Second Tree**

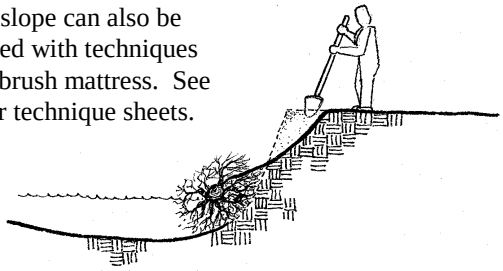
Pound a t-post near the second tree and secure tree to post. Continue placement of trees and posts till area is treated.



**Step Three: Continue Placement**

Streambank can be knocked down on to the revetment. Slope should be seeded with grass and planted with willows.

The slope can also be treated with techniques like brush mattress. See other technique sheets.



**Step Four: Optional Bank Shaping**

## How To Install

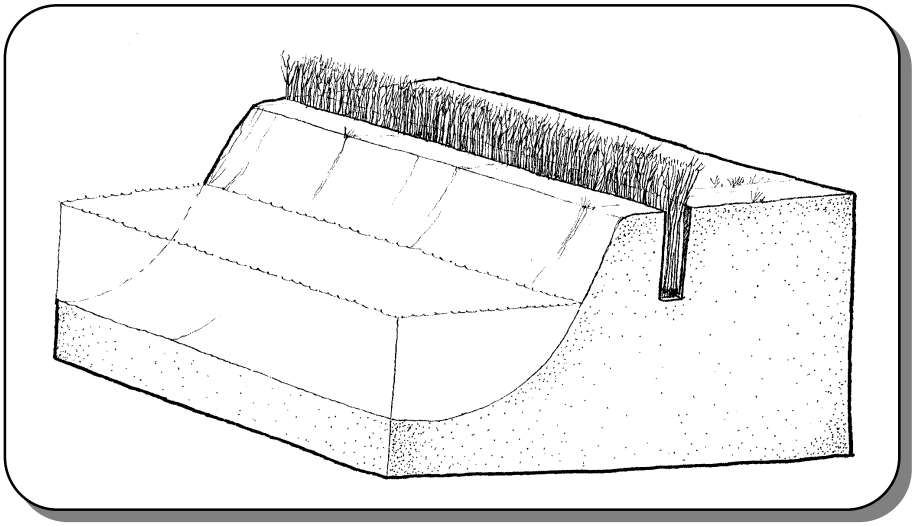
1. Harvest the trees for the revetment and stage near site. Pound a t-post at the downstream end of the site. Secure the first tree to the post with the trunk pointing upstream.

2. Place the second tree so the branches overlap the trunk of the first tree. The goal is to provide for a continuous row of dense branches to protect the streambank. Wire the main trunks together, leaving the branches loose. Pound in another t-post to secure the trunk of the second tree.

3. Continue the process of placing and securing trees until area is treated. Fill in the space between the bank and the revetment with branches to create a dense matrix of brush or willow wattles.

4. (Optional ) To enhance recovery of the treated area, knock down the sloughing streambank on to the revetment to create a more gentle streambank slope. Plant willow cuttings on the new slope using techniques such as willow wattles, vertical bundles or willow pole plantings (see other Technique Sheets).

# Brush Trench



## Materials:

- willow cuttings
- clothesline cord or wire
- chain saw or loppers (to harvest willows)
- shovel or pick-ax
- 1 person minimum

## Description and Use

This technique uses bundles of willow cuttings (*Salix* spp.) in a buried trench along the top of an eroding streambank. This willow "fence" filters runoff before it enters the stream and is a good method for alleviation of piping problems. The willow cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots. This technique should be used in combination with toe and mid-bank protection methods such as wattles, fiberschines, brush revetment, brush mattress, rock., etc. See other Technique sheets.

## How To Install

1. Harvest willow cuttings from a local, native stand that is in healthy condition taking no more than 2/3 of each plant.

Cuttings should be at least 1/2 inch in diameter or larger to ensure an adequate supply of stored energy for rooting, but there should be a good mixture of various sizes. This ensures better entrapment of sediment which will promote better root growth.

Ideally, cuttings should be collected during the dormant season to ensure the highest success rate. Cuttings can be collected during the growing season if all the leaves are removed from the stem, although establishment success will be lowered.

2. The cuttings can be tied into bundles to facilitate transportation to the project site. The terminal bud should be removed so that stem energy will be re-routed to the lateral buds for more efficient root and stem sprouting.

3. Soak the bundles for 5 to 7 days prior to planting.

4. Install the toe protection and mid-bank treatments if needed prior to constructing the brush trench. Excavate a 3-4 inch wide trench at the top of the streambank. Locate the trench about 12 inches from the edge of the top of the streambank. The trench should be at least 18 inches in depth. A pick-ax with a broad blade is useful in excavating the trench. Place the excavated material on the upslope side of the trench.

5. Cut the twine on the bundles and place the cuttings in the trench. Make sure the cut ends reach the bottom of the trench. Spread the cuttings in the trench until the desired thickness is achieved. In general, the thicker and denser the cuttings are, the better the technique will work. A good rule of thumb is that one 8 to 12 inch diameter bundle can be spread out over 1 linear foot. The height of the cuttings above ground should extend above the competing ground vegetation.

6. Backfill the trenches with the excavated soil. To remove air pockets around the cuttings, water the soil when backfilling.

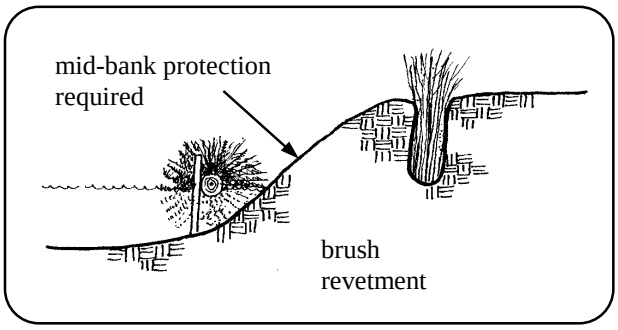
# Brush Trench

## Inventory & Planning Considerations

1. Coyote willow (*Salix exigua*) is a particularly good species for this method because of its' dense root system. This technique can also be used with redoiser dogwood (*Cornus spp.*). However, to encourage rooting with dogwoods, the stems need to be manually nicked or cut and treated with rooting hormone.

2. A critical inventory step is to determine the availability of moisture for the cuttings. Either the cuttings will have to reach the capillary fringe of the permanent water table or there will need to be sufficient overland runoff or bank seepage to sustain the willows.

3. Another critical step with this technique is to determine if toe protection is necessary. Analysis and calculations will provide some guidance (see Chapter 3 Streambank Bioengineering Guide). In some cases, brush revetment or fiberschines may be adequate (See other Technique Sheets), while other instances may require rock. In addition to the toe protection, a treatment for the mid-bank may also be needed.




Brush Trench with Brush Revetment

5. Give careful attention to both endpoints of the treatment to prevent flows from getting behind the trench. Tying into existing features on site such as trees or rocks or utilizing additional brush or rock are some possible solutions.

6. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

## Management

To ensure the highest success for the treated area, determine the land management practices that created the eroded streambanks and modify those practices as necessary.

If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put the exclosure fences at the high water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time.

If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Check with your local NRCS district conservationist for cost-share programs and volunteers for fencing, planting, and other restoration activities.

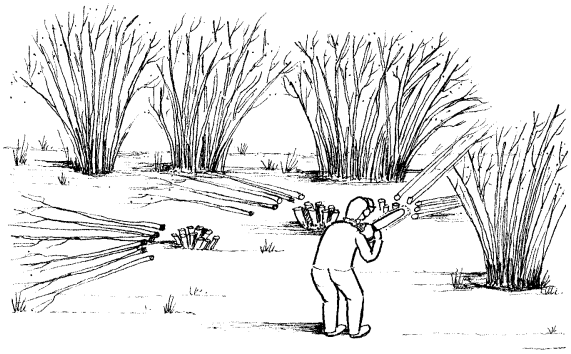
Finally, a stream is an interconnected system and land use practices both upstream and downstream will affect the success of your bioengineering work. Talk with your neighbors and work together to create a healthier riparian and stream system that can benefit everyone.

## Monitoring & Maintenance

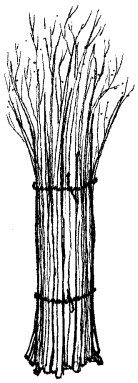
Do not ignore the project after it has been installed. Periodic monitoring of the project will provide valuable insight into the stabilization process and may offer important information for future projects.

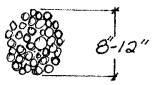
Periodic maintenance includes making sure the streambank is not eroding close to the side of the trench. It may be determined that some additional protection is necessary to allow more time for the cuttings to take root and stabilize the streambank.

# Procedure for Brush Trench



**Step One**: **Harvest Willow Cuttings**

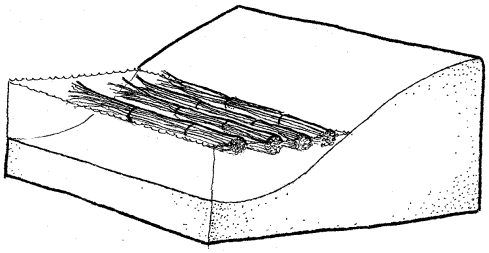





Tie cuttings into bundles using 2 pieces of twine for ease of transportation.

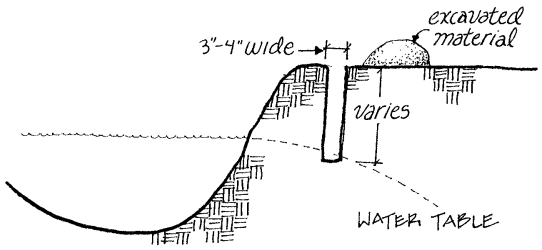
**Step Two: Willow Bundles**

Soak bundles for 5 to 7 days. Remove them from water before roots emerge.



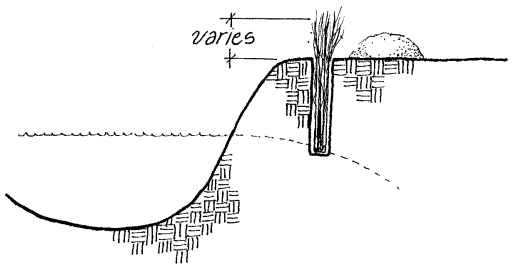
**Step Three: Soak Willow Bundles**

Make sure the bottom of the trench reaches the capillary fringe of the permanent water table.



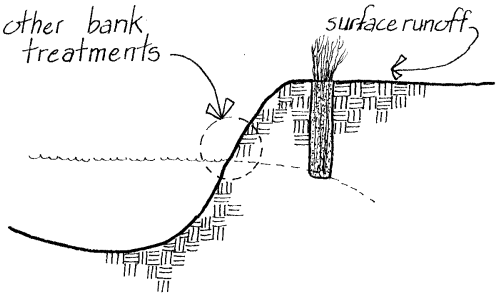

**Step Four: Excavate Trench**

Cut twine and place the cuttings in trench. Spread cuttings for desired thickness.



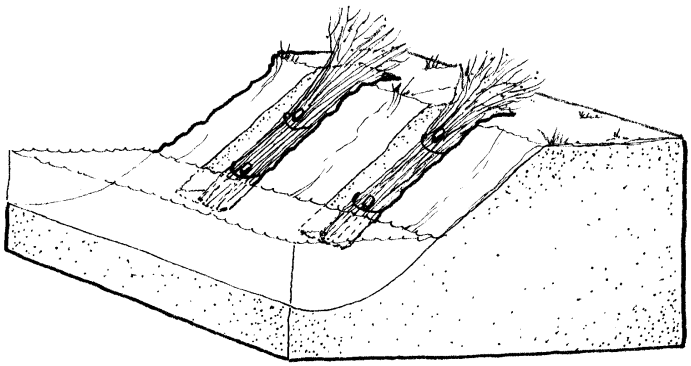

**Step Five: Cutting Placement**

Backfill soil and water into the trench to remove air pockets.




**Step Six: Backfill**

# Vertical Bundles



## Materials:

- o willow cuttings
- o clothesline cord or wire
- o chain saw or loppers (to harvest willows)
- o shovel
- o 1 person minimum

## Description and Use

This technique uses bundles of willow cuttings (*Salix* spp.) placed in vertical trenches along an eroding streambank. The willow cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots. Revetment and/or erosion control fabric should be used to protect the bundles until they have become established. This technique is good for areas with fluctuating water levels.

## How To Install

1. Harvest willow cuttings from a local willow stand that is in healthy condition taking no more than 2/3 of each plant.

Cuttings should be at least 1/2 inch in diameter or larger to ensure an adequate supply of stored energy for rooting, but there should be a good mixture of various sizes. This is to ensure better entrapment of sediment that will promote better root growth.

Cuttings should be collected during the dormant season to ensure the highest success rate. Cuttings can be collected during the growing season if all the leaves are removed from the stem, although establishment success will be lowered. Spring plantings are generally more successful than fall plantings.

2. The cuttings should be tied into bundles approximately 3 to 18 inches in diameter depending upon use and position with all the growing tips orientated up. The terminal bud should be removed so that stem energy will be re-routed to the lateral buds for more efficient root and stem sprouting.

3. The bundles should be soaked for 5 to 7 days.

4. Excavate a vertical trench with a slope of 2:1 or more in the streambank. Make sure the bottom of the trench will still be under water during low flows.

5. The trenches should be excavated approximately 3 foot centers to ensure adequate protection of the streambank and to encourage rapid growth to fill in between the bundles.

6. Place the bundles in the trenches with the cut ends in the water and then secure them to the bank with wooden stakes. In tight soil, spud links or rebar can be used instead of wooden stakes. Partially backfill around the bundles with soil.

7. It may be desirable to cover the bundles with some type of erosion control fabric to hold the soil in place. See “Erosion Control Fabric Technique” sheets.

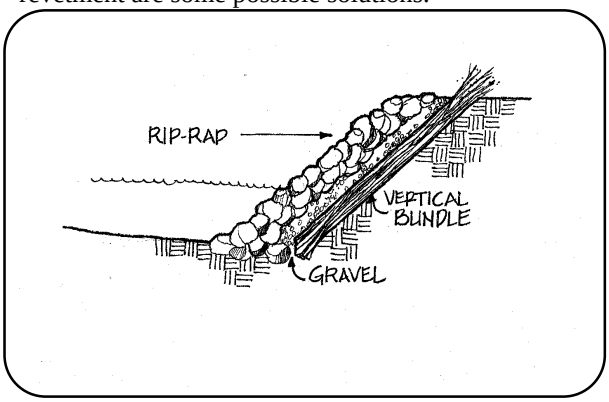
8. Brush revetment or other suitable toe protection should also be installed to protect the toe of the bank from scour. Be sure to protect both the upstream and downstream ends of the treatment area to prevent flows from getting behind the bundles.

# Vertical Bundles

## Inventory & Planning Considerations

1. Coyote willow (*Salix exigua*) is a particularly good species for this method because of its' dense root system. This technique can also be used with a mixture of redoiser dogwood (*Cornus spp.*) and willow, but to encourage dogwood rooting, the stems will need to be manually nicked or cut and treated with rooting hormone.

2. Some protection should always be placed in front of the bundles. In particular, the toe of the slope is very susceptible to erosive flows and scour. Analysis and calculations of forces will provide guidance for suitable toe protection (see Chapter 3 Streambank Bioengineering Guide). Careful attention must be given to both endpoints of the treatment to prevent flows from getting behind the bundles. Tying into existing features on site, such as trees, rocks, etc. or utilizing additional brush revetment are some possible solutions.




**VERTICAL BUNDLES UNDERNEATH RIP-RAP**

3. In areas where rip-rap is being placed, vertical willow bundles can be installed prior to placement of the rip-rap. Instead of installing a geotextile fabric on the streambank, pea gravel should be used. This will allow willow growth to protrude through the rip-rap.

4. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is disturbed, the easier it will be to restore.

## Management

To ensure the highest success for the treated area, determine the land management practices that created the eroded streambanks and modify those practices as necessary.

If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put the exclosure fences at the high water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time.

If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Check with your local NRCS district conservationist for cost-share programs and volunteers for fencing, planting, other restoration activities.

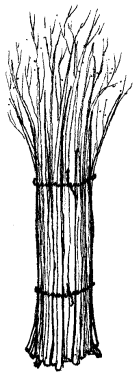
Finally, a stream is an interconnected system and land use practices both upstream and downstream will affect the success of your bioengineering work. Talk with your neighbors and work together to create a healthier riparian and stream system that can benefit everyone.

## Monitoring & Maintenance:

Do not ignore the project after it has been installed. Periodic monitoring of the project will provide valuable insight into the stabilization process and may offer important information for future projects.

Periodic maintenance includes making sure the bundles are secured to the streambank and that some soil cover remains on the bundle. Additional plantings may be necessary between the vertical bundles to speed up the rate of vegetative establishment and spread.

# Procedure for Vertical Bundles



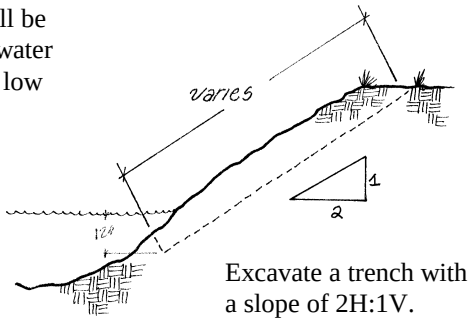
Harvest and tie cuttings into 3 to 18" diameter bundles depending upon appication using 2 pieces of twine.

3-18" or as required by the design.

Soak the bundles for 5 to 7 days. Remove them from the water before roots emerge.

**Step One**: **Acquire Willow Cuttings**

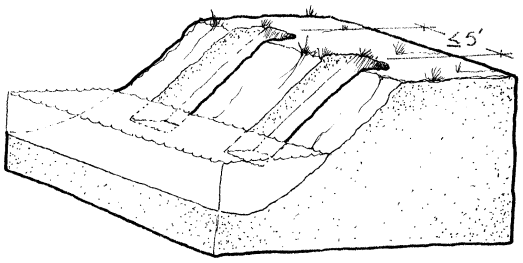
Make sure the bottom of the trench will still be under water during low flows.




Excavate a trench with a slope of 2H:1V.

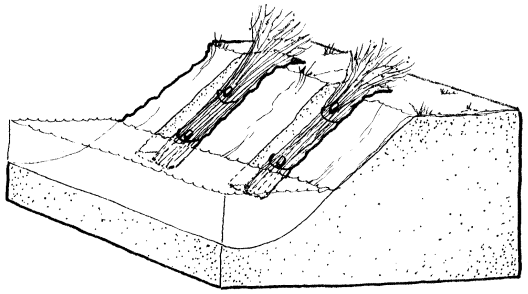
**Step Two: Excavate Trench**

Excavate trenches on 3 to 5 foot centers.



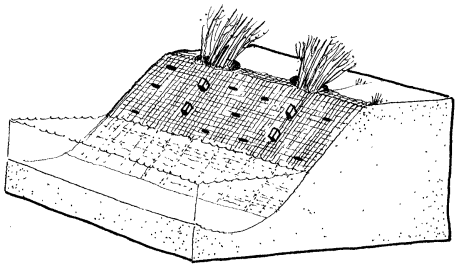

**Step Three: Horizontal Spacing**

Secure bundles to trench with stakes and partially backfill. Make sure cut ends are in the water.



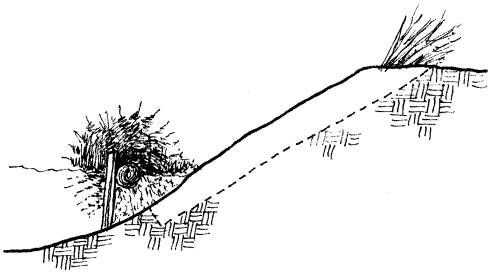
**Step Four: Bundle Placement**

**Option 1**: Secure erosion control fabric over the bundles. See "Erosion Control Fabric Technique Sheet". Stake on both sides of bundle to secure fabric.



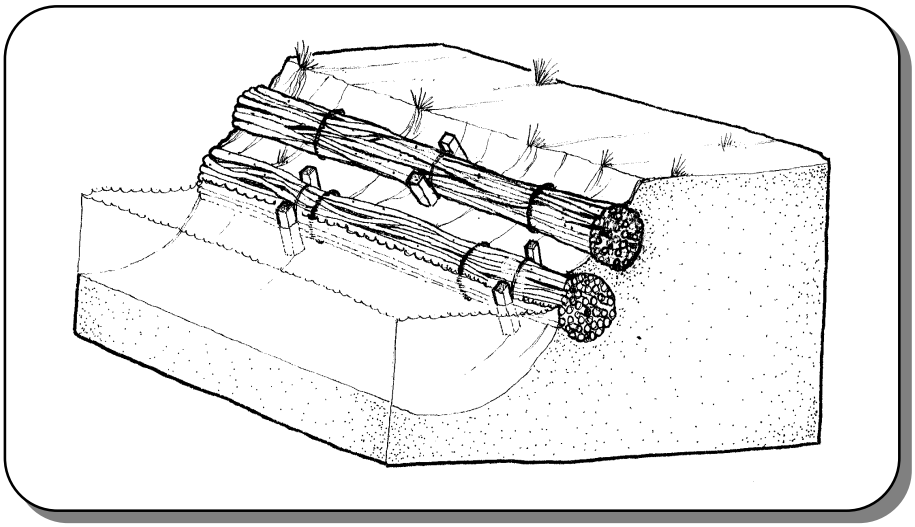
**Final Step: Fabric Placement**

**Option 2**: Secure brush revetment or other suitable toe protection at the toe of the slope.



**Final Step: Revetment Placement**

# Willow Wattles or Fascines



## Materials:

- o willow cuttings
- o clothesline cord or wire
- o wood stakes
- o chain saw or loppers (to harvest willows)
- o shovel
- o 1 person minimum

## Description and Use

Willow wattles (*Salix* spp.) or live fascines are cigar or sausage-like bundles of live cuttings tied together and inserted into a shallow trench dug into the streambank. The willow bundles will sprout and take root, thus stabilizing the streambank with a dense matrix of roots. This is a good technique to break up slope length and minimize erosion.

## How To Install

1. Harvest willow cuttings from a local stand that is in healthy condition taking no more than 2/3 of each plant.

Cuttings should be at least a 1/2 inch diameter or larger to ensure an adequate supply of stored energy for rooting, but there should be a good mixture of various sizes. This is to ensure better entrapment of sediment that will promote better root growth. Ideally cuttings should be collected during the dormant season to ensure the highest success rate. Cuttings can be collected during the growing season if all the leaves are removed from the stem, although establishment success will be lowered.

2. The cuttings can be tied into bundles to facilitate transportation to the project site. The terminal bud should be removed so that energy will be re-routed to the lateral buds for more efficient root and stem sprouting.

3. Soak the bundles for 5 to 7 days before planting.

4. After soaking, the bundles should be laid out in one, long sausage-shaped bundle with the cut ends placed in alternating directions. The bundle should be tied every 18 inches.

5. Excavate a horizontal trench 2/3 the diameter of the wattle in the streambank at approximately the low flow line.

6. Place the wattle in the trench and stake every 3 to 4 feet with 24 to 42 inch wedge-shaped wooden stakes Stake length will depend on soil conditions. Place stakes on both sides of the wattle and wire across the bundle. Backfill around the wattle by knocking the top of the bank on to the wattle, making sure to work soil into the branches.

Often a second wattle is placed up the bank behind the first wattle. If the streambank consists of saturated soils for most of the growing season, a series of wattles can be established up the streambank. However, in the arid and semi-arid regions, there is normally not enough moisture near the surface to establish several layers of wattles. Pole plantings might be a good option behind the initial wattle since the poles will reach the permanent watertable. It should also be noted that some additional toe protection such as rock may be necessary for this technique.

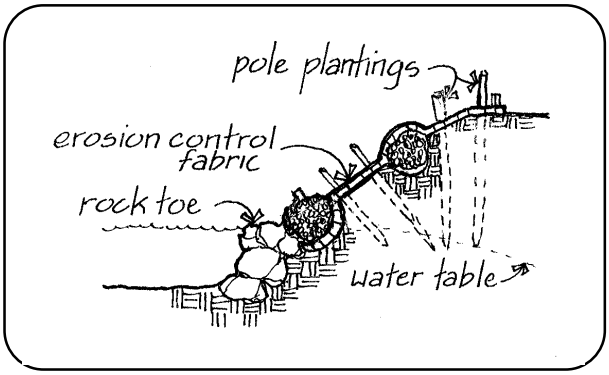
# Willow Wattles or Fascines

## Inventory & Planning Considerations

1. Coyote willow (*Salix exigua*) is a particularly good species for this method because of its' dense root system. This technique can also be used with a mixture of redoiser dogwood (*Cornus spp*) and willows. To encourage rooting in the dogwood, the stems need to be manually nicked or cut and treated with rooting hormone.

2. If this method is used in a highly erodible area, some protection should be placed in front of the wattles to prevent scour. Analysis and calculations of forces will provide guidance for suitable toe protection (see Chapter 3 Streambank Bioengineering Guide). In some cases, brush revetment or fiberschines may be adequate (See other Technique Sheets), while other situations may require rock. If no other protection is used, the wattle should be 12 to 24 inches in diameter.

3. Another variation of this technique is to cover the wattles with erosion control fabric to prevent the soil from being washed away from the wattles. Secure the fabric under the first wattle. Poles can be planted into the permanent water table between the wattles. The following illustration also shows the use of a rock toe to prevent scour.




**WATTLES WITH FABRIC AND POLE PLANTINGS**

4. Rooting hormones and fertilizers do not significantly improved success for the cost of the materials.

5. Never disturb the site unnecessarily. Remember the goal is to stabilize a site. The less it is

## Management

To ensure the highest success for the treated area, determine the land management practices that created the eroded streambanks and modify those practices as necessary.

If the area is grazed, restrict livestock from treated areas to allow the eroded section of streambank to heal. Exclosure fences are the most efficient means to accomplish this goal. Managers should resist the temptation to put the exclosure fences at the high water line. The exclosure areas should include enough of the riparian zone to allow the stream to shift naturally over time.

If the area is farmed, a riparian buffer strip should be established and maintained. A buffer strip on both sides of the stream should be set aside to allow for natural riparian vegetation and stream function. A wider buffer strip is strongly encouraged and will yield greater benefits.

Check with your local NRCS district conservationist for cost-share programs and volunteers for fencing, planting, and other restoration activities.

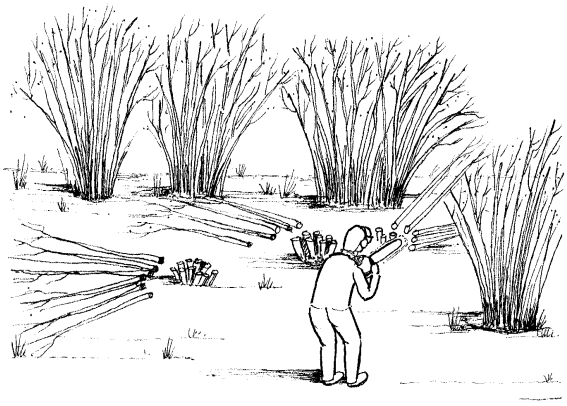
Finally, a stream is an interconnected system and land use practices both upstream and downstream will affect the success of your bioengineering work. Talk with your neighbors and work together to create a healthier riparian and stream system that can benefit everyone.

## Monitoring & Maintenance

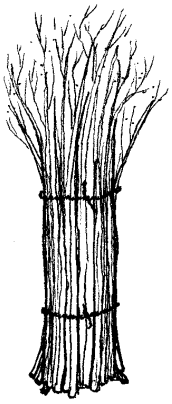
Do not ignore the project after it has been installed. Periodic monitoring of the project will provide valuable insight into the stabilization process and may offer important information for future projects.

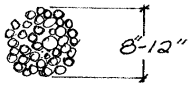
Periodic maintenance includes making sure the wattle is secured to the streambank and that some soil cover remains on the wattle. Additional plantings may be necessary to speed up the rate of vegetative establishment and spread.

# Procedure for Willow Wattles or Fascines



**Step One**: **Harvest Willow Cuttings**

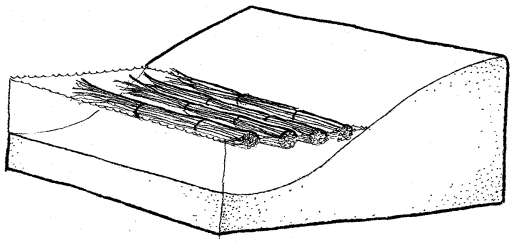





Tie cuttings into bundles using 2 pieces of poly twine for ease of transportation.

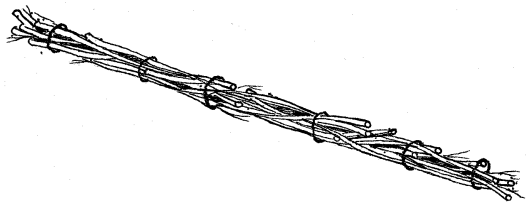
**Step Two: Create Willow Bundles**

Soak bundles for 5 to 7 days. Remove them from water before roots emerge.



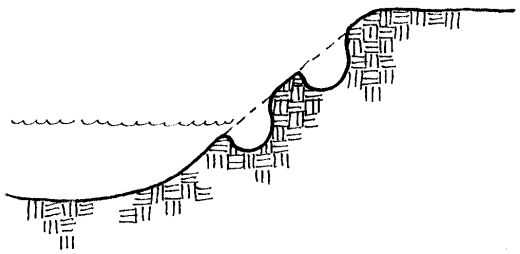
**Step Three: Soak Willow Bundles**

Build one long sausage-shaped bundle with the cut ends alternating directions. The bundle should be tied every 18 inches.



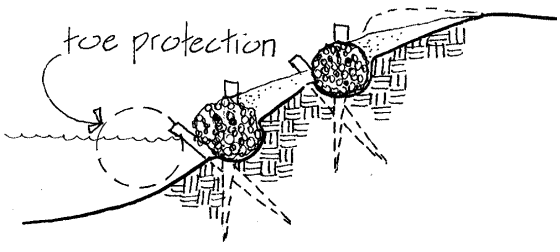
**Step Four: Build Wattle**

Excavate a horizontal trench 2/3 the diameter of the wattle along the streambank at approximately the low flow line at the toe of the bank.



**Step Five: Excavate Trench**

Place the wattle in the trench and stake with wedge-shaped stakes. Backfill around the wattle by knocking the top of the bank onto the wattle. Leave some of the branches exposed to sprout.




**Step Six: Place Wattle**